California State University Long Beach

College of Engineering

Computer Engineering Computer Science Department

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Sixfold Development Technology Specification V2.1

Group Members:

Michell Kuang (Team Lead)	**013421094**
Joshua McDaniel	**014542786**
Jingyan Du	**014436615**
Peter Park	**002948398**
Jacen Tan	**012393782**
Daniel Gione	**016513144**

Version History

Version	Date	Author(s)	Comments
V1.0	10/10/2019	All members	- Original Document
V2.0	11/12/2019	Michell Kuang	- Added more relevant comparisons - Included more alternative solutions - Added section for languages + versions - Updated system requirements - Added tech - Added a references page (denoted in text by superscripts)
V2.1	11/12/2019	Michell Kuang	-Added non-relational database tech

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Executive Summary

Introduction

This document describes the technical specifications of our project. It details the technologies that we will be using for the development and deployment of our single-page web application, as well as define the requirements necessary for using it. We compared and contrasted alternatives to find the option that works best for our goals and purposes. In addition to ensuring optimal functionality for our application, we focused on two main goals for choosing our technologies:

- Free/budget-friendly
- Easy to moderate learning curve

Project Overview

Our application is a single-page web application that aims to alleviate problems stemming from cohabitation and searching for a home. It offers collaborative management tools fit for dealing with these issues, as well as a platform for searching for available households. Users will be able to search for available households in California that are registered within the application, from which they can connect with other users to discuss living arrangements. Additionally, they will be able to better manage household expenses, tasks, and supplies with the help of features such as due dates, notifications, and relevant descriptions.

Why a Single-Page Web Application (SPA)?

Our team is creating a single-page web application to ultimately improve user experience. Multiple-page web applications are considered the “traditional” or “classic” web application, and involve multiple page refreshes each time a request is made to the server. Conversely, single-page web applications require just a single page load, as is implied by the name. It often uses Asynchronous JavaScript and XML (AJAX) techniques that implement dynamic loading, which allows new content to be refreshed onto a single page rather than on multiple pages, thus improving load speed and minimizing session interruptions. Progressive web applications are an alternative that offers these same features, but additionally utilizes service workers to offer offline support, as well as other tools to mimic native applications for those who are more partial to handheld mobile device environments. Since our current goals aren’t focused on that, those tools aren’t necessary. However, if we decide to expand our scope in the future, the transition to a progressive web application is easier from a single-page than a multiple-page.

Table 1

Features	Web Application Types		
	Single-page Web Application (SPA)	Progressive Web Application (PWA)	Multiple-page Web Application (MPA)
Dynamic Loading	Yes	Yes	Partial
Offline Support	No	Yes	No
JavaScript Dependency	High	High	Low
Page Load Speed (in comparison to each other)	Faster	Faster	Slower
Rich UI Capabilities	Yes	Yes	Limited
References	- https://docs.microsoft.com/en-us/dotnet/architecture/modern-web-apps-azure/choose-between-traditional-web-and-single-page-apps#decision-table--traditional-web-or-spa	- https://developers.google.com/web/progressive-web-apps/ - https://developers.google.com/web/ilt/pwa/introduction-to-progressive-web-app-architectures	- https://pdfs.semanticscholar.org/c440/ae765ff19ddd3deda24a92ac39cef9570f1e.pdf - https://developers.google.com/web/updates/2018/05/beyond-spa#reliably_fast

Minimum User System Requirements

OS: Windows 7 and later
Browser: Google Chrome Version 63.0.3239
RAM: 2 GB
CPU: Intel Pentium 4 or later (SSE2 capable) x86 [1]
Graphics: Intel HD Graphics 400 or comparable
Free Disk Space: 15MB
Language: English

Languages

C Sharp (C#) V7.3 [2]
For the majority of our back-end development, C# will be the language that we code in. Since it was developed by Microsoft, it has high compatibility with other technology that we are using, such as Visual Studios Community and ASP.NET. Aside from that, its object-oriented nature will help make the learning process a lot easier for our entire team that is most familiar with coding in Java, another object-oriented programming language.

HyperText Markup Language Revision 5 (HTML5) [3]
HTML5 is the most current major version of HTML (currently in its 3rd minor revision), and will be used by our team to drive the structure of the content in our web application, as displayed on web pages. HTML is a markup language that uses conventions such as elements/tags to encode text. It specifies what and where things should be on a web page, using tags that can be nested within each other to create a more structured format. With HTML5, many tags were removed or updated, such as the <meta> tag that no longer requires a scheme attribute, and can now be found in the <head> and more easily defines the character set being used for a web page. New tags were also added, including <canvas> and <video>.

ECMAScript 6 (ES2015) [4]
ECMAScript, known colloquially as JavaScript, is a scripting language that dictates how the content on a web page will behave. End user interactions such as mouse scrolls and button clicks all invoke a response that is driven primarily by JavaScript. These events help to create a more dynamic web page by performing client-side tasks that don't need to make a request to the server, thus resulting in a faster response time and a more engaged end user. While the language itself can be kind of quirky, many frameworks exist to help integrate JavaScript into applications, which will ultimately ease the learning curve for our team.

Cascading Style Sheets 3 (CSS3) [5]
CSS3 is a styling language that dictates how content is presented on a screen. It is typically used in tandem with a markup language such as HTML, and is responsible for the colors, fonts, and layouts that are seen on a web page. With CSS3, more functionality is granted to developers, allowing for designs such as rounded corners and gradients. Using this language will allow us to design a web application that is more inviting and aesthetically pleasing to the end user.

Technical Software Specifications

Development Tools

Integrated Development Environment (IDE)

Visual Studio Community V16.3.29418.71 [6]
For our IDE, we are using Microsoft's Visual Studio Community 2019. It markets itself as the free version made suitable for students and open-source developers, in comparison to its counterpart versions, Professional and Enterprise, that have more features but require purchase. Arguably the most popular of the three, it has few alternatives that can offer the same community resource and version reliability. Since our team is comprised entirely of students working on a senior project, the software seemed most fitting for our development purposes.

Source Code Editor

Visual Studio Code (VS Code) V1.39.2
For front-end development, we decided to use a code editor for any workload that doesn't require all the stacked features offered by an IDE. Microsoft's VS Code provides a faster and more lightweight environment for developers to write and edit source code. In comparison to

the minimum 800MB of free disk space that VS Community 2019 requires, VS Code has a disk footprint of just 200MB. Although regular text editors such as Notepad or Wordpad typically come installed with your computer, VS Code has tools such as Intellisense that suggests code completion and error sensing for simple syntax errors. It additionally has a large collection of extensions that can be installed at your discretion when you need them. One such extension is LiveServer, which relieves the hassle of constantly refreshing your web page with live reload during development. Although unnecessary for the current scope of our project, it also offers cross-platform compatibility across Windows, macOS, and Linux systems, which will make it easier for us to integrate those systems further down the road.

Some popular alternatives to VS Code include Atom and Sublime Text. Atom takes up a similar amount of disk space on your machine, and is great for those using GitHub because it has full GitHub integration. However, since all our team is already familiar with the interface, it's easier for us to use VS Code, which has an extension that allows you to manage pull requests from GitHub anyway. As for Sublime, it was a weaker candidate simply due to the $70 license cost. Its free evaluation period currently has no time limit, but extended use of the software will be interrupted with the periodic reminder to purchase the license.

Table 2

Features	**Source Code Editors**		
	Visual Studio Code	Atom	Sublime Text
Latest Stable Version	1.39.2	1.41.0	3.2.2
Developed by	Microsoft	GitHub (Microsoft Subsidiary)	Sublime HQ
License(s)	MIT	MIT	Proprietary
Cost	Free	Free	Free ($70 for continued use)
Minimum Disk Space	200 MB	200 MB	35 MB
Unique Features	- Intellisense - Peek - Breadcrumb Navigation - Goto Navigation - Built-in Debugger	- Autocompletion - GitHub integration - Teletype	- Goto Anything navigation - Multiple selections - Symbol navigation - Incremental Diff - Text transposition
References	- https://code.visualstudio.com/updates/v1_39 - https://code.visualstudio.com/docs/supporting/requirements	- https://atom.io/	- https://www.sublimetext.com/docs/3/ - http://docs.sublimetext.info/en/latest/intro.html

Team Communication

Discord V0.0.305

Discord is a free, widely-used communication platform that is popular among the video gaming community as well as the software development community. Although initially developed for the

former, it has become a useful tool for any teams that require remote communication through voice or chat. Its voice-chat feature makes it simple for audio channels to be created and connected to. Discord has a large cap on the amount of users who can be connected to a session at once, so it works well for our modest team of six.

Slack is another popular option for remote team communication, and has an interface very similar to that of Discord's. In comparison, it's used more than Discord by companies such as Intuit, Target, and Lyft. In the professional sphere, a larger competitor to Slack is Microsoft Teams. It's free version offers features on par with the other two, but includes the integration of Microsoft Office tools such as Word, Excel, and Powerpoint (web versions). Nonetheless, while all three of these applications have both free and paid plans, Discord's free plan has more to offer for the purposes of our project. Table 3 compares their free plans.

Table 3

Features	**Communication Platforms**		
	Discord	Slack	Microsoft Teams
Latest Stable Version	0.0.305 (Windows) 0.0.9 (Linux) 0.0.255 (macOS)	4.0.2 (Windows)	1.2.00.4664
Developed by	Discord	Slack Technologies	Microsoft
License(s)	Proprietary	Proprietary	Proprietary
Cost	Free	Free	Free
Message History Storage and Access	Unlimited	10,000 messages	Unlimited
Max Number of Users	Unlimited	Unlimited	300
Text Chats	Public and private	Public and private	Public and private
Voice Chats	1-to-1 and Group	1-to-1	1-to-1 and Group
Video Chats	1-to-1 and Group (up to 8 users)	1-to-1	1-to-1 and Group
File Storage	Unlimited	5GB per user	2GB per user, 10GB shared storage
Security	- IP location lock - Two-factor authentication	- Tier D-compliant - Two-factor authentication - SAML-based SSO - CSA compliance - Data encryption	- Two-factor authentication - Active Directory SSO - SharePoint encryption - OneNote encryption - CSA compliance
References	- https://support.discordapp.com/hc/en-us/articles/223657667-Group-Chat-and-Calls - https://blog.discordapp.com/security-discord-and-you-1f8b1a	- https://www.slack.com/plans - https://slack.com/help/articles/360016548313-about-slacks-features	- https://products.office.com/en-us/microsoft-teams/group-chat-software - https://docs.microsoft.com/en-us/microsoftteams/sec

	718891 - https://discordia.me/en/stable	- https://slack.com/security	urity-compliance-overview

Gmail

Since its initial release in 2004, Gmail has had huge traction over its competitors just with storage space alone. At the time, competitors like Yahoo! Mail and Hotmail (now Outlook) were only offering up to 5MB of storage, but Gmail's first launch offered up to 1GB. Today, Yahoo Mail actually offers more storage space than Gmail, but the latter still beats it in security and compatibility with other services that our team is utilizing (Google Drive and Google Docs). Table 4 illustrates the differences among the three for the free basic plans.

Table 4

Features	**Email Services**		
	Gmail	Yahoo! Mail	Outlook
Developed by	Google	Yahoo!	Microsoft
License(s)	Proprietary Software	Proprietary Software	Proprietary Software
Cost	Free	Free	Free
Storage Space	15GB (shared across Gmail, Google Drive, and Google Photos)	1TB	15GB
Security	- Opportunistic TLS (STARTTLS) - Secure/Multipurpose Internet Mail Extensions (S/MIME) - Two-factor authentication	- TLS - Two-factor authentication - On-demand passwords	- Opportunistic TLS (STARTTLS) - Office Message Encryption (OME) - Secure/Multipurpose Internet Mail Extensions (S/MIME) - Information Rights Management (IRM) - Two-factor authentication
References	- https://support.google.com/mail/answer/6374270?hl=en - https://myaccount.google.com/security - https://support.google.com/mail/answer/6330403?hl=en	- https://help.yahoo.com/kb/SLN22068.html - https://policies.yahoo.com/xa/en/yahoo/privacy/topics/security/index.htm	- https://support.office.com/en-us/article/storage-limits-in-outlook-com-7ac99134-69e5-4619-ac0b-2d313bba5e9e - https://docs.microsoft.com/en-us/microsoft-365/compliance/email-encryption

Project Documentation

Google Drive

Google Drive is an online service developed by Google that offers free cloud file storage and synchronization. It offers up to 15GB of free storage shared across Google Drive, Gmail, and Google Photos, and is arguably the most popular of cloud storage services on the market because of its link with Google's office suite. It offers web-based software such as Google Docs, Google Sheets, and Google Slides, all of which are saved directly into your drive when you're working on them. Our team uses Google Drive to share documents and other relevant project material, and specifically Google Docs to collaborate and work on documents together

simultaneously. All documentation for this project will be created and updated through Google Docs. Google Sheets is being used to track our sprint hours and tasks for agile development.

Some alternatives to Google Drive include Dropbox and OneDrive. Dropbox has paid plans that offer up to 3TB of storage, but its free plan offers only 2GB. Microsoft's OneDrive is more comparable since it also offers access to a web-based office suite. However, its free plan offers 5GB of storage, which is still less than what Google Drive offers, despite that space being shared across three services. Table 5 compares their free plans.

Table 5

Features	**File Hosting Services**		
	Google Drive	Dropbox	OneDrive
Developed by	Google	Dropbox	Microsoft
License(s)	Freeware	- GPLv2 - Proprietary Software (Linux Nautilus)	Freeware
Cost	Free	Free	Free
Storage Space	15GB (shared across Google Drive, Gmail, and Google Photos)	2GB	5GB
Security	- 256-bit Advanced Encryption Standard (AES) - Secure Sockets Layer (SSL)/Transport Layer Security (TLS) - HTTP Strict Transport Security (HSTS)	- 256-bit Advanced Encryption Standard (AES) - Secure Sockets Layer (SSL)/Transport Layer Security (TLS) - HTTP Strict Transport Security (HSTS)	- Transport Layer Security (TLS) - HTTP Strict Transport Security (HSTS)
Web-based Office Suite	Yes	No	Yes
References	- https://one.google.com/storage?hl=en - https://www.google.com/drive/terms-of-service/ - https://support.google.com/a/answer/100181?hl=en	- https://www.dropbox.com/individual - https://www.dropbox.com/business/trust/security/architecture	- https://onedrive.live.com/about/en-us/plans/ - https://support.office.com/en-us/article/how-onedrive-safeguards-your-data-in-the-cloud-23c6ea94-3608-48d7-8bf0-80e142edd1e1

Draw.io

Draw.io is a free and open-source diagram software that provides a stacked but simple interface for creating diagrams. It makes diagramming easier with popular templates for different document needs, as well as commonly used containers and shapes for different modeling purposes. Its online web version allows users to save their work on their devices or in the cloud, including services like Google Drive, Dropbox, and GitHub. Our team takes advantage of these tools to create our sitemaps and other design documents.

Time.graphics
Time.graphics is a free, online timeline creator that allows quick and easy access to basic timeline tools. Utilizing the free version limits the amount of customization allowed on the project; the system only allows for a certain amount of events to be added in a single timeline. However, for our Project Roadmap's high-level timeline, the available features fulfill our needs.

SequenceDiagram.org V8.3.0 (PENDING APPROVAL)
SequenceDiagram.org is an online tool that makes creating sequence diagrams a lot easier by providing a drag and drop interface. It uses textual notation that creates connections between lifelines with a simple click and drag with a mouse, and allows for unlimited creation of elements. While projects are saved as source text, they can also be exported as a PDF or JPEG file. Our team will be using SequenceDiagram.org to aid with our low-level feature designs.

Project Management

GitHub
Github is an open-source, web-based repository developed by GitHub (now a subsidiary of Microsoft) that provides a collaborative space for developers to manage source code, version control, documentation, and other code tracking. Using the Git system, it is easily one of the most popular free platforms available for teams that have to simultaneously work on projects together. It offers features such as forking, pull requests, commits and commit history, and branching.

Our team will utilize this platform for these features to simplify the development process of this entire project. On occasions where meeting up in person to work is not possible, GitHub will allow us to remotely send in updates and other contributions so that our progress is not impeded. While updates by default are made to a master branch that will reflect the current overarching project progress, developers can also create their own branches to work on the code separately to avoid accidental commits. From there, developers can test out preliminary code before final commits are made to the master branch.

While there are multiple alternatives on the web that offer similar capabilities, our team ultimately decided on GitHub for cost and familiarity reasons. It offers free unlimited repositories, both public and private, that are more than sufficient to support the scope of our project. However, because private repositories have a limit of 3 collaborators, our project will be public access. Bitbucket, on the other hand, offers free unlimited private repositories with no cap on collaborators, but enforces a user limit of 5. Since our team consists of 6 developers, this offers little extra benefit. Table 6 compares the two for their free plans.

Table 6

Features	Git Repositories	
	GitHub	Bitbucket
Developed by	GitHub (Microsoft Subsidiary)	Atlassian
Cost	Free	Free
Public Repositories	Unlimited	Unlimited
Private Repositories	Unlimited (up to 3 collaborators)	Unlimited
General File Storage	- 100GB hard limit per repository (75GB soft limit) - 100MB file size limit (per file)	- 2GB hard limit per repository (1GB soft limit) - No limit on file size
Git Large File Storage (LFS)	1GB	1GB
References	- https://github.com/pricing - https://help.github.com/en/github/managing-large-files/what-is-my-disk-quota	- https://bitbucket.org/product/pricing?tab=cloud-tab - https://bitbucket.org/blog/repository-size-limits - https://community.atlassian.com/t5/Bitbucket-questions/What-kind-of-limits-do-you-have-on-file-upload-size/qaq-p/319055

Web Development

Web Browser

Google Chrome V63.0.3239

One of the most widely-used browsers, Google Chrome provides compatibility with multiple services utilized in our project. It offers an abundance of extensions to users, some of which are development tools suitable for web development. Within Chrome DevTools, Google's built-in web developer tools, users have the ability to manage and analyze network resource usage, debug JavaScript, and even seek out memory leaks. To keep your data secure, Google Chrome uses sandboxing and site isolation that protects from malware installation and limits processes. Safe Browsing technology is also employed to protect from phishing attacks by warning users before they attempt to access a dangerous site or download something harmful. This can possibly be utilized in our project later on, as it is free and public to use. Its API documentation can be found on Google's Safe Browsing subdomain.

Mozilla Firefox actually has its own wide range of developer tools as well, including a debugger and a responsive design mode that allows you to view your application on different devices and network types. However, it lacks many tools that Chrome offers, such as an extension for Live Edit debugging that immediately generates changes made to front-end code in the browser. Safari, while also a good choice, just isn't compatible for Windows platforms.

Table 7

Features	Web Browsers		
	Google Chrome	Firefox	Safari
Latest Stable Version	77.0.3865.120	69.0.2	12.1.2 (OS X)
Developed by	Google	Mozilla	Apple
License(s)	Proprietary Freeware	- GNU General Public License - GNU LGPL - Mozilla Public License	- Proprietary Freeware - GNU LGPL
Platform(s)	Cross-platform	Windows, Linux, macOS X	macOS X
Cost	Free	Free	Free
Security	- HTTP Strict Transport Security (HSTS) - Root CA verification - Mixed script blocking - Sandboxing - Site Isolation - Safe Browsing - Private Browsing	- Firefox Sync - Two-step authentication - Phishing and Malware Protection - Private Browsing	- Sandboxing - Safe Browsing - Intelligent Tracking Prevention (ITP) - Private Browsing
References	- https://chromereleases.googleblog.com/ - https://www.google.com/intl/en/chrome/privacy/eula_text.html - https://cloud.google.com/chrome-enterprise/browser/security/	- https://www.mozilla.org/en-US/firefox/releases/ - https://support.mozilla.org/en-US/products/firefox/privacy-and-security - https://www.jetbrains.com/help/webstorm/debugging-javascript-in-firefox.html	- https://developer.apple.com/documentation/safari_release_notes/safari_12_1_release_notes - https://www.apple.com/safari/ - https://webkit.org/blog/8142/intelligent-tracking-prevention-1-1/

Web Server

Microsoft Internet Information Services (IIS)

Microsoft's Internet Information Services (IIS) is a Windows web server developed by Microsoft that allows us to deploy and host web applications and handle HTTP requests. It allows for scripts and applications in our project to be handled and sent to the requesting user. IIS also supports many valuable extensions for features such as advanced logging, log analyzers, and database management that will support our single-page web application. IIS comes free and built-in with Windows systems, but can be used only on Windows platforms. Since our entire team is developing on Windows systems, this isn't a problem for us.

There are other web servers including Apache and Nginx. Apache is the most popular because it's free, open-source, and cross-platform, but its flexible configuration settings may lead to

security flaws if mishandled. IIS, on the other hand, comes with a variety of GUIs which reduces the learning curve for the web server. Nginx was built to “address the performance limitations of Apache” (Nginx Blog), and is supposedly faster when it comes to running concurrent connections. However, since we are developing primarily with the Microsoft Stack, IIS was ultimately the better choice for us.

Table 8

Features	**Web Servers**		
	Internet Information Services (IIS)	Apache HTTP Server	Nginx
Latest Stable Version	10.0.18362.1	2.4	1.17.5
Developed by	Microsoft	Apache Software Foundation	Nginx
License(s)	Proprietary	Apache License 2.0	2-clause BSD
Platform(s)	Windows	Windows, Linux, macOS X	Windows, Linux, macOS
Cost	Free with Windows	Free	Free
Typical Stack	Microsoft	LAMP	MEAN
References	- https://docs.microsoft.com/en-us/iis/get-started/whats-new-in-iis-10/new-features-introduced-in-iis-10	- https://httpd.apache.org/docs/2.4/ - https://httpd.apache.org/docs/2.4/new_features_2_4.html	- http://nginx.org/en/CHANGES - http://nginx.org/LICENSE - https://www.digitalocean.com/community/tutorials/understanding-and-implementing-fastcgi-proxying-in-nginx - https://www.nginx.com/blog/nginx-vs-apache-our-view/

Cloud Computing Service (Web Server Host)

Google Cloud Platform

In order to host our server, our team is implementing cloud computing through the Google Cloud Platform (GCP). We chose this cloud computing service because it offers a free 12-month trial that comes with $300 credit for you to spend on whatever services your team may need. While it comes with tons of products such as AI Hubs and tools for API management, our team is focused on utilizing the virtual machines (VMs) and database options they offer. Their VMs come with many different options, allowing developers to choose one that fits their specific needs. Among these choices are general purpose machines that are more or less equal in compute power and memory, and CPU- or memory-optimized machines for those who need one more than the other. Since we will be utilizing this during development, we won’t need too much compute power, and can even utilize the always-free products that include micro instance VMs and 5GB storage databases, relational and non-relational. This along with the $300 credit will be more than enough for our team to develop and test our product on a cloud environment.

Table 9

Features	Cloud Computing Services				
	Google Cloud Platform (GCP)	Amazon Web Services (AWS)	Microsoft Azure	IBM Cloud	DigitalOcean
Developed by	Google	Amazon	Microsoft	IBM	DigitalOcean
Cost Options	- 12-month free trial + $300 credit - Pay-as-you-go	- 12-month free trial - Pay-as-you-go	- 12-month free trial + $200 credit - Pay-as-you-go - 1- or 3-year reservations	- Free Lite version - Pay-as-you-go - 1- or 3-year reservations	- Monthly payment plan per service
Virtual Machines	- Gen Purpose - CPU-Optimized - Memory-Optimized - Shared-Core	- Gen Purpose - CPU-Optimized - Memory-Optimized - Accelerated Computing - Storage-Optimized	- Burstable - Gen Purpose - CPU-Optimized - Memory-Optimized	- N/A - Container: Kubernetes	- Burstable - Gen Purpose - CPU-Optimized - Memory-Optimized
Relational Database Products	- Cloud SQL - Cloud Spanner	- Amazon Aurora - Amazon RDS - Amazon Redshift	- Azure SQL Database - Azure Database for MySQL, PostgreSQL	- IBM Db2 on Cloud - IBM Cloud Databases for PostgreSQL - IBM Compose for MySQL for Cloud	- Managed Database: MySQL, PostgreSQL
Non-relational Database Products	- Cloud Bigtable - Cloud Firestore - Firebase Realtime Database - Cloud Memorystore	- Amazon DynamoDB	- Azure Cosmos DB - Azure Table storage - Azure Cache for Redis	- IBM Cloudant - IBM Cloud Databases for MongoDB, etcd - IBM Compose for ScyllaDB for Cloud	- Managed Database: Redis
References	- https://cloud.google.com/ - https://cloud.google.com/compute/all-pricing	- https://aws.amazon.com/products/	- https://azure.microsoft.com/en-us/ - https://azure.microsoft.com/en-us/services/virtual-machines/	- https://www.ibm.com/cloud	- https://www.digitalocean.com/

Web Frameworks

.NET Framework V4.7.2
Developed by Microsoft, .NET is an object-oriented framework that utilizes a common language runtime that automatically guarantees certain aspects of an application, similar to that of Java. .NET can be used to create applications with multi-platform support alongside cross-server support, allowing for implementation of our system across most platforms. The large amount of features offered by .NET, including libraries, compilers, and API, assist developers by providing easy access to resources during development. One such API that will be helpful to us is the DateTime struct within the System namespace. It will allow us to grab the current UTC date and time that will be recorded in our logs.

Although .NET was built only for Windows platforms, our entire team is developing on Windows systems anyways. Having been developed by the same company, .NET will be super compatible with Visual Studios Community, which we are using as our IDE. Using this framework will save us time by removing a large portion of the required coding, thereby increasing production speeds, and ultimately saving time and money that could be spent elsewhere.

ASP.NET V4.7.1 (ASP.NET MVC V5.2.7)
ASP.NET is an extension of .NET that includes tools and libraries used specifically in web application development. It allows for programming in C# while still providing access to the libraries and packages provided by .NET. Using HTML and C# also allows for web pages to be created dynamically, evaluating code on the server and sending content to the user. From within the framework, we are additionally employing ASP.NET's Model-View-Controller (MVC) Pattern, which can be installed as a NuGet package. With this package, we can build our product around an MVC or even a Model-View-ViewModel (MVVM) architecture.

Just like .NET and IIS, ASP.NET was built by Microsoft. Since we will be using both of the aforementioned technology, ASP.NET is the optimal choice for web development to add to our stack. Choosing to use an integrated pipeline with our application pools, for example, will allow for full integration with ASP.NET's request pipeline. Some alternatives to ASP.NET include ASP.NET Core, which was also developed by Microsoft, and Django. ASP.NET Core is a complete rewrite of ASP.NET that mainly tackled the problem of cross-platform compatibility. It additionally introduced the concept of middleware in lieu of ASP.NET's pipeline concept. While Microsoft itself states on their website that ASP.NET Core has "higher performance than ASP.NET 4.x", developers have to download the ASP.NET Core native IIS module in order to plug into the IIS pipeline. Rather than going through the trouble, we decided to just stick with ASP.NET that works just as well for our purposes. Both offer an MVC architecture package.

Django, on the other hand, follows the Model-Template-View (MTV) architectural pattern. While similar to MVC in that it has a model and view, its "layers" have functionality that differs from the MVC pattern. Its "controller" is said to be taken care of by the framework itself, while the template can be related to the view in MVC. To spare confusion, we decided not to go with this framework.

Table 10

Features	Server-side Web Frameworks		
	ASP.NET	ASP.NET Core	Django
Latest Stable Version	4.7.1	3.0	2.2.7
Developed by	Microsoft	Microsoft	Django Software Foundation
License(s)	Creative Commons Attribution 4.0 International Public License	Apache License 2.0	3-clause BSD
Cost	Free	Free	Free
Primary Supported Languages	- C# - VB.NET	- C# - VB - F#	Python
Security	- Authentication: *Forms-based, Passport-based, Windows-based* - Authorization: *File authorization, URL authorization* - Code access security - Impersonation: *IIS authentication with authenticated token* - Encrypting Configuration	- Cross-site scripting (XSS) protection: *HTML Encoding using Razor, JavaScript Encoding using Razor, Validation* - Cross-site request forgery (CSRF) protection: *ASP.NET Core Data Protection* - HTTP Strict Transport Security (HSTS) middleware - Open redirect attack protection	- Cross-site scripting (XSS) protection - Cross-site request forgery (CSRF) protection - SQL injection protection: *Query parameterization* - Clickjacking protection: *X-Frame-Options middleware* - HTTP Strict Transport Security (HSTS): *SSL/HTTPS* - Host header validation
References	- https://github.com/aspnet/AspNetDocs	- https://docs.microsoft.com/en-us/aspnet/core/?view=aspnetcore-3.0	- https://www.djangoproject.com/ - https://docs.djangoproject.com/en/2.2/topics/security/ - https://djangobook.com/mdj2-django-structure/

Vue.js V2.6.10

Compared to its popular counterparts, React and AngularJS, Vue.js is the newest JavaScript web framework on the market. To ease the learning process of software during development, we decided to implement the Vue.js framework, version 2.6.10. Its website offers an extensive guide and introduction to the software, as well as a free video course to learn Vue basics. Unlike React (which is actually a library and not a framework), Vue implements more traditional methods for web application development by separating its HTML, JavaScript, and CSS. Its development style will provide more flexibility for junior developers like us, so that conversion to React and Angular in the future is simpler.

Table 11

Features	JavaScript Frameworks/Libraries		
	Vue.js	React	AngularJS
Latest Stable Version	2.6.10	16.11.0	1.7.8
Developed by	Evan You and Active Core Team	Facebook and Community	Google
License	MIT	MIT	MIT
Cost	Free	Free	Free
Security	- Automatic HTML escaping to prevent script injection - URL sanitization for safe DOM insertion - Cross-site scripting (XSS) protection	- JavaScript extension JSX: automatic HTML escaping to prevent script injection	- Content Security Policy (CSP) to prevent cross-site scripting (XSS) - URL sanitization for safe DOM insertion - Built-in support for prevention against XSS and cross-site request forgery (CSRF)
References	- https://vuejs.org/v2/guide/ - https://vuejs.org/v2/guide/security.html	- https://reactjs.org/docs/getting-started.html - https://reactjs.org/docs/introducing-jsx.html#jsx-prevents-injection-attacks	- https://angularjs.org/ - https://angular.io/guide/security

Databases

Relational

Structured Query Language (SQL) Server 2017 Developer Edition
Our team has decided to use SQL Server for our project's database platform. Developed by Microsoft, it is a free relational database management system that offers high compatibility with Windows systems. Microsoft's website provides an abundant amount of information, including release notes, installation help, and tutorials for those who are beginning to learn the software. As junior developers, this software will provide an easy learning curve that will allow for efficient progress of our project during the development phase.

There are alternatives to SQL Server, including SQLite, which is an open source, C-based embedded database, and DBeaver. While relational, SQLite is different in that it is not a client-server database engine, hence the description of it being an "embedded" database. As can be guessed from the name, it's supposed to be a light version of SQL that doesn't require as many resources, and also has a lighter setup. DBeaver is free and open-source, and offers many of the same features as SQL Server, such as statement generation and handling of a variety of server and database types. However, DBeaver is developed by the open-source community. Since Microsoft SQL Server is developed by a larger, more-trusted corporation, we decided this would be the best option.

Table 12

Features	Relational Databases		
	SQL Server 2017 Developer Edition	SQLite	DBeaver Community Edition
Latest Stable Version	14.0.1000.169	3.30.1	6.2.4
Developed by	Microsoft	D. Richard Hipp	Open-source community
License	Free Developer's License	Public Domain	Apache License 2.0
Cost	Free	Free	Free
Operating Systems	Windows, Linux	Cross-platform	Cross-platform
Language Implementation	C++	C	Java
Data Scheme	Yes	Yes	Yes
SQL Support	Yes	Yes	Yes
References	- https://sqlserverbuilds.blogspot.com/	- https://www.sqlite.org/index.html	- https://dbeaver.io/

Structured Query Language (SQL) Server Management Studio (SSMS) V. 18.3.1
SQL Server Management Studio is a free environment for handling all SQL servers and databases. It allows for database management, and it includes tools that can assist in this, such as row selection and statement generation. Our team has decided to use this for its abundance of functionality and coverage, as it is able to handle many different databases, ranging from Azure SQL Databases to SQL Server.

Non-Relational

MongoDB Community Server V4.2.1
Our team will be utilizing MongoDB as our non-relational (NoSQL) database primarily for purposes of logging. Unlike relational databases, data is saved in document format instead of a relational table. Specifically, these documents are saved in JavaScript Object Notation (JSON) format, which formats data as name and value pairs that are separated by commas. Since we will need to log our data into a flat file, having data in JSON format will make the transition simple because flat file data can delimit fields with commas.

An alternative to MongoDB is Redis, which is an open source, NoSQL database. While it is supported in many cloud environments for easy data migration, it is an in-memory data store, which is actually offered by MongoDB Enterprise. For the purposes of our project, however, we feel that an in-memory data store isn't absolutely necessary. Additionally, Redis itself says that Redis on Windows isn't recommended because it doesn't support the fork system call. Since MongoDB is a query-rich language, it was ultimately the better choice for us.

Table 6

Features	Non-relational Databases	
	MongoDB Community Server	Redis
Latest Stable Version	4.2.1	5.0.6 (POSIX systems)
Developed by	MongoDB	Redis Labs
License	MongoDB, Inc.'s Server Side Public License (SSPL) v1.0	BSD 3-clause
Cost	Free	Free
Operating Systems	Cross-platform	- POSIX systems (Linux, OS X) - Windows: precompiled version
NoSQL Data Model	Document (JSON format)	Key-value (In-memory store)
References	- https://www.mongodb.com/community/licensing - https://docs.mongodb.com/guides/server/introduction/ - https://www.mongodb.com/community/licensing	- https://redis.io/ - https://redislabs.com/ebook/appendix-a/a-3-installing-on-windows/a-3-1-drawbacks-of-redis-on-windows/

MongoDB Compass V1.19.12
To access our data in the MongoDB server, we will be using MongoDB Compass, which is a GUI developed by the same company that offers complete CRUD capabilities. While there are other options on the market for you to manage your MongoDB data, we felt it was best to stick with a product made by the same company to ensure compatibility between software. To make it easier for those who are less familiar with query syntax, MongoDB Compass has its own query operations that puts SQL statements in layman's terms. For example, the SQL statement "SELECT * from table" is executed with "db.table.find({})", with the parameter substituting for the select criteria.

Application Programming Interfaces (APIs)

Google Maps Static API V2.0 [7]
Google Maps Static API is a pay-as-you-go application programming interface that allows embedding of a static map supplied by Google. Our team plans to use this to assist in finding the locations of different households. It allows for easy searching by address and radius due to its well-documented functions. This is an easy to implement API, which benefits us as developers due to its simplicity.

Some alternatives to Google Maps include OpenLayers and Mapbox. OpenLayers is a great, free option that allows developers to implement a dynamic map in their application. Their website explains how to get started with implementing the API into your application, but dependencies are recommended to be built in with the project. Mapbox is another alternative, but has a pay-as-you-go pricing model. Like Google Maps, it offers a standalone static map that OpenLayers

does not. Ultimately, we felt that Google Maps' API was the right choice since we will be utilizing the Google Cloud Platform that grants us $300 credit, which can also be used towards this.

Table 13

Features	Map Application Programming Interfaces (APIs)		
	Google Maps Static API	Mapbox Static Images API	OpenLayers
Latest Stable Version	2.0	1.0 (last updated October 17, 2019)	6.1.1
Developed by	Google	Mapbox	OpenLayers
License	Freemium	Freemium	2-clause BSD
Cost	- Free to use - Pay-as-you-go: $2/1000 (0-100,00 requests), $1.60/1000 (100,001-500,000 requests)	- Free: up to 50,000 monthly loads - Pay-as-you-go: $5/1000 (50,001-100,00 requests), $4/1000 (100,001-200,000 requests), $3/1000 (200,001-1,000,000 requests)	Free
Rate limit	- Up to 25,000 authenticating requests/day with API key - Exceeding 25,000 requests/day requires API key and digital signature	- Default 1,200 requests/min	N/A
References	- https://developers.google.com/maps/documentation/maps-static/intro - https://developers.google.com/maps/documentation/maps-static/usage-and-billing	- https://docs.mapbox.com/api/maps/#static-images - https://docs.mapbox.com/accounts/overview/pricing/#static-images-api - https://docs.mapbox.com/api/changelog/	- https://openlayers.org/en/latest/doc/quickstart.html

References

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[2] https://www.google.com/url?q=https://docs.microsoft.com/en-us/dotnet/csharp/language-reference/configure-language-version&sa=D&ust=1573518010272000&usg=AFQjCNFoESOJ4Ek-AIN4m5DiO_Ewv6cwCg

[3] https://www.w3.org/TR/html53/

[4] http://www.ecma-international.org/ecma-262/6.0/

[5] https://developer.mozilla.org/en-US/docs/Archive/CSS3

[6] https://docs.microsoft.com/en-us/visualstudio/releases/2019/system-requirements