Lab1: Descriptive Paper of ODU Spring 2019 CS411 Team Silver Project

Crime HotSpot

CS411W Spring 2019 Team Silver
Professor: Thomas Kennedy
Author: Raphael J. Sandor
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1. Introduction

Crime HotSpot's objective is to help the end user find areas that are within in the user's safety tolerance. With crime being prevalent in all societies it can become difficult to decide whether an area is safe. The volume of these crimes can be seen in the 7.7 million property crimes and the 1.2 million violent crimes committed in the United States of America in the year 2017 (FBI, 2017). Judging if somewhere is within safety tolerances is challenging given the possibility that two people may have different safety concerns, due to socioeconomical demographics. Suppose one person owns a car and another chooses to only take public transportation. The person that takes public transportation may be more concerned with becoming the victim of a robbery or assault, while the other person is more concerned with vandalism, larceny, or theft of the automobile. Presumably each person would do research to find an area that is within tolerance, but to do so is tedious and time consuming, and can often leads to negative or unreliable results. People concerned with safety frequently rely on common knowledge and opinions from locals in the area. One problem with this approach is that information that is regarded as common knowledge to one person may be foreign to another. There are other potential drawbacks to relying on the consensus of others when it comes to safety, for one there is not always a local nearby to query. Sometimes people are biased and areas that are relatively low risk are said to be dangerous due to racial biases, and social class structures. Another consideration is the source of the opinion; it is possible the person offering advice has vested interests in making some neighborhoods and business distracts appear safer than others to locate, or travel. The other case, that is perhaps just as bad, is people even without bias and only honest opinions and common knowledge, is peoples' safety standards differ. Each person offers advice to the other based one's own concerns; in the case of the two fictional people, the person without the car may not pay much attention to larceny from autos.

Figure 1. Screen shot of crimes for the city of Norfolk, Virginia. Reprinted from Helping You Build a Safer Community in CrimeMapping.com., 2018 Retrieved from CrimeMapping.com

The other option, aside from using people to gather information, is to use the Internet as a tool to help decide what neighborhoods are safe and what areas to avoid. The problem with this resolution is that the tools currently available overwhelm users with information. The user's interface quickly becomes cluttered with a plethora of icons representing crimes, refer to the *Figure 1*. While these tools help the user see the crimes in the area, they do not ascertain the level of danger present. As an example, a shopping center will have many cases of shoplifting but the risk of becoming a victim of a crime against one's person or personal property are low.

Areas that appear dangerous on these online applications are safer than assumed. In the case of election years where crime involving campaign yard signs spikes, areas appear more dangerous due to the property crime activities being reported equally to the other incidents, refer to *Figure 2*; "due to theft, trespassing and vandalism of said signs. That is due to an individual's political beliefs that have little to no actual effect on one's personal safety. And with so many crimes committed around the same area it can be difficult to differentiate between the types of crimes committed that hold value to individual crime-mapping user" (Crime HotSpot, 2018). Crime Hotspot solves this problem by focusing on quantitative data while allowing the user to prescribe qualitative meaning to the data displayed. Thereby allowing one to make the decision on the area's safety. Crime HotSpot will use a heat map in balancing qualitive and quantitative information. The heat map will be discussed in more detail under the product description, refer to *Figure 4*.

Figure 2. Campaign yard signs from person whose yard was vandalized. Reprinted from Campaign Signs from Minnesota Brown, 2018. Retrieved from minnesotabrown.com/wp-content/uploads/2018/07/campaign-signs.png

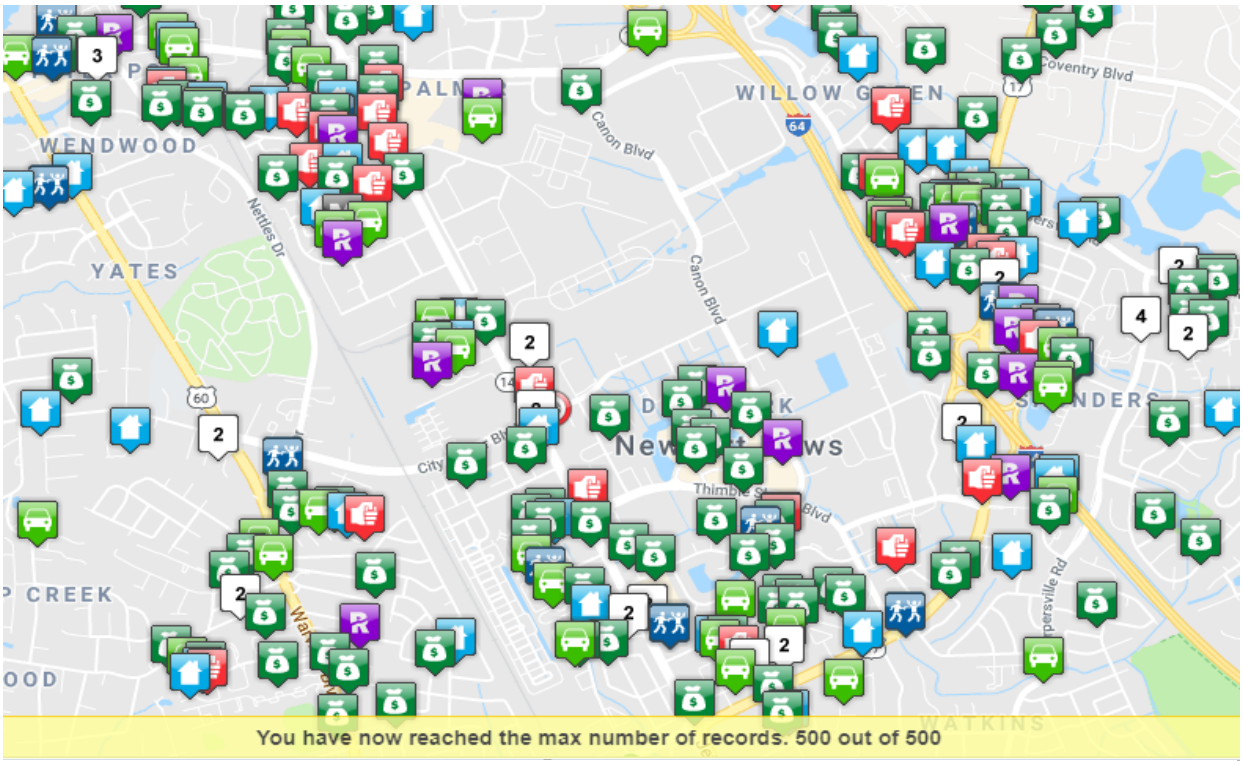

Figure 3. Once again, another example of how prevalent the icon graph is in displaying crimes and how difficult it is to interpret anything from the information. Reprinted from Lexus Nexus in Lexis Nexis Community Crime Map, 2018. Retrieved from https://communitycrimemap.com/.

2. Product Description

Crime HotSpot's solution to the cluttered displays of icon graphs, shown in *Figure 1* and *Figure 3*, is to display crime on a heatmap. The application will allow the end user to modify the crimes that are of interest and display the modification on a heatmap. A heatmap is a technique of applying a radial color, with nontransparent or brighter colors meaning a higher statistical significance and lighter and more transparent colors generally meaning lower density or statistical significance. Examine *Figure 4* for an example of a heatmap. Crime HotSpot uses the number of crimes and the user's provided significance of the crimes to decide the SafetyScore and the color displayed on the map. A comparison of *Figure 3* and *Figure 4* demonstrates how a crime heatmap can abstract the individual details of the myriad number of crimes of area while at the most basic level improves readability of crime density. Heatmaps provide opportunities to represent crime data in new ways, such as prescribing severities of the crimes committed and showing the level of danger in area and allow the user to see density of individual crime types.

To maximize the effectiveness of the heatmap Crime HotSpot will relate every color to a numerical score, which is the SafetyScore. The SafetyScore is unique to the user's personal preferences, the number of crimes, frequency, surrounding population density, and the level of danger associated to each crime incident. All these factors impact the SafetyScore and thereby the depiction of color on the map, thereby going one step further than the other applications

available in displaying meaningful information to user about the level of danger. Previously when a user would use a crime mapping tool the user would follow *Figure 5*'s process flow bellow, which is the process flow Crime HotSpot aims to simplify.

Examine the proposed solution process follow, *Figure 6*, there is a notable difference in the number of steps between *Figure 5* and the solution flow of *Figure 6*. Another key difference is that the user can find the information needed at any point in the process in *Figure 6* while in *Figure 5*, the user only has one solution.

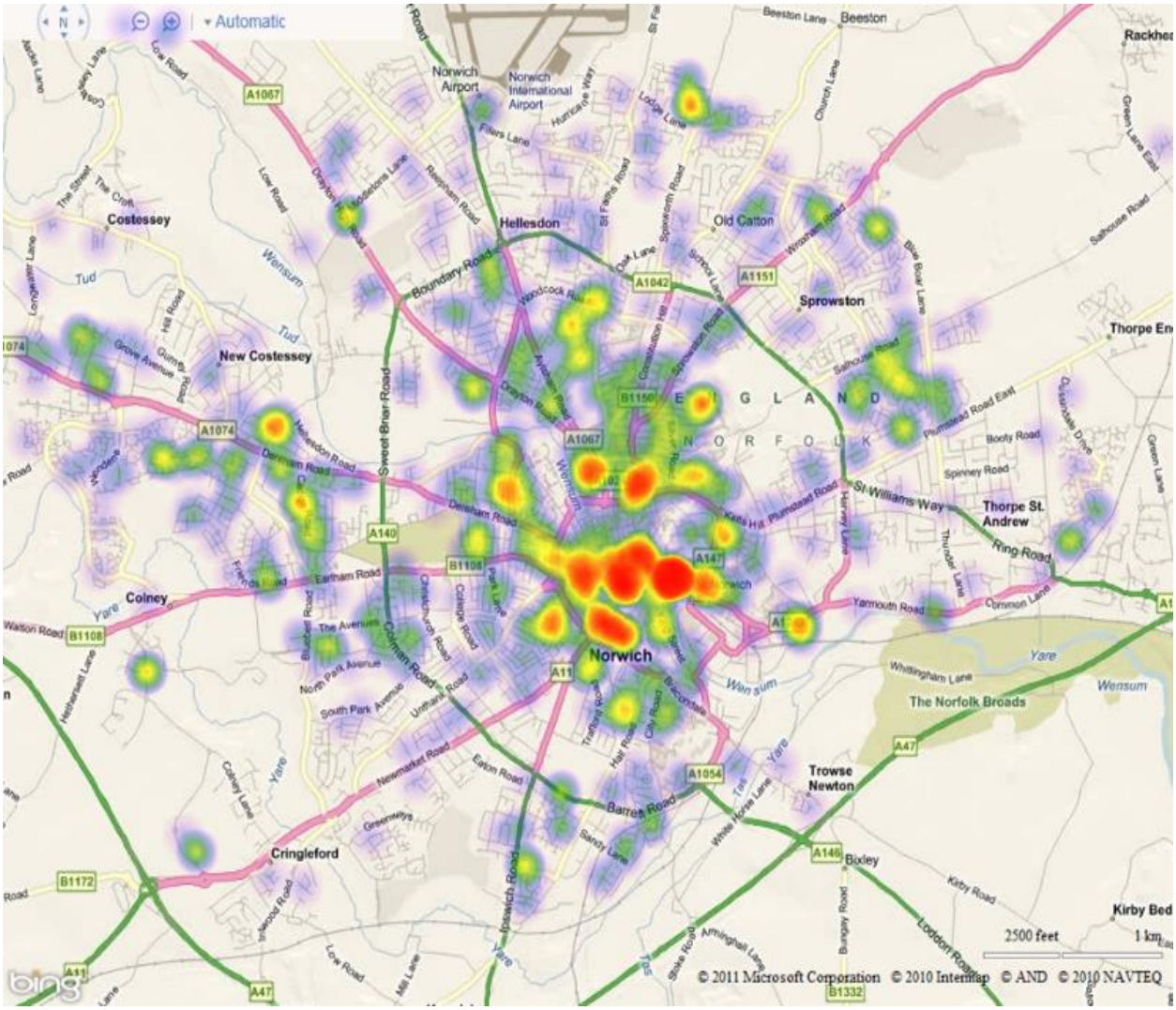

Figure 4. Example of a heatmap, with the red areas depicting a hotspot which where there is higher density of crimes. Reprinted from "Heat Map" by Microsoft, 2011, Retrieved from alastaira.files.wordpress.com/2011/02/image24.png.

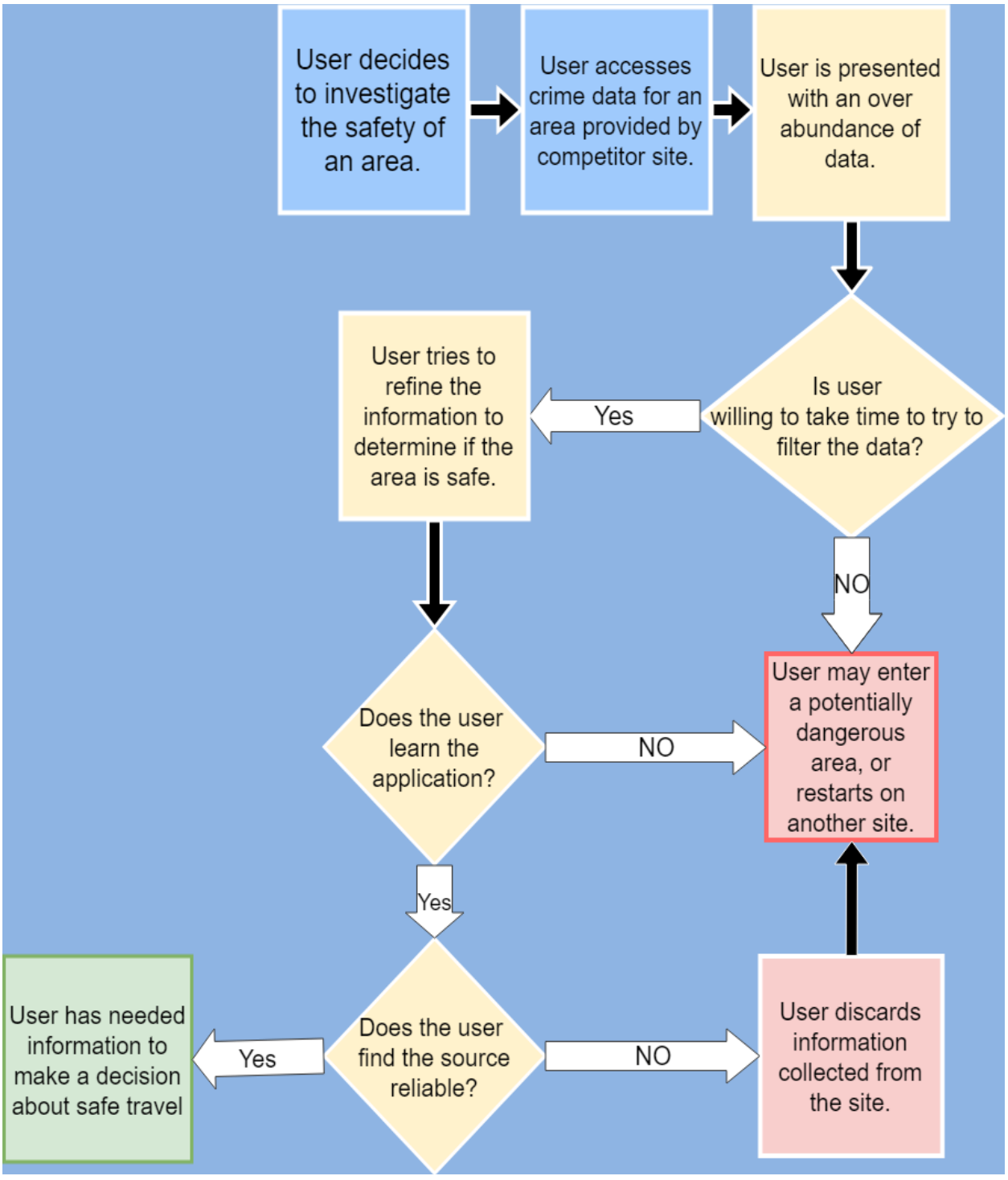

Figure 5. Current problem process flow, there is clearly only one way to decide if an area is safe and requires all previous steps to be correct. If at any point the user gives up or does not get the correct information, then the person may choose an unsafe location. Reprinted from 'Presentations' in Crime Hotspot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation.html

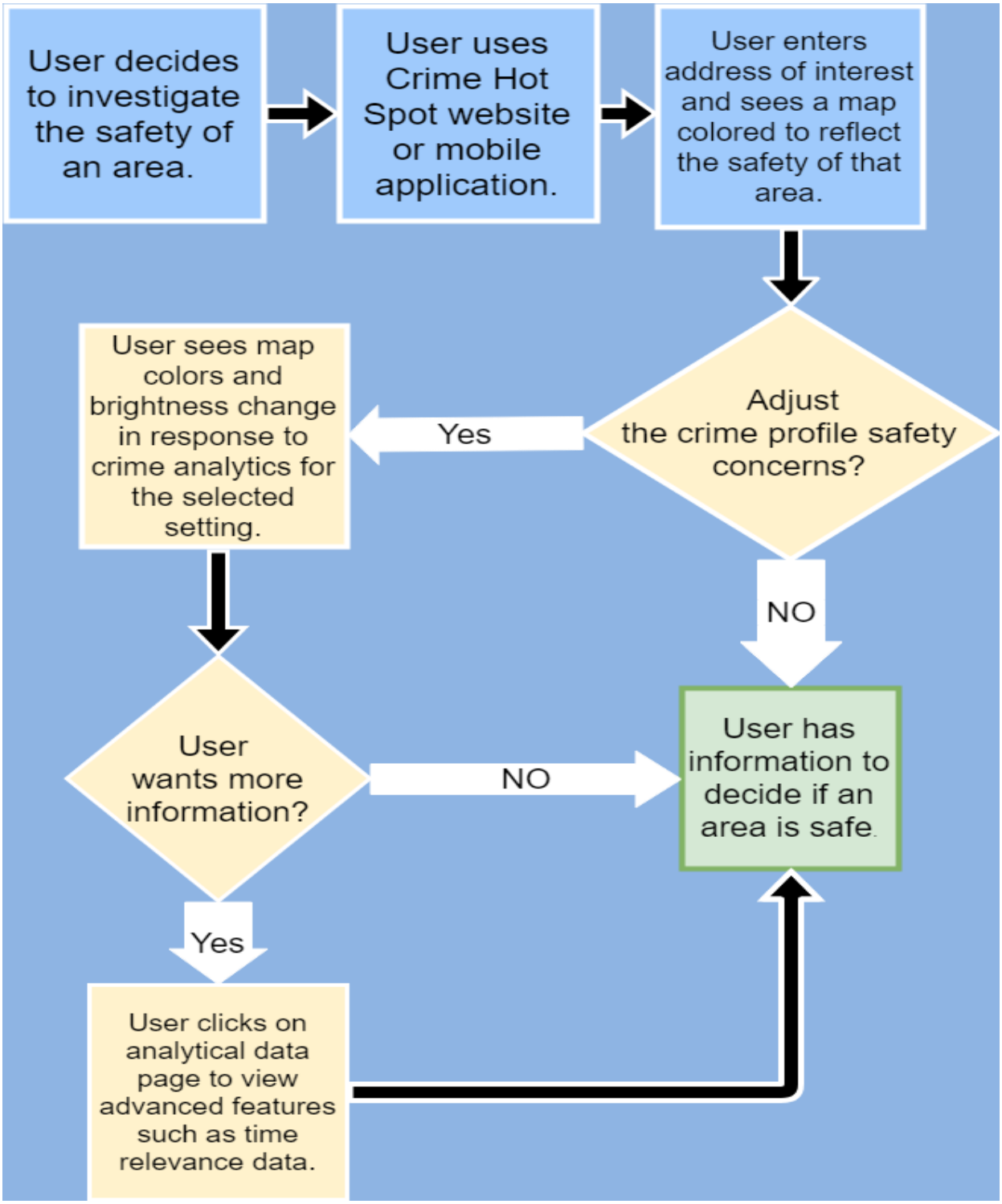

Figure 6. Simplifying the process while maintaining the useful information. Reprinted from 'Presentations' in Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

2.1 Key Product Features

There are various products that offer an assortment of tools that do crime mapping, however not all the tools offer all same functionality and features. Referring to *Figure 6* one can examine some of the proposed features Crime HotSpot will implement in the full production scale product. Even features that Crime HotSpot has in common with its competition have differences from Crime Hotspot those key differences and features are listed below.

2.1.1. Crimes type differentiation. Crime HotSpot does not differentiate by unique crime types such as assault or burglary but by crime categories. These categories include crimes against the person, crimes against property, and crimes against the general public. There are unique crime incidents underneath each crime category that impact the SafetyScore for an area on the map.

Characteristics / Programs	Crime Hot Spot	LexisNexis Community Crime Map	SpotCrime	CrimeMapping	AreaVibes	Trulia
Generalized crime data	✓	✓			✓	✓
Crime types differentiated	✓	✓	✓	✓		
Filter options: date, crime type	✓	✓		✓		
Weighted to user relevance (SafetyScore™)	✓					
Supplemental analytics	✓	✓	✓	✓	✓	
Companion app	✓					
Distributes data evenly across area of concern	✓					
Cluttered icon graph presentation		✓	✓	✓	✓	✓

Table 1. Table 1. Competition matrix highlighting some key features of Crime HotSpot. Reprinted from 'Presentations' in Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

2.1.2. Geographical crime references. Crime HotSpot does not want to expose the location of where crimes are committed and instead elected to use general locations, e.g., street blocks, and neighborhoods. Using general locations does two things, it allows the identities of the victims to remain anonymous. Second, it prevents criminals from finding soft targets that have been targeted in the past. If a criminal sees that a store has had several break-in incidents in the past, then they might think it's a good target.

2.1.3. Filter options. Crime HotSpot will allow the end user to affect the output of the heatmap to the various crime categories that have been toggled on or off by the user. The user can then make further selections on the crime categories to eliminate various crime that are from underneath the broader crime categories, for example abduction is a severe crime against the person but abduction generally is crime committed against women more frequently than men. A male user may choose to turn such a threat off. Thus, allowing the end user to modify the heatmap to meet their safety profile and concerns.

2.1.4. SafetyScore. The SafetyScore is then compiled against the crimes in the user's preferences, the number of crimes that have happened in the nearby area, the age of the crimes, the density of the population, and user's multiplier for said crimes. Each crime will impact the general area and crimes which overlap in radius of each other impact the score for the intersecting locations. The population density will also impact the coloration of the heat map as areas that are densely populated will have more incidents of crime but the risk of becoming a victim may not be increased. The user's multiplier is where a user can make a crime as mentioned previously more or less significant. The score ranges from zero to ten, with ten being the maximum score for a location, and being unsafe.

2.1.5. Supplemental analytics. In addition to the heatmap, the application will allow those users that are more curious to know more about what is impacting the area by clicking a spot on the map. A user will be able to see the numeric safety score with accompanying details of the crimes committed in the general area and data about the incidents.

2.1.6. Crime heatmap. The heatmap will have the color scheme of red meaning areas that have a higher SafetyScore while lighter colors such as blue will indicate that crime exists here but is mostly safe and yellow means to be cautious in the area. There will be a heatmap key around the map. Crime HotSpot will also have a grey scale option for users who are colored blind and otherwise would be unable to distinguish being the colors of the map.

2.1.7. Mobile application. The users of Crime HotSpot are apt to be travelers unfamiliar with the areas they visit, a desktop application, or even a web application will not meet the needs of the on the go urban explorer. Crime HotSpot's mobile app fits in the equation by giving the users a more simplified user interface than the full application, focusing more on time related analytics. this allows a user to know what times are safer than others or that they have entered a dangerous area for a given time. The application should then user a notification when they have entered a more dangerous area.

2.2 Major Components

Crime HotSpot has six components, not including the user. A geological information system, the Google Maps API, the application server Node.JS, the database, MongoDB, a terminal service, which is nothing more than a place than administrator can go to maintain the server and provide new data to the database. The website which the user interacts with and the mobile application for the demographic of users who are interested in the on the go features. *Figure 7* demonstrates how all these pieces are intended to work together in the full production application.

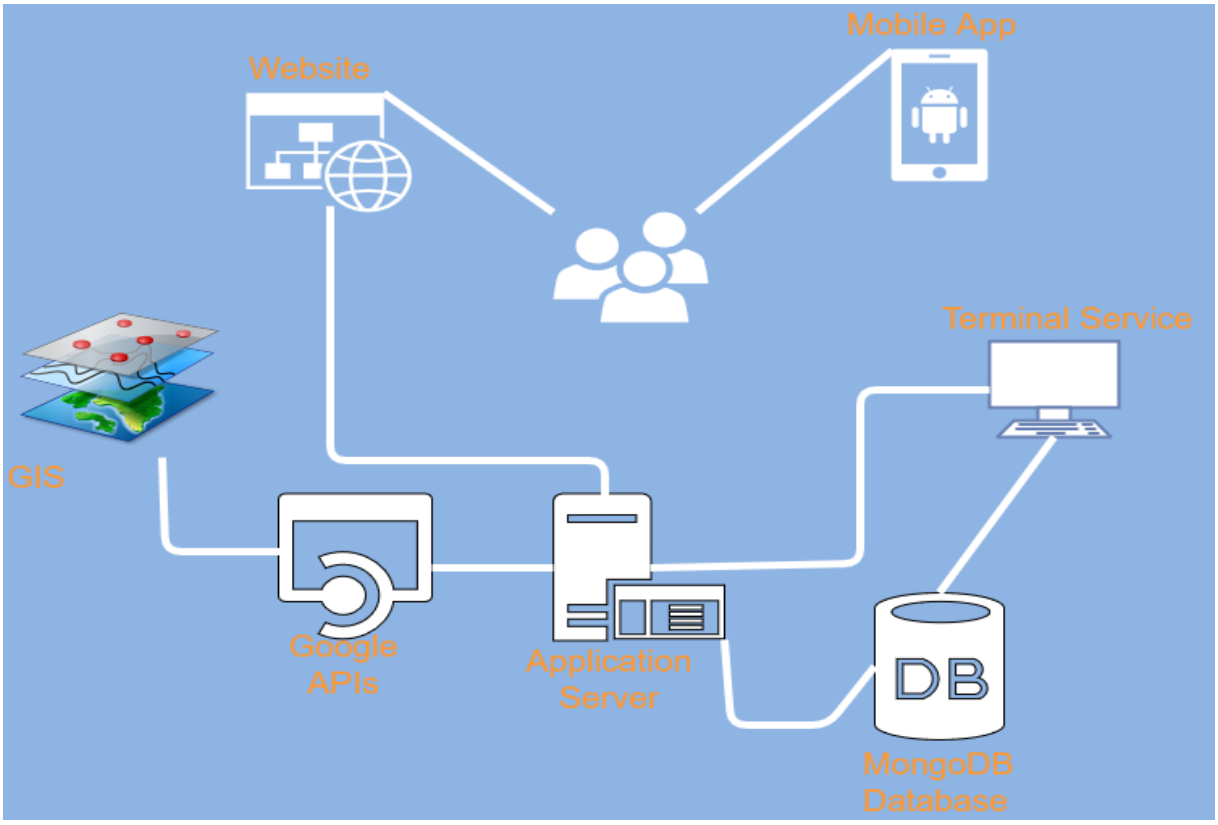

Figure 7. Major Functional Components. Reprinted from 'Presentations' in Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

2.2.1. Crime HotSpot website. The Crime HotSpot website is the graphical user interface to the application and will allow the user to interface with the heatmap and the analytics page among a selection of sliders and options. It will be written in JavaScript, HTML, CSS3, and Angular.js in accordance to the MEAN Stack methodologies. The MEAN Stack is a conglomeration of MangoDB for the database, Express.js for creating APIs to handle requests in the application, Angular.js to make the application interactive, and lastly, Node.js to serve the application on the Internet. Mongo DB and Node.js are backend technologies, the backend deals with interactions that are not transparent to the end user such as server request, database queries. The front-end is as suspected the opposite and deals with the development of visible features and the logic of interactions with the user, such technologies such as Angular.js and Express.js.

2.2.2. Google Maps API. “We first researched the ESRI ArcGIS system, which is one of the most used GIS systems in the world, as well as open source options. The open source tools did not offer enough functionality and flexibility, while ArcGIS was too powerful for our purposes, too expensive, and had a steep learning curve. After researching the Google Maps API, we determined this was a nice goldilocks option, offering free API use for low traffic applications, a straight forward API with good documentation, and enough power to do what needs to be done**”** (Crime HotSpot, 2018).

.**2.2.3. Crimes database.** The crime database will be managed by MongoDB as previously stated and will include data about the crimes such as the radius i.e. what is the area of impact the crime has, latitude and longitude of where the crime was committed, a crime report container that will have the crime type and general location, occurrence date, the database will give the crime a unique ID and will record the time of day which the incident occurred, which will allow the application to produce crime statistics based on time of day.

2.2.4. Application server. “The Dynamic Application server will also interact with the GIS system to perform actions which are related to geographical positioning, but not necessarily mapping, such as alerting a user who is using the mobile app that they are entering a dangerous area in real time.” (Crime HotSpot, 2018).

2.2.4. Application mobile application. The mobile application will allow the end user to get notifications when the user enters an area that is unsafe for the given time. The application will allow the user to provide their current address or enter area of interest and get the general safety of the area of the hour by hour analysis of the area of interest.

2.2.5. Terminal Service. The terminal service is how administrators of Crime HotSpot will manage the host server. Provide data to MongoDB as new crime data from an agency arrives. Here is also where the administrator would make changes to the server.

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3. Identification of Case Study

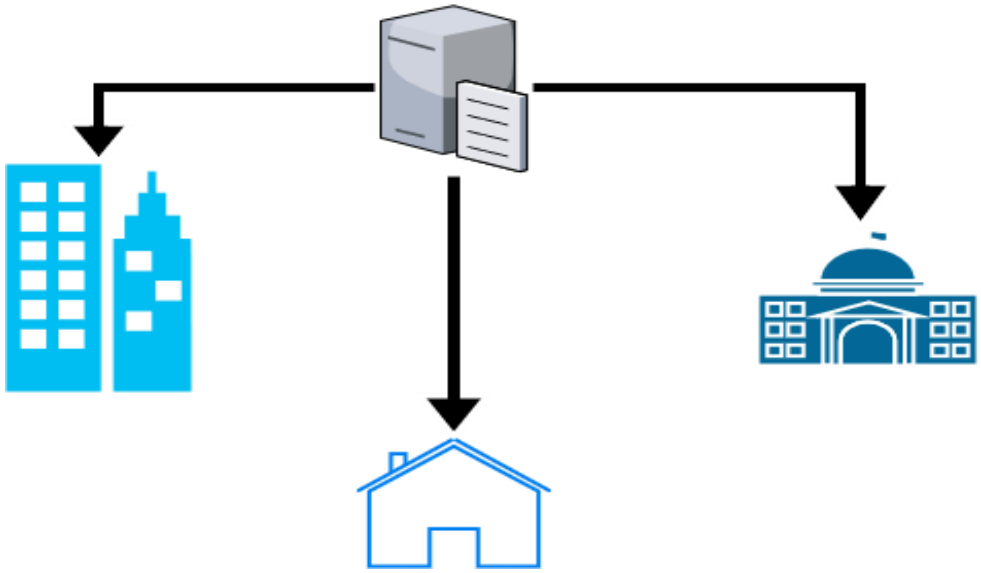

Figure 8. Customers of The Application. Reprinted from 'Presentations' in Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

The case study is a local business looking to find an area that are looking to minimize the risk of burglary and vandalism. Non-profits organizations and local governments would also be able to use this product to help study crime and protect communities against crime. This product would be of use to travelers who are unfamiliar with an area; the mobile application would suit the needs of this user. Lastly, realtors could use this application in helping find homes within neighborhoods that meet the safety standards of realtor's clients, *Figure 8*, is an example of the cases studies for Crime HotSpot; from left to right businesses, travelers and realtors in the middle, and governments and not profits on the far left.

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4. Product Prototype Description

Crime HotSpot leverages multiple technologies in delivering crime analytics and safety information to the end user. These tools include GPS and locations services provided by Google Maps among other technologies such as MongoDB and Angular.JS to deliver an interactive interface to the end user.

4.1. Prototype Architecture

The major functional components for the prototype will be focused around demonstrating the advantages of a heatmap in crime mapping, and a proof of concept of the power of a simple user interface. The Prototype will use Google Maps API as in the full production. The prototype will only demonstrate the web application with key functionality, discussed below. The application server will still serve the application and query the database for crimes but will not do real-time processing on a user's location on location changes as in the full production. The databases data will be focused only on Old Dominion University data and will implemented through MongoDB Atlas, MongoDB's managed database service.

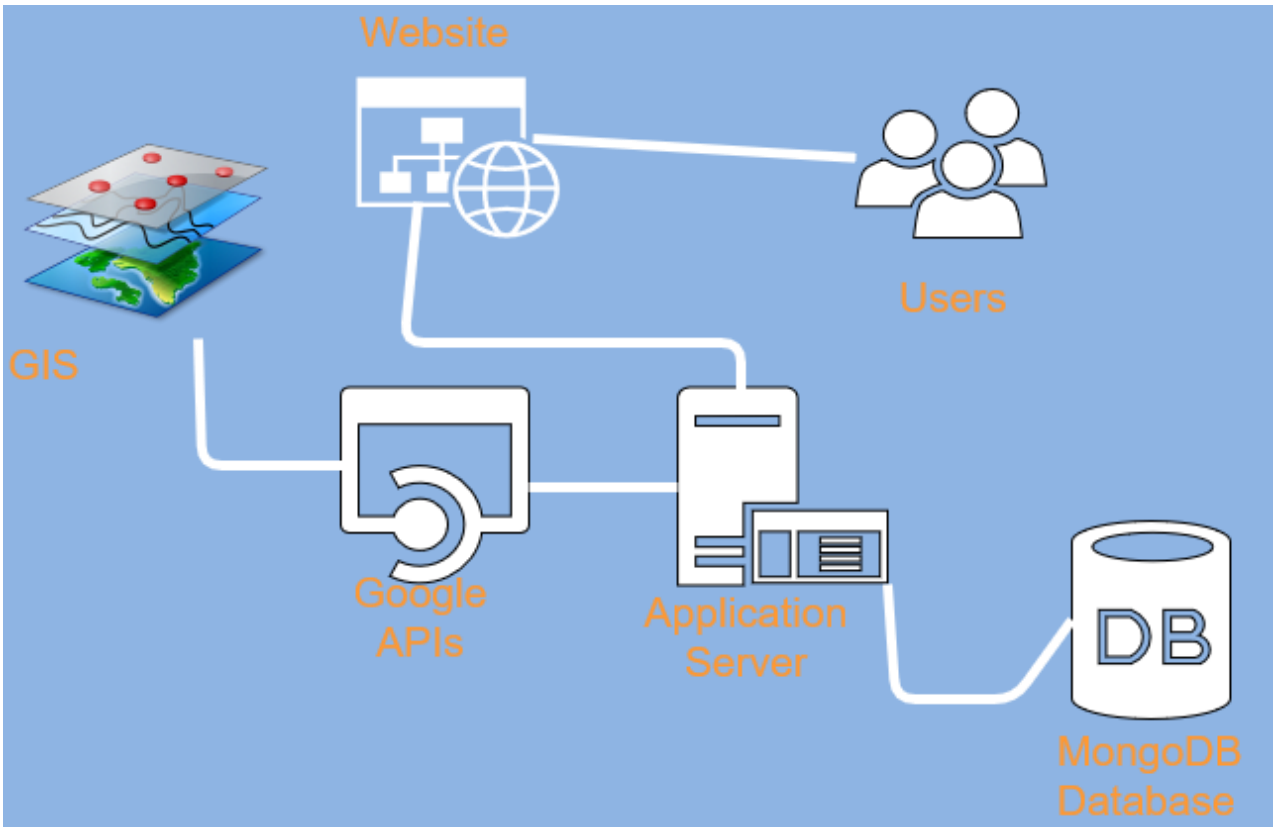

Figure 9. Prototype Major Functional Components. Reprinted from 'Presentations' in Crime HotSpot, 2018, Retrieved from https://www.cs.odu.edu/~cpi/old/410/silverf18/presentation

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4.1.1 Crimes database. For the prototype Crime HotSpot is opting to use MongoDB Atlas which is fully automated cloud service. The reasoning behind using MongoDB Atlas instead of installing and running the database by the Crime HotSpot team, is the cloud service will allow the Crime HotSpot development team to focus on managing the front end, the data, writing queries, validating the application. MongoDB Atlas handles the time-consuming administration tasks of infrastructure provisioning, setup, availability, and database backups.

4.1.2. Web page. The objective of the website is to maintain a clean and functional heatmap with a slimmed down version of the full product. The focus will be on placing crime incidents on the heatmap and allowing for minor user filters to be applied against the map, such as how significant a crime category is to the end user.

4.1.3. Application server. The application server is an Ubuntu Linux virtual machine with Node.js serving the application. The server should handle the requests to Google Maps API and create a unique session for each user who is making requests to the server. Meaning that if two users visit Crime HotSpot then each could make changes to the setting of the map without impacting the others view of the map.

4.1.4 Google Maps API. Google Maps will power the Crime HotSpot application as it will take latitude and longitude and place the point on the map. The API has a heatmap setting a myriad of options to set the radius, color and has algorithms inside of the API to determine the color palette of heatmap points that overlap each other.

4.2 Prototype Features and Capabilities

4.2.1. Crime categories. For the prototype the application will be simplified to four categories with limited number of unique crime type under each category. The categories are severe crimes against the person, crimes against the person, crimes against property, crimes against the public. The severe crimes against the person are crimes that have risk to life such as abduction, aggravated assault, while normal crimes against the person include moderate to low risk of life such a robbery. Property crimes include acts such as burglary and the impact are solely based around a monetary amount without direct contact between the perpetrator and the victim. For example, a burglary with the resident at home is a crime against the person as it possesses risk of life. Crimes against the public are crimes which impact the community such as graffiti, or a DUI, or a narcotics violation; these are low impact on a single individual’s safety but none the less can provide meaningful indicators of an areas safety without becoming too large of a factor.

4.2.2. Location. The prototype is focused around the campus of Old Dominion University. The crime data for the prototype is from the campus police department for the year of 2017. The user will not be able to update the location. The map will be focused around Old Dominion University.

4.2.3. Static Database. Data in the database will have the severity assigned to each crime upon being upload for the sake of simplicity for the prototype. Under normal development practices the severity of the crimes would be calculated from the application dynamically but given the constraints in development time Crime HotSpot will store the calculated value. The calculation is based on the category of which the crime belongs, with the scale ranging from one to ten. Severe crimes against the person are a severity of eight, non-severe crimes against the person are a four, property crimes are a two, and crime against the public being a one. A stored crime with multiple offenses will be the value of the greatest offense and the second greatest offense divided by four; for example, an aggravated assault with vandalism and a narcotics offense would provide a severity of eight and a half. The aggravated assault would have the largest value of eight and the property offense which is a value of two divided by four then added together, while ignoring the value of the crime against the public in the severity score. The crime record would be stored with the nature of the crime being the most severe of the subsequent offenses.

4.2.4. Crime Heatmap. The heatmap will not have the full functionality of the on click analytics for displaying the crimes that are creating the scores in the heatmap. The other functionality such as displaying an accurate visual representation of the SafetyScore should proceed as in the full production application.

4.3 Prototype Development Challenges

4.3.1. JavaScript MEAN Stack. The mean stack entails four different technologies that no single team member has mastered. The mean stack encompasses both the frontend and the back-end of the application, including the operation the application through Node.js. Given the breadth of information it is possible that issues arise in mastering the mean stack on top of the Google API. To redact these issues the team has broken up to tackle functional areas of the project.

4.3.2. Cross-browser compatibility.

Cross-browser functionality is an obstacle of the application given the nature of web development and the exhaustive list of browsers and security settings, options, and configurations. In an ideal world the prototype would be able to run on nearly any modern browser.

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5. Glossary

.1. Application Programming Interface (API) - a set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service.

.2. Crime Map - A map that has crime statistical data overlaid on it to provided information on the criminal activity of an area.

.3. Heatmap - a representation of data in the form of a map or diagram in which data values are represented as colors.

.4. JavaScript MEAN Stack - MEAN is a free and open-source JavaScript software stack for building dynamic web sites and web applications. The MEAN stack is MongoDB, Express.js, AngularJS (or Angular), and Node.js.

.5. JavaScript Object Notation (JSON) - a lightweight data-interchange format. It is easy for humans to read and write. It is easy for machines to parse and generate. It is based on a subset of the JavaScript Programming Language.

.6. SafetyScore - A number, proprietary to Crime HotSpot, that represents the relative safety of an area.

.7. Soft Target: A person or property which presents as having poor defense against crime.

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