**Lab 1 - Product Description**

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# Introduction

Moving is a stressful life event that presents Do-It-Yourself movers with a variety of challenges. These challenges include logistics planning, effective space usage in their moving truck, packing and managing moving costs: all activities that moving families are unlikely to undertake frequently. Making effective use of a moving truck is difficult in its own right: there are many weight distribution considerations one must make on top of trying to maximize space usage, not to mention keeping track of the location of every box (White, 2020). All the while, Do-It-Yourself Movers must navigate the business model of the companies they rent trucks from, and often encounter hidden fees that unexpectedly increase their cost (Manwaring, 2020).

Why, when they’re faced with so many challenges, do these families not hire professional movers? Cost appears to be a major factor! On average, hiring professional movers for a short distance move is approximately 7 times more expensive than only renting a moving truck (Manwaring, 2020; Meyers 2018).

Figure 1 Comparison of Cost between Do-It-Yourself Moving and hiring Professional Movers

As a result of this huge price disparity, only 21% of moves utilize the help of professional movers, leaving a large majority of movers to fend for themselves when it comes to managing the logistics of their move. In 2019, 31 million people, nearly 10% of the population, moved residences in the United States of America (*29+ Moving Industry Statistics* 2020). This fact, when taken into consideration with the fact that most movers do it themselves, reveals that millions of Americans go without the expertise and skills of professional movers every year.

Enter, Load.In. Load.In is an Android app developed by Team Yellow that utilizes Artificial Intelligence and Computer Vision to simulate the expert knowledge of professional movers at a price attainable to Do-It-Yourself movers.

Load.In has multiple features that assist the Do-It-Yourself mover throughout the move process. Most notably, Load.In will generate customized plans for truck loading using a computer vision algorithm and 3D models created from images taken by a smartphone camera through a process called photogrammetry. This load plan will balance efficient space usage, weight distribution, protection of fragile items, and unloading priority with minimal user input. Users will have the ability to view the load plan throughout their move, giving them insight as to which boxes are already unloaded, on the truck, or have yet to be loaded. As a side effect of the load plan generation algorithm, users will have unique insights in to how many trips a move will take with a specific truck, giving them the unique ability to minimize either their cost or the time spent in the moving process: a difficult feat to accomplish without Load.In, where rough estimates are used to determine truck size and hidden fees determine pricing. Finally, Load.In will provide expert tips and tricks in the packing process, serving as an information hub and resource to Do-It-Yourself movers throughout every step of the moving process.

# Product Description

In summary, Load.In is an Android application that uses Computer Vision and Artificial Intelligence to enable Do-It-Yourself movers to efficiently and effectively perform their move. This application seeks to serve the Do-It-Yourself moving market, which is a majority of the moving industry, by simulating the expert knowledge of Professional Movers for at an accessible cost.

This section will provide an overview of the features and capabilities as well as the major hardware and software components of Load.In.

## Key Product Features and Capabilities

The most notable feature of Load.In is its Load Plan generation. The Load Plan is made possible through photogrammetry, a technique used to take three dimensional measurements from two dimensional images. Through this technique, accurate 3D models of boxes, furniture, and other household items can be obtained with just a smartphone camera. These 3D models are used to simulate the truck loading process, through a modified Container Loading Algorithm. This algorithm calculates the most effective space usage, giving each user a completely customized set of automatically generated instructions to most effectively utilize their moving truck. In this process, approximate weight, fragility, and unloading priority are also considered.

This load plan is not useful only for helping Do-It-Yourself movers load their truck, but also in giving them logistical insights throughout the move. By keeping a digital record of which boxes are loaded on to the truck, Load.In can keep track of which boxes are at the destination, at the starting point, or are currently loaded on the truck. If a move takes multiple moves, Load.In will generate a load plan each time the truck is re-loaded. This enables Load.In to present the user with a timeline of sorts, showing which boxes were loaded in which trip. This feature gives Load.In users the ability to approximately locate a box through the app, giving them peace of mind with minimal effort.

Another powerful effect of the Load Plan is that it enables accurate rental costs estimation. It’s no secret that truck rental prices are based on time and mileage: these costs are unclear until after a move has taken place, which can leave families renting trucks with a bill higher than they expected. With Load.In’s move plans, an accurate estimate of how many trips a move will take can be obtained. This information, combined with the travel distance between the origin and destination and truck rental fees, can be used to accurately predict truck rental costs before the move, allowing users to minimize cost, move time, or if they’re lucky, both. The Rental Estimate feature is supported by a web scraper that collects data from rental truck company websites in order to provide up to date information for the cost estimate. Other information, such as local gas costs, moving supply costs, and average loading and unloading times will be obtained from various sources and used in the estimation.

Separate from Load.In’s Load Plan generation and its related features, Load.In also offers a variety of tips and tricks for the packing process. These tips and tricks are specifically written for Load.In users by expert packers and can be accessed easily through a search feature inside the Load.In app. While this feature couldn’t be more different than the Computer Vision driven Load Plan, both features aim to impart expert knowledge upon Load.In users. In this way, they work cohesively towards the same goal.

As a companion to the “Tips and Tricks” feature, Load.In will also feature a chat option where users can directly ask questions. These questions will first be received by an AI chat-bot. However, a human operator will also be available if the AI is unable to help the user. The goals of this feature are to guide the user to the tips most relevant to them and to serve as an information collection point in order to improve the app over time.

The AI Chatbot is not the only feedback mechanism within Load.In. Load.In features usage analytics that allows Team Yellow to understand how the app is being used in practice and, most importantly, when users abandon the app for unsuccessful moves. In addition, the app features feedback screens where users can specifically call out problematic aspects of the app’s performance. Combined, this feedback will be incorporated into an iterative development process to improve Load.In over time.

## Major Components (Hardware/Software)

The major technical components of Load.In are its backend database, smartphone client, website client, Web API, Web Application and Vendor Synchronization system. This section will outline the technical details of each.

Diagram

Description automatically generated

Figure The Major Functional Components of Load.In

Load.In’s database back-end is maintained in the Amazon Web Services cloud service as a MySQL powered Relational Data Service (RDS). This database system will be used to store a variety of data, from user account data to usage data to 3D model data used in Load Plan generation.

The end-user of Load.In primarily interacts with the Smartphone Client. Because this is the functional component is the primary data input point, there are certain requirements to ensure that the system can function properly. These requirements can be viewed below.

|  |  |
| --- | --- |
| Specification | Estimated Targeted Value |
| Operating System | Android 4.4 (KitKat) |
| RAM | **4GB RAM** |
| CPU | **8 Core @ 1.8Ghz per core** |
| Storage | At least 2 GB internal storage for cache for images and rendered model data  1GB reserved cache for 3D Models  Target is 100 cached photos  100 \* 55.84 Mb per photo = 5,584 Mb ~ 698 MB |
| Cellular Connectivity | **4G Cellular up to 15 Mbps** |
| Wireless | 2.4 GHZ @ Wireless N with min 150 Mbps |
| Internet Connectivity | 30 Mbps |
| Camera | Single camera lens @ 12 Megapixel |
| Photo Size | 4290x2800 (~12MP)  PNG Compression Approx. 6.98 MB per photo or  55.84 Mb per photo |
| Photo Transmission Time | **< 3 Second @ 30 Mbps Internet Speed**  **< 6 Seconds @ 15 Mbps Cellular** |

The Load.In ecosystem also features an internet dashboard that collates usage data into a dashboard of moving trends and other insights into the moving industry. Viewing this dashboard will require a computer with an internet connection, which imposes its own set of hardware requirements. These requirements can be viewed in the table below.

|  |  |
| --- | --- |
| Specification | Estimated Targeted Value |
| Operating System | Linux, Windows, Mac OS    **Any operating system that supports current browsers** |
| Browser | Edge, Chrome, Firefox, Safari  Browsers must support ES6 or above and HTML 5    **Firefox 78 and Above**  **Chrome 84 and Above**  **Edge 83 and Above**  **Safari 13.4 and Above** |
| RAM | 4GB RAM |
| CPU | 2 cores @ 2GHZ |
| Storage | 1 GB Cache for images and website content |
| Wireless | 2.4 GHZ @ Wireless N with min 150 Mbps |
| Internet Connectivity | **30 Mbps** |

The Mobile and Website clients are both served by a Web API, which is programmed in Java and served on Amazon Elastic Beanstalk using the Apache CFX framework. These technologies used in conjunction allow for a maintainable and scalable services infrastructure.

Finally, Load.In contains a Vendor Synchronization system, which is used to obtain data regarding Truck Rental prices, fees, and other information. This system is written in Java and uses Amazon Web Services Lambda to scrape data on a predetermined schedule.

# Identification of Case Study

Load.In will first be developed for the average Do-It-Yourself move. Most moves occur over a short distance (Yale, 2019), so this Case Study will look at cross-town moves where travel time does not prohibit the possibility of making multiple trips throughout the move. The average house size in the United States is 2,200 square feet (Andrew, P. 2020), and the average family size is approximately 3 people (US Census Bureau, 2019). It is assumed that a move of this size requires the usage of a moving truck, as most personal vehicles do not have the capacity to efficiently move a house of this size. As established in section 1, most moves occur without the assistance of professional movers, so it will be assumed that this family wants to minimize cost. Friends or other family members may be called upon to help in the moving process. It will be assumed that the family does not have any exceptionally un-ordinary items that need to be packed or loaded.

In the future, Load.In may be adapted for smaller or larger moves. As time goes on, Load.In will need to be adapted to support packing and loading of unusual items as the need arises. Overall, Load.In’s technology has potential for productization for many markets.

# Glossary

Algorithm - A finite sequence of well-defined, computer-implementable instructions, typically to solve a class of problems or to perform a computation.

Analytics - The analysis of data, typically large sets of business data through mathematics, statistics and computer software.

Artificial intelligence - The capacity of a computer, robot, or other programmed mechanical device to perform operations and tasks analogous to learning and decision making in humans, as speech recognition or question answering.

Chat-bot - An automated software designed to imitate human interactions and provide information to the user.

Equilibrium - A state of balance due to the equal action of opposing forces, in this case weight within a moving truck.

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

Machine learning - a field of computer science that aims to teach computers how to learn and act without being explicitly programmed. More specifically, machine learning is an approach to data analysis that involves building and adapting models, which allow programs to "learn" through experience. Machine learning involves the construction of algorithms that adapt their models to improve their ability to make predictions.

Packing problems - Are a class of optimization problems in mathematics that involve attempting to pack objects together into containers. The goal is to either pack a single container as densely as possible or pack all objects using as few containers as possible.

Photogrammetry - Photogrammetry is the science and technology of obtaining reliable information about physical objects and the environment through the process of recording, measuring and interpreting photographic images and patterns of electromagnetic radiant imagery and other phenomena.

Professional movers - Professionals who move all your belongings for you from one place to another.

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