SIBR Grant Application

Box 1: Overview, Key Words, and Subtopic Name

The fast-paced world we live in today requires the need to better mobilize and organize events like protests and marches. Our project offers planning for the mobilization of people in events such as protests and large gatherings. The app will result in a decrease in the likeability of violence breaking between two opposite groups of a protest and allow for a safer environment both for those involved in the protest as well as the general public.

The potential outcome of the product is to better mobilize individuals and groups of people. The product will give users the ability to better respond to their surroundings when moving through their city on foot. With the influx of applications and resources for people to use to find better driving directions when it comes to avoiding traffic, accidents, or road closures, this product will utilize similar concepts, but with focus on people on foot.

Areas of technical expertise: Cloud Computing, Mobile Application, Cloud Platforms, Location API

Areas of Application: Mobile phone development, Mobilization, Location-tracking, Routing,

The subtopic of this project is Software Engineering

Box 2: Intellectual Merit

This Small Business Innovation Research Phase I project demonstrates the creation of an algorithm that computes the routing people based on large crowds and events. The intellectual merit is the product's algorithm that calculates the number of people per specific area and decides whether a route needs to be adjusted to avoid a highly crowded area or accidents that will impede the continuation of the user's trip. The development of this algorithm includes location tracking of the app users, computing the best route for getting from one place to another, and determining when an area is to be avoided. Technical hurdles for this product include being able to respond promptly when directions need to be adjusted for users. The algorithm must be able to take in and analyze data fast enough to be effective in giving the user the best experience.

Goals of the R&D include providing users with an experience that will give them the most up-to-date information in the quickest response time. In order to reach these goals, the product will focus on two major elements: accuracy and response time. Accuracy will be measured in the algorithm's ability to find all appropriate paths and give the user the best one. Response time will be measured in the program's ability to continuously pull data about location tracking, accident reports, etc that will aid in adjusting the user's path in real time.

Box 3: Broader/Commercial Impact

The broader impacts of the project are benefits to society by providing an innovative way to better mobilize individuals and groups through a medium that focuses on the movement of people at the ground level. On a commercial level, our project provides a tool for better controlling large gatherings of people in a safe way, which is very appealing in today's global climate. On a social level, a more organized system for protests will cause a positive social impact through allowing protest participants to take part of a more organized and thoroughly

planned protest. Another aspect of the social level is the impact on the general public that does not take a part of the event but benefits from the safer environment that is resulted from the app.

Elevator Pitch

Have you ever wanted to join a march late but were concerned you won't be able to find it? Have you participated in a march like the Women's March in D.C where there were so many participants that you were not able to actually march? People Movement is here to solve that problem.

People movement is an app for orchestrating the movement of individuals and groups of people on foot. The app focuses on providing directions getting from point A to point B for large groups of people on foot. Furthermore, the app incorporates live updates from the users to improve and adjust the route accordingly. Our app will focus on large groups of people on foot. Some of the potential applications of the app include directing protests and marches across cities, to create a safer environment for the protest participants as well as the city's residents.

Our product focuses on improving the efficiency of four main groups of people: the organizer, the group, the individual, and the community. Any organizer managing large groups will be able to more efficiency manage the moving group. He or she will be able to have up-to-date information to more quickly react to changes in the group's movement. Any group will be able to move more smoothly as a whole. Any individual will be able to join groups late, reconnect if lost, or report any incidents and/or suggestions for the route. And lastly, but most uniquely to our application, is the benefit this will have on the community. Large groups moving on foot tend to disrupt daily activities of the surrounding community and People Movement works to limit those disruptions faced by the community.

People Movement will highlight key features that current market apps do not support. First, the app will ensure a constant-fluent movement of large gatherings and will prevent "deadlocks" situations from occurring. Second, the app will provide tools for group management, allowing a user to create a group as well as join existing groups.This tool can also be used for day-to-day activities such as organizing a social gathering that will travel from one place to another for example a group of friends walking to the movies together. Third, directions will be provided based on the individual's location as well as the group location as a whole.

One does not need to worry anymore about being separated from the group since People Movement will keep track of where all group members are located while on a trip. While there are apps that provide directions for driving while taking into account traffic information, People Movement is the first to provide walking directions with respect to live events and given updates.

Join our movement and move with People Movement!

Commercial Opportunity and Social Impact

Everyone uses apps. Students use Evernote. Craft-lovers use Pinterest. Sports fans use ESPN. Friends use SnapChat. Parents use Urbansitter. The app store marketplace is booming because everyone uses app. More apps are being pushed to the marketplace everyday and more people are downloading these apps. And the statistics prove it. According to Statista, from 2016 to 2017, there was a 25.6 billion increase in app downloads. In 2016, the mobile app store revenue was over 36.2 billion US dollars. And the number of apps in the Apple Store and Google Play combined is over 4 billion. Everyone uses apps.

People Movement is a mobile application built for Android and sold in Google Play store. In order to determine its potential for success, our team had to determine its ability to be marketable: Who would our customers be? What category would the app fall under? Which apps can we target as competition? Our customers can be described in a broad sense as people who travel in large groups. However, this is not descriptive enough when identifying those who will actually need or want to download the app. With more fine-tuning, our customers can be described as big-city residents or visitors who attend marches and/or protests, are part of an organization that holds events within walking distance, and/or have a desire to avoid large groups if they are traveling by foot. Our customers are smartphone users who need directions for on-foot travel.

Understanding the competition is important for any new business. If the competition already dominates the market with a good product, it may be hard for other products to enter that market and be just as successful. However, People Movement faces a unique challenge when observing the market: there is no market for the product as a whole. Currently, the apps on the market cover issues like Waze's walking directions, Find My Friend's tracking friends feature, or Zello Walkie Talkie's group messaging, but there is no current product that combines all of these into one to support a group's movement. Protesters must use three apps at once just to communicate with, locate, and get to their group. Organization leaders must post to social media groups about departure time or route changes only to hope that everyone in the group gets notified. City residents must use on-the-spot judgement when they approach a crowd blocking their way in order to determine which route to take next. None of these problems are addressed on the market, and People Movement is made to solve them.

Bringing a product to market has risks, and it is important to understand those risks. The biggest risk that our team has identified is the risk that the market does not need a product like this now. App downloaders might not see the need for an application that helps people move around in large groups on foot, but People Movement has potential. When discussing the product idea with some fellow students, our team found that there is more need for a product like People Movement than most people would think. A fellow student was describing her disappointing day when she mentioned: "There was a protest at Union Station today, but I think I got there too late because no one was there. I think the group had moved on in their march around DC". The fellow student did not know of anyone participating in the protest and had no way of contacting its organizer. If she had downloaded People Movement, her disappointing day would have actually been a productive day. Another student was talking about a movie he saw one weekend and mentioned: "If I would have known there would be such a large march on my way, I wouldn't have been late to the movie". This is just the second of many situations where People Movement could have led to a more productive and satisfactory day for a city resident. Although

the risk of pushing a product to market that does not see a lot of downloads exists, People Movement caters its features to fit the needs and wants of the users it targets. People Movement is making a good product that people will use.

The commercialization approach for People Movement will start small and then expand. Our team will first target GW students who are living in DC. We plan to use a medium-sized subset of students to test this product. This group will be members of our Computer Science graduating class and members of our Greek chapter on campus. That subset of students will then be included in our wider subset of students that we will use to market the product. The Greek life chapter has the highest potential for number of potential user reached. Currently, the chapter has 150 members. There is at least one member that has a first connection with a member of a different chapter. Since there are over thirty chapters on the campus, ranging in total membership between 30-175, the average direct-to-consumer advertising possible hits roughly 2500 potential customers. This number is only on the campus of The George Washington University! If our team was able to connect to other active chapters on other campuses, then our number of potential users, just between the ages of 18-22, would increase at an extremely high rate. On top of this, there is the potential of students marketing to students outside of Greek life, to their friends, to the families, etc. Additionally, being in the heart of the nation's capital adds a level of possible users to tap into for marketing. Our team will reach out to protest/march organizers, demonstrate People Movement's success in testing, and encourage them to use the app. These channels will be highly effective in marketing the People Movement product.

The social impact of People Movement goes beyond the call to action that the typical app addresses. We did not create People Movement for our own benefit. We created People Movement to benefit society as a whole. Our app addresses a social need and provides a solution to a problem that affects society on a daily basis. People movement is not directed for specific groups or individuals, but is rather for anyone and everyone. The two ways that People Movement affects society are direct and indirect. The direct impact is related to the app's users while the indirect impact is the way People Movement affects non-users.

The first type of user affected by People Movement is the group event organizer. The task of organizing events will never again be complicated thanks to People Movement. When users download the app, they open a whole new window to better group-organizing experience. Our app allows users to easily create group events such as marches, protests, and other events that demand large crowds in movement. It provides users with the ability to add people to their group event and provide a walking route for all group members. The app algorithms for route calculations takes into account events around the city from the different groups in the app as well as location data from other users, and comes up with the best route for each specific group. This way, the group organizer can ensure a smooth and continuous movement of the group. Furthermore, the group organizer also gains a better control over the group through the app's feature of tracking all group members. The organizer can track where the group is at all times during the trip and make sure no one is lost or split up from the rest of the group. Lastly, the group organizer will have access to the analytics of the trip. After the event is over, the event organizer can look back at analytics from the event, such as how many members actually showed up. From this, organizers will have a better understanding of how to improve for next event.

The next direct group that benefits from People Movement are the group members. Group members gain the ability to join a group, see in advance who else is a part of that group, and have transparency to what the route is in order to unite with the rest of their group. This has a huge effect on the user's safety since it assures no user will ever be in a situation where they will not be able to find the rest of their group members. In addition, this also allows for more flexibility on the user's side in the event that a user needs to join the group after it has already begun its route. In the past, attempting to track down a group to join in the middle of the trip was a hard task that involved guessing how far the group made in a specific amount of time. This is no longer an issue since People Movement lets users easily keep track of how far the group is going and join them accordingly. All of these provide sense of security and community for the group as they use the app.

Both of the groups mentioned above also have a mutual benefit from our app that is time efficiency. People value their time and how it is spent. No one likes to be stuck in traffic just as much as no one likes to find out last minute their walking route is blocked. This is why People Movement uses the best algorithms that keep up to date with live events around the city. Our app will use these live events when calculating walking routes. People Movement values its user's time, and we want to treat it accordingly. That is why we provide users with only the most efficient walking route to ensure their time is used effectively. Organizers, groups, and individual users are all direct customers being effective by our app.

In terms of indirect effects, People Movement not only has effects on our app users, but it has just as equally large effects on non-app users. Those non-app users are the city's residents, tourists, and other people staying in the city. People Movement affects the city as a whole by allowing for the flow of people around the city to move more smoothly and to avoid situations of deadlocks. It makes the sidewalks less crowded and easier to navigate. The people living in the city will be affected by this without even realizing People Movement is the reason. They will have a quieter and safer city. In the end, they will have to spend less time running into unorganized crowds and more time enjoying their route.

Moreover, People Movement has a larger benefit that has to do with a major issue which is global warming. One of People Movement goals is to encourage people to walk more and drive less. We hope that creating a better walking environment will increase the number of people choosing to use walking as a form of transportation rather than driving. According to UCSUSA, vehicles account for nearly one-fifth of all US emissions with around 24 pounds of carbon dioxide emissions per gallon of gas. This data goes to show how much of a large impact cars have on global warming. Reducing the usage of cars means reducing CO_2 emissions and helping fight global warming. We see People Movement serving a larger role than only making cities easier to navigate. We're foreseeing the long-run effects of People Movement on the global society. Even if People Movement will operate in specific cities, it will cause a world-wide improvement to all.

Technical Discussion and R&D Plan

Key Technical Challenges

The biggest technical challenges in PeopleMovement project include managing large sets of data and building algorithms that are time efficient and scalable. For the first challenge, the goal for PeopleMovement is to be adopted internationally and to be used by large amounts of people. For that reason scalability will have to be kept in mind while building this product. PeopleMovement will have to store a lot of location data and be able to access it easily in real-time. In addition, since the users locations will be changing constantly due to their movement, there will need to be a way to alter the data in an efficient manner.

The second challenge that is a part of PeopleMovement is dealing with coming up and implementing an algorithm for determining crowds on the map. This is a main algorithm the app will be using, since based on it PeopleMovement will determine a rerouting is needed to be done for a specific path. Because this algorithm plays such a major role in the app it will have to include these three aspects: reliability, scalability, and efficiency. In terms of reliability, the algorithm will have to be reliable for the product to be able to base our rerouting on the algorithm's results. Therefore it has to be accurate and be able to detect what data is reliable to use. In order to avoid a case of rerouting a group of people when it is not necessary, reliability should be kept as a priority. The second aspect, scalability, goes back to working with large sets of data. The algorithm will have to by dynamic and allow different sizes of data to go through it. Some areas where PeopleMovement will be used might have tens of people, while others could have hundreds and even thousands. PeopleMovement's algorithm will need to be scalable to these different sizes in order to successfully provide its functionality. Lastly, the algorithm will have to have a fast time complexity for it to run efficiently. Since the algorithm will need to scan a lot of data, PeopleMovement will need to implement a fast algorithm that will have an efficient runtime.

Risks

PeopleMovement is a product that is user-dependant. The algorithm runs on data from the user's location and bases the result on it. The main algorithm takes in all the locations and calculates clusters of people and reroutes other users based on it. This poses a risk of fake information that can be inputted or hacked by mal-users. An example for a potential risk is in the case of march. PeopleMovement could be used to create a group associated with a march where all the users receive a route to march through. Due to the nature of marches, many times there are opposers who want to sabotage the march. This creates a security risk of hackers who could create a fake crowd cluster in PeopleMovement's system and cause the rerouting of the march while there is no reason to. This puts our product in a high risk of being hacked, and therefore asks for extra security efforts to make the product safe.

Innovation and Target Application

The PeopleMovement algorithm is extremely innovative in multiple ways. Current technology for mapping deals with predictive modeling for individuals. That modeling is done on a case by case basis, considering the method of transportation and a singular location, regardless of how many people are traveling in the same direction or the amount of people that will be in the path

along the way. This new model is innovative because it takes geographical information of all its user to provide a predictive model in walking directions, where a user will be able to have the most optimized route if they are approaching crowds of people on foot in their path or if they are a user that is part of a bigger group traveling together. This algorithm will be able to predict the best directions for walking based on live updates of app users in a particular area. In the first case, that which a user will have an optimized route if their current path is heading toward a large crowd, PeopleMovement will continuously monitor the clusters of crowds on the map and if a cluster of people becomes too large or too high risk for the user to safely pass through them, then our algorithm will send updated directions to the user. In the second case, that which an individual is a part of a large group, PeopleMovement will respond to the need to readjust directions if the threat of overcrowding becomes an issue for the group to smoothly move onward.

The innovativeness of the algorithm to focus on the analysis of clusters of moving groups, rather than the analysis of high traffic areas as a result of vehicle clustering. Being able to obtain information on locations of people rather than locations of vehicles will improve the results of administered directions. When someone is walking through a big city or participates in a protest, information on how busy the sidewalks are with people is more valuable to the user than information on how busy the streets are with cars.

Questions to determine feasibility

- How large of a database should be used?
- How to come up with algorithms that are time efficient?
- What population of people is this product targeted at? How will it be marketed to them?
- What cloud functions should be used to compute the different functionalities?
- How will PeopleMovement detect fake data?

Technical Milestones

PeopleMovement's goal is to build an application for optimizing the movement of people on foot by providing an Android app interface to interact with. Therefore the milestones to get the product to market must satisfy this overall goal. The first milestone in achieving this goal is the Android app user interface. In order to deliver to market, we must have an app that will provide the users with the functionality to create an account, create a group, join a group, receive directions and their updated versions, and communicate with other group members. PeopleMovement's interface must deliver all of these functions in order to be ready for market.

The second milestone is the algorithm. PeopleMovement's algorithm will focus on two things: rerouting a user based on if their path is blocked by an upcoming group or if their group is experiencing a blockage. In order for this product to be on track to get to market, the algorithm needs to be tested and implemented properly. This is a four part solution: 1. Build, 2. Test, 3. Edit, 4. Repeat. Testing is a very important part of this solution because it allows a chance to find all of the potential use cases. Without the testing portion of this solution, PeopleMovement would not be able to perform well in a live market setting.

With the combined aspects of the user interface in the form of an Android app and the algorithm implementation through firebase cloud functions, PeopleMovement will be ready for the market.

R&D plan

Time frame for R&D on this project is September 2017 through April 2018. That is a eight-month time frame split up by 4-week sprints structured around the beginning to end of each month. In the first two sprints, R&D focuses on research and library/service investigation. The main objective of this phase is determining which platforms, tools, APIs, or services the application will need. These tools will have to at least include Android Studio, Google Maps API, and a database with cloud functionality, Firebase. Once this list is solidified, PeopleMovement's timeline can move forward with more of the implementation aspects of the design.

In the middle three sprints, R&D focuses on development of environment and data flow between all services in the application as well as the beginning stages of the algorithm. There are quite a few objectives for this phase of the research and development. One is the need to integrate the different technologies that PeopleMovement team has decided to focus on and use. To be sure that the environments are setup correctly, the development stage must incorporate tests to be run to confirm the functionality. The second objective for this phase is the beginning design of the algorithms. Algorithms for this project will need to be able to reroute users based on current status of the entire map of users. Hence, this algorithm will need to incorporate a clustering technique that will be appropriate for the dataset. The algorithm will also need to be written and deployed using cloud functions in Firebase. Cloud functions will be a collection of different parts of the algorithm and will set off each other depending on the case. The first half of this phase will need to be completed before the second half. Once the environment is set, then the algorithms can be written and tested on a large sample datasets. After these two parts are completed, R&D can continue with the rest of its objectives and move into the testing and editing aspect of the algorithm building.

In the next two sprints, R&D will focus on testing and altering the algorithm based on test results as well as cleaning up the functions of the Android app interface. When People Movement goes live, the algorithms will need to be functional regardless of the size and diversity of the dataset. Therefore, there needs to be an aspect of R&D that encompasses this objective. In order to move forward, the app must be able to run smoothly in typical situations and edge case situations. This phase will continue testing that has already be started and introduce new nuisances into the sample dataset. During this time, PeopleMovement team will also be focusing on cleaning up the user interface. Having a functional user interface in the Android app is key to the continuation of R&D. The team needs to be sure that the app is market ready in order to do the final stage of live testing. After these objectives are met, the project will proceed to the next and final phase of R&D.

In the last sprint, R&D will focus on making sure the application runs smoothly for all our test cases and getting a small focus group together to test the app in a more formal and live environment. To be successful in market, PeopleMovement needs to prove successful on a

smaller scale. This is where the last sprint becomes the most crucial step before introducing the project to market. In this last phase, the objective is determining functional usefulness. PeopleMovement's team will reach out to a small subset of typical users to live test the algorithm. Typical users will be split into two groups, one to be in the way of the other. From there the team will be able to obtain actual results from users and come up with a summary of how these results will affect future results that come from a larger scale of users.

Testing and Experiments

1) **Cluster recognition test**
   The main algorithm of PeopleMovement will be tested using the cluster recognition test. As a part of this test, a large amount of data will be fed to the cluster algorithm to test the skill of crowd recognition. This test will first be done in the small scale of only tens of people. The test will be declared successful if it will be able to detect a crowd from the data fed to it. In addition, the accuracy of the test is important for success. The algorithm will have to be able to not only detect the crowd, but also come up with the right coordinates to represent it. Theses coordinates will represent the most dense area of the crowd. Once this was successfully completed on the small set of data, the algorithm will be tested on the larger scale. As a part of the larger scale test, the algorithm will be tested on hundreds of location data. This test will be determined successful similarly to the small scale test. If the cluster was detected, with the right coordinates, then success was achieved.

2) **Rerouting test**
   The rerouting test purpose is to check that rerouting is done in a right way. The way this test will be conducted is: an original route is given to a specific user or a group of users. Then, a cluster will be manually fed to the system to indicate a crowd in the middle of the route. Then, the test will call the rerouting algorithm and test its results. The result will have to be the new route generated after the indication of a cluster in the way. The new route will have to avoid the area of high density of people but still be the best route that could be given for the users. This test will be done with a small cluster at the beginning the size of half a block. Once it successfully returns a good new route, it will be tested on a larger area than a block.

3) **Mal-data test**
   Test to indicate if data given by the users is valid and should be used in PeopleMovement's algorithm. The way the test will be conducted is that data that is not consistent with real-life location data will be inputted into the system manually. This data will represent a crowd that does not exist in real life. The test will have to detect that this data is not accurate nor consistent with other data it is receiving, and therefore will mark it as fake. It will be indicated as a success if the fake data will be detected and not used in any of PeopleMovement's functionalities.