Lab 1 – Pest Patrol Product Description

Anton Rasmussen

Old Dominion University

CS 411

Professor James Brunelle

September 18, 2022

Version 3

1 Introduction

Pest encounters happen frequently and occur widely across the United States but due to their distributed nature are a problem that appears to occur randomly (US Census Bureau, 2021). Neighborhood specific Facebook Pages and the *Nextdoor* Application page for communities both contain more than a few incidents related to pests or encounters with pests (i.e., frequent and widely occurring encounters); but, because this reporting is ad-hoc and not centralized to a "pest-specific" application, much of the encounter data gets lost in the high volume of otherwise unrelated distributed communication (i.e., seemingly random encounters). Pest encounters happen but because there is no single source to compile pest encounter data specifically, the true frequency of these encounters is all but lost.

Even in cases where pests are entirely preventable, because of the lack of information regarding where pest "hot spots" are within a community, avoiding an encounter is akin to contending with and trying to manage completely random probabilities. For example, the knowledge a family in a community gains when it overcomes infestation is knowledge that is unable to easily flow to others because there is no good, central, place to share lessons-learned, and therefore does not aid in the ability for others in the community to take proactive measures. Additionally, one finds that because there is no central repository of pest information for a certain community or region, planning of outdoor activities and events comes with risks that could otherwise be mitigated more easily were there some "place" to host this information.

The Pest Patrol application is designed to address the issue with aggregating pest-specific information into one easy to use application so that a community can coordinate the fight against pests. Pest Patrol plays the role of "do one thing well" in that its design is based on filling the gaps that exist in the currently distributed ad-hoc pest reporting space. While aggregating the

information allows for more transparency around the ongoing "State of the Union" for pests in a certain area, the primary benefit of this application is making it possible for communities to pro-actively take measures to respond to pests, therefore taking back some determinism in an otherwise seemingly stochastic problem space.

Pest Patrol is not just an application for aggregating pest information related to a specific area but is itself tailored to act as a "community" in the sense that users are able to share about their encounters, interact with each other to obtain helpful and often crucial key details surrounding pests, as well as trigger insight into where pests may be coming from/moving to, where they might be more or less prevalent, and/or how intense the population of pests is for a given area of concern.

Ultimately the community aspect of Pest Patrol is the key driver of keeping individuals informed, minimizing the risk of pest encounters based on user reporting, projecting future pest movements/patterns, and providing an assist in and avenue for risk-mitigation when planning outdoor activities that otherwise may have resulted in a spoiled outing, a minor injury, or worse.

2 Pest Patrol Description

Pest Patrol is a cross-platform web application that relies on community-based (crowdsourced) information aggregation tied back to location services that help to map pest-related information geographically within the community. The network effect of this community-based crowdsourcing affords the ability to raise near real-time awareness through the application's reporting mechanism because as more people use the application, more areas are monitored for pests, and, ultimately, more people fall into those "monitored" areas, thus driving the incentive for even more people to use the app. As each report is associated with a location (a location that can be made to be more- or less-granular based on the user's choice), users

themselves become both the source of pest encounter information as well as the consumers of related pest encounter reporting. The ultimate power of this location information is that the intensity of pest encounters can be mapped (e.g., using a heat-map) and used for predictive modeling of pest movements over an area (e.g., based on season, pest-type, etc.).

As users of Pest Patrol work through the process of addressing any kind of pest problems directly affecting them, they can share the knowledge they learn to other members of the community with the benefit of ultimately slowing or stopping the spread of pests throughout the community. As more and more data are collected related to pests and pest encounters, it will be possible to provide help in how to prevent pests as well as how to stay safe should one find themselves in a pest encounter.

The two main goals of Pest Patrol are 1) to make communities safer by broadening pest awareness in a community and thereby lessen encounters 2) to minimize the damage specific pests can do to an area by aggregating information that will help to slow their spread and predict future spread.

2.1 Key Product Features and Capabilities

The key features of Pest Patrol begin with the fact that the application is web-based and, therefore, multi-platform. Opting to implement a web-based application instead of an Android or iOS native application means that the application will remain easy to use no matter what type of a device a person will be using. Given that a major factor of Pest Patrol is the community crowdsourcing aspect, it is important that the ability to use the app is not hampered by the technology.

Setting up an account with Pest Patrol is not a pre-requisite to benefit from the app's data. However, without being a registered user, access is limited to read-only. Again, this design

choice tips its hat to the idea that Pest Patrol is meant to be community-based and thus easy for all community members to use (indeed that's the key-differentiator of this app versus similar apps on the market); however, because there is a desire to maintain a healthy community, any user who has access to write data to the application for others to see (e.g., a pest report, user comments, etc.) will have to be validated and their credentials verified.

The main screens a user will interact with are the Dashboard, a landing-page interface that affords the ability to navigate to anywhere else on the site, which provides three separate modes: *Incident Map*, *Discussions*, and a *Hybrid* experience where the Incident Map and Discussions are all on the same screen. The Incident Map is where reported incidents populate and includes attributes such as location, incident timestamp, pest type, submitter, report incident, and heat map. All these attributes are self-explanatory but what's notable is that the attributes are customizable, filterable, and will adjust based on one's location settings. In addition to user-activated functions there are also community discussions that populate based on discussion threads as well as pest alerts that send notifications of pest encounters. The discussion and private messaging features of Pest Patrol give it the true community power that is necessary for such an application to thrive in the marketplace. That said, the alerting and filtering features of Pest Patrol provide the community with the true power of achieving the goals of making communities safer and minimizing the damage of pests.

2.2 Major Components (Hardware/Software)

The overall architecture design of Pest Patrol is that of a multi-platform Web Application (Web App) and its Major Functional Components Diagram can be seen in Figure 1. As a Web App, Pest Patrol will allow easy access so long as a user has an Internet enable device. Access to

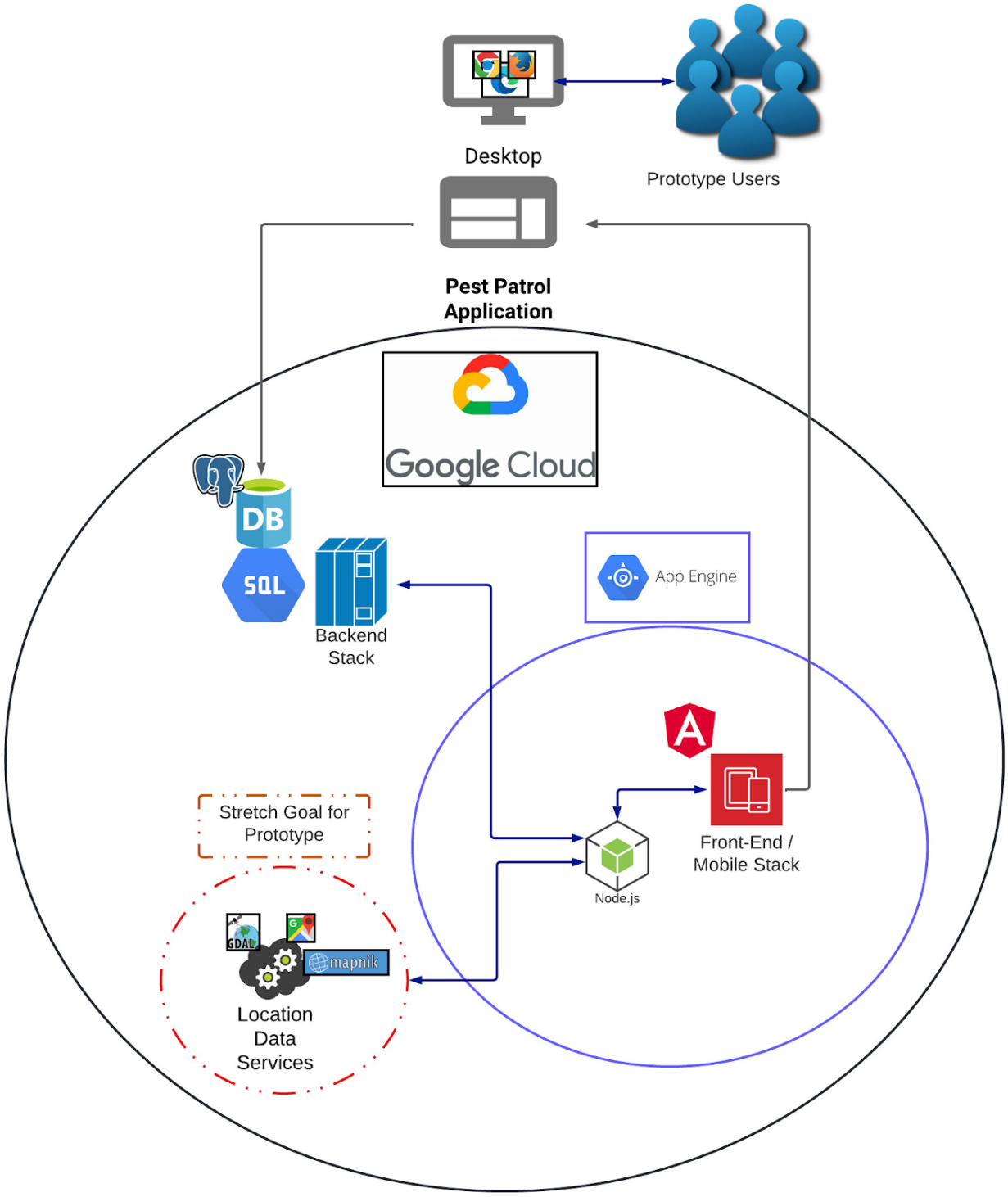
a camera and a touch screen device or other peripherals (e.g., keyboard and mouse) are all that is needed from a hardware standpoint.

Because Pest Patrol will be hosted in the Google Cloud Platform (GCP), the need for servers and other "infrastructure" hardware has been abstracted away from the user. The key software components are: a web browser (note that the Pest Patrol Web App will be tested against various device sizes using the browser's dev tools and against at least three different browsers (Chrome, Firefox, and Edge)). The Web App's primary software can be broken up into *front*-end and *back*-end stacks, tied together with middleware: in order to create a responsive JavaScript experience Pest Patrol will use a framework such as Angular.js and TypeScript (a type-safe version of JavaScript, which Angular uses) in the front-end; in order to write the APIs (REST endpoints), which serve up data from the backend into the UI, the prototype will use Node.js middleware; the back-end will consist of a PostgresSQL Managed SQL server via Google Cloud SQL. The front-end and back-end services for Pest Patrol will run in Google App Engine.

Lastly, though rather opinionated, the code-editor of choice for developers working on Pest Patrol, given the nice UI and the power of awesome plugins, will be Microsoft Visual Studio Code; that said, Code-editing is a personal matter so this will not be mandatory. We will, however, firmly commit to the use of a GitHub Repository and GitLab CI/CD integrations that will work through GitHub commit triggers as this tool set is widely used in industry and at ODU.

Figure 1

Major Functional Components Diagram (MFCD)



One can begin looking at the whole MFCD from the users' point of view. Given use of a responsive front-end stack, users have multi-platform access to the Pest Patrol application through either mobile or desktop devices. Between the user accessing the application through the front-end / mobile stack and the data stored in the back-end, there exists a layer of middleware services. In the middleware one ideally has location data services (that allow for viewing and tagging geo-location of pests), the typical front-end/back-end messaging found in web applications, and CI/CD services (that allow the dev team to quickly address application fixes and improvements).

3 Identification of Case Study

Pest Patrol is targeted at community members, hikers/campers, outdoor businesses, and cities. While the main user of Pest Patrol will likely be that same market of individuals dispersed across several apps reporting their encounters with pests (so-called "community members"), there are also potentially significant opportunities for targeting toward people who spend a lot of time outdoors, thereby becoming veritable "super" users of the app. Therefore the first Case Study will be a hybrid study of both community members and outdoor enthuisasts. If Pest Patrol can target the application toward both community members and those who are frequently outdoors, the expansion to outdoor businesses and cities will minimize downside risk while maximizing upside potential. For example, one of the major pests that people would be very interested in being alerted to (given the risks that these pests carry disease) are ticks. In certain places tick populations are so prevalent that it is almost impossible to go on a short walk in the woods and not come home with a few crawling on one's clothes. In these cases, it would be both helpful and useful for hikers, campers, and other outdoor enthusiasts to have an easy way to log

their encounters, including their exact location of encounter and any pictures they may have that help to identify the species of tick with which they have come in contact. In addition to being contributors of this data, other hikers and campers would be informed of the locations with the most densely distributed tick populations and thereby know to avoid those areas during their hike or when looking for a place to set up a tent. Given the value of this information it makes sense that businesses oriented toward outdoor activities would also want to both contribute to as well as consume information from Pest Patrol. Ultimately by providing the app freely to community members as well as hikers and campers, through targeted ad campaigns via social media (gaining users with the least informational friction) and in-person demonstrations in outdoor equipment retailers (leveraging the business relationships naturally following from the utility of Pest Patrol's service), the market research gained from the first case study will enable the shipment of a more effective product to market in a much more timely manner.

In addition to outdoor enthusiasts and the companies that serve them, there is a market for cities, pest control companies, HOAs, government agencies, and academic researchers to be contributing members of the Pest Patrol community. Based on information gathered from the case study of Pest Patrol adoption by community members and hikers/campers, there should be ample data to help transition targeted advertising toward these larger markets.

4 Pest Patrol Prototype Description

4.1 Prototype Architecture (Hardware/Software)

Frontend

- In its ideal state, the prototype's frontend stack would consist of an Angular web application running on Google App Engine within the Google Cloud Platform. That said, because of

resource and time constraints the minimum viable state of the protype's frontend stack will consist of an Angular web application running in its own Docker container.

Middleware

- Like the frontend, an ideal state for the prototype's middleware would involve Node.js running on Google App Engine within the Google Cloud Platform. Again, however, the minimum viable state of the prototype's middleware will consist of Node.js running in its own Docker container.
- A stretch goal will be to have Location Data Services integrate with the middleware.

Back End

- Just like the frontend and middleware, the ideal state for the prototype's backend would involve a PostgreSQL instance of Google Cloud SQL managed service will hold the data for our prototype. However, for this prototype the PostgreSQL instance will, like the frontend and middleware, run in its own Docker container. Additionally, because a Docker container does not lend itself to persistent data storage, it will be necessary to include an import function for ingesting CSV files to load data each time the Docker container is initialized. Any writes to the database will only persist for as long as the prototype is running in its containers.
- A stretch goal will be to have years' worth of mock data in a Big Query Dataset that would allow for demonstration of analytic capabilities (AI/Machine Learning).

4.2 Prototype Features and Capabilities

Frontend

- The frontend will allow us to provide a responsive web application with emphasis on a high-quality UI/UX experience.
- With a responsive frontend it will be possible to demonstrate Pest Patrol's key features and functionalities in both a desktop and mobile view via the browser.

Middleware

- Node.js middleware will hold the control flow logic to queries for each endpoint.
- Each query will be triggered based on requests sent from the frontend using POST requests (thus helping to prevent URI SQL injection).
- The middleware will send (ideally) prepared statements to the back end and (minimally) receive query responses in a JSON format, which it will serve up to the frontend, thus demonstrating CS410 risk mitigation techniques.

Back End

- By leveraging PostgreSQL server, our backend will leverage the transactional query efficiency of a Relational Database Management System that provides timely query results in all of the prototype's use-cases.
- An additional ideal scenario feature of having all data stored within Google Cloud SQL is that the security of our data would be managed by Google.
- The initial prototype will have all images stored on disk and references to the image location will be stored within Google Cloud SQL for retrieval. However, as a stretch goal, it may be possible to explore storing image data in Google Cloud Storage

4.3 Prototype Development Challenges

The main expected challenges to be encountered while completing the prototype are:

- Technical Challenges
    - *Frontend technology:*
        - Use of a complex web application framework (in our case Angular) and the ability to write code in type-safe Javascript (Typescript).
        - Familiarity with the MVC architectural pattern, Style Sheets (e.g. CSS), and HTML
        - Knowing how to develop the frontend in a way that does not get blocked by the back end (e.g. use of stubs or mock data)
        - Error Handling
        - Writing Unit Tests
    - *Middleware technology*:
        - Ability to write APIs that connect our frontend UI to our database server. In order to successfully write these APIs developers will need to understand how asynchronous Javascript works, how the HTTP request/response protocols function, and how SQL Prepared Statements function
        - Ability to write SQL Queries to return data in the correct way
        - Ability to work with JSON files
        - Error Handling
        - Writing Unit Tests

    - *Back End technology*:
        - Understanding the best design practices for an RDBMS
        - Creating Schemas that are normalized properly
        - Understanding query performance and how indexing works
        - Knowing how to develop in the backend in a way that does not block the frontend (e.g., creating temporary tables with mock data so that frontend developers can do their work while creating the final data structures as different tables)
- Development Challenges
    - Developer experience
    - Distributed team
    - Scope of project
    - Working locally vs on the Cloud
    - Front-to-Back-End Integration
- Unforeseen Challenges
    - Cloud Costs
    - Deployment complexity

5 Glossary

Pest: Any animal or plant harmful to humans or human concerns

Community Member: A member of a community, see Community definition

Community: The people with common interests living in a particular area broadly the area itself

Incident: An occurrence or sighting of a pest reported by a user

Geo-targeting: Method of determining the geolocation of an application user and delivering different content to that visitor based on their location

Geo-tagging: The process of appending geographic coordinates based on the location of a mobile device

Bot Moderation: The automatic screening of user content to ensure proper user behavior

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