Load.In Product Description

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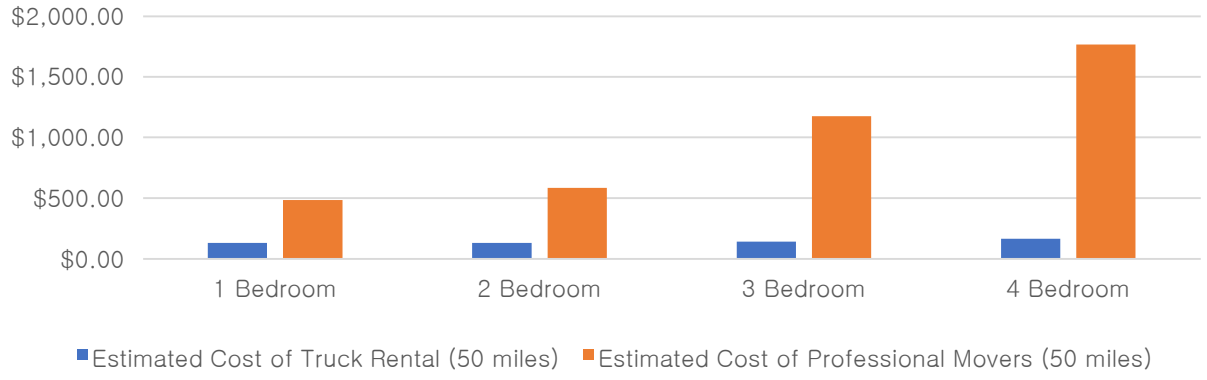
1 Introduction

Relocating to a new home is a stressful life event that presents Do-It-Yourself movers with a variety of challenges. These challenges include logistics planning, packing, dealing with fragile or heavy items, managing moving costs, enduring long distance travel, time management and efficiently loading the moving truck. When loading a moving truck there are many weight distribution considerations one must make on top of trying to efficiently fill the truck – not to mention keeping track of the location of every box (White, 2020). Do-It-Yourself Movers must also navigate the business model of the companies they rent trucks from and often encounter hidden fees that unexpectedly increase their cost (Manwaring, 2020).

Cost is a major factor that prevents families from hiring professional movers. On average, hiring professional movers for a short distance move is approximately seven times more expensive than renting a moving truck (Manwaring, 2020; Meyers 2018). Figure 1 illustrates that the cost difference between Do-It-Yourself and Professional moving grows with the size of the move.

Figure 1

A Comparison of the Cost of Do-It-Yourself Moving and Hiring Professional Movers



Note: Figure generated using truck Rental Cost data from Manwaring (2020) and Professional Mover cost data from Meyers (2018).

As a result of this huge price disparity, only 21% of moves utilize the help of professional movers (Wood, 2020) – 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 (Wood, 2020). This fact, when taken into consideration with the fact that most movers do it themselves, reveals that millions of Americans struggle without the expertise and skills of professional movers every year.

Load.In is an Android application 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 enables Do-It-Yourself movers to perform their move efficiently and effectively by providing the expert knowledge of Professional Movers at a low cost.

2 Product Description

Load.In has multiple features that assist the Do-It-Yourself mover through the move process, including packing, finding a moving truck, effectively loading the moving truck, and finding boxes once they've been moved. Most notably, Load.In generates plans for truck loading. These plans are generated using a Computer Vision algorithm and 3D models created from images taken by a smartphone camera through a process called Photogrammetry. This algorithm balances efficient space usage, weight distribution, protection of fragile items, and unloading priority. Once generated, the Load Plan can be reviewed throughout the move – giving them insight as to which boxes are already unloaded, on the truck, or have yet to be loaded. As a result of the Load Plan generation algorithm, users are given unique insights into how many trips a move will take with a specific truck size. These insights provide Do-It-Yourself movers the unique ability to minimize either their cost or the time spent in the moving process without sacrificing safety or efficiency. Without Load.In, only rough estimates are used to determine truck size and hidden fees can drastically change the final cost of relocating – making the final cost unclear. Load.In provides expert tips and tricks in the packing process – serving as an information hub and resource to Do-It-Yourself movers throughout the moving process.

2.1 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 processed through a modified Container Loading Algorithm that simulate the truck loading

process to calculate the most effective way to load the truck. This algorithm provides each user a completely customized et of automatically generated instructions based on their boxes and furniture. In this process, approximate weight, fragility, and unloading priority are also considered.

This Load Plan is useful for helping Do-It-Yourself movers load their truck as well as giving them logistical insights throughout the move. By keeping a digital record of where items are loaded on to the truck, Load.In can keep track of which items are at the destination, at the starting point, or are currently loaded on the truck. If a move takes multiple trips, Load.In generates a load plan each time the truck is re-loaded. This enables Load.In to present the user with information about which boxes were loaded in which trip. This feature gives Load.In users the ability to locate a box through the application – giving them knowledge about the progress of their move with minimal effort.

Another useful aspect of the Load Plan is that it enables accurate rental costs estimation. Truck rental prices are based on time and mileage (Manwaring, 2020). This means that the total cost of a move is 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 estimated. 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 and move time. 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 are obtained from analytical data gathered from previous Load.In moves and used in the estimation.

Separate from Load.In's Load Plan generation and its related features, Load.In also offers helpful advice for the packing process. These helpful articles are specifically written for Load.In users by vetted expert packers and can be accessed easily through a search feature inside the Load.In application. This Tips and Tricks feature works synergistically with the Computer Vision driven Load Plan, both features work together to impart expert knowledge upon Load.In users.

Load.In also features a chat option where users can directly ask questions. These questions are first be received by a Chatbot. However, a human operator is 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 expert knowledge that Load.in provides.

Load.In features usage analytics in order to understand how the app is being used in practice and, most importantly, when users abandon the app mid-move. In addition, the app features feedback screens where users can bring attention to problematic aspects of the app's performance. This feedback is utilized in an iterative development process to improve Load.In over time. These analytics features capture the start and end location of the trip, the total number of trips taken during the move, and the total distance traveled. In addition the cost of gas, moving supplies, and truck rentals are be recorded. To improve Load Plan generation, statistics regarding item weight, fragility, furniture and box measurements are gathered.

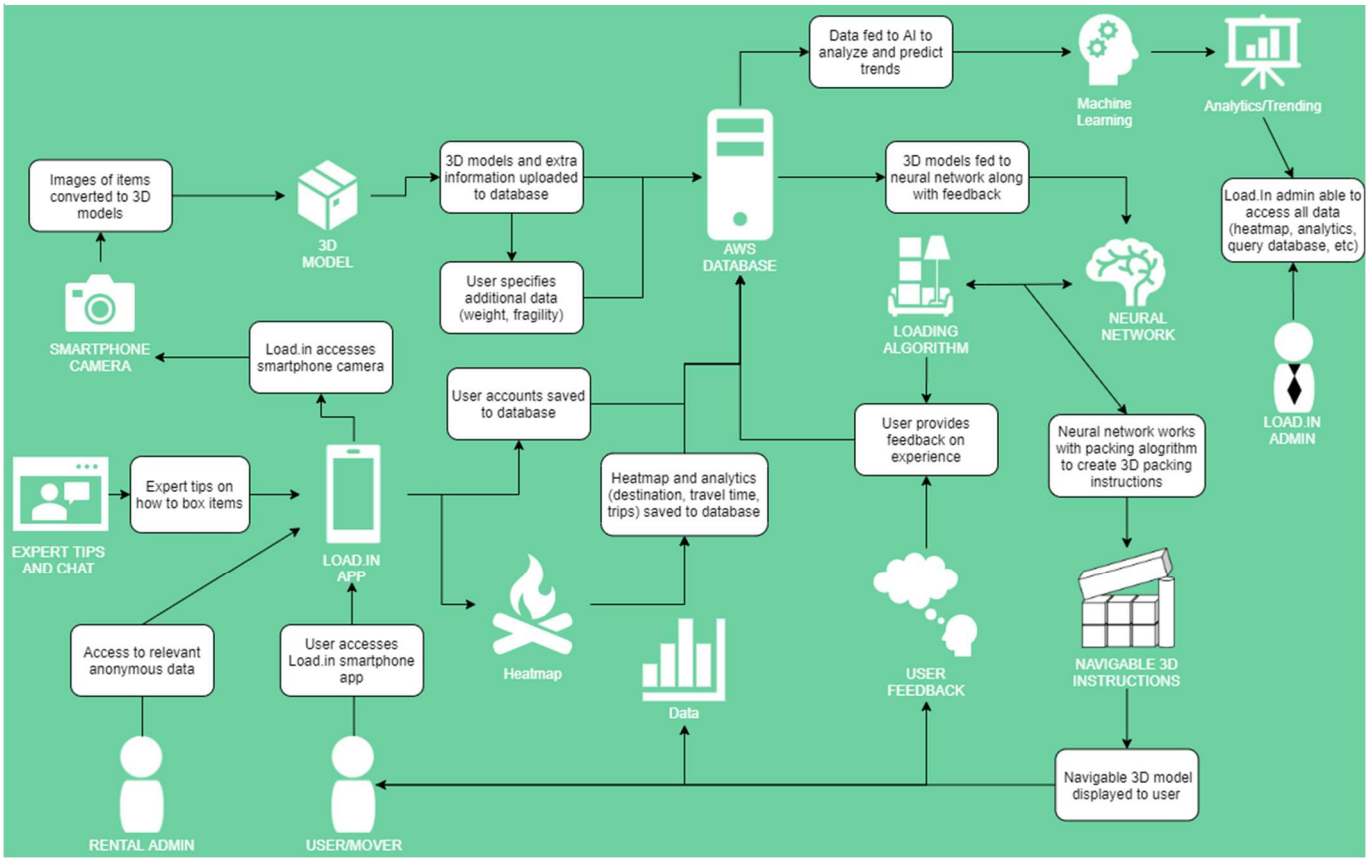
To support iterative User Interface improvement, a Heatmapping feature are included in Load.In that tracks which screens in the application and records frequency and duration of visit to each screen. This data isused to infer potential issues with the user interface in practice.

2.2 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 outlines the technical details of each. Figure 2 provides a visual overview of the working components and their interactions.

Figure 2

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 is 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, which serves as the primary point of data input. In order for Load.In to function properly, there are certain requirements to ensure that the system can function properly. These requirements can be viewed in Table 3.

Table 3

The Minimum System Requirements for the Load.In Smartphone Client

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 relocation trends. Viewing this dashboard requires a computer with an internet connection, which imposes its own set of hardware requirements. These requirements can be viewed in Table 4.

Table 4

The Minimum System Requirements for the Load.In Website Client

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.

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.

3 Identification of Case Study

Load.In is tailored for the average Do-It-Yourself move. 53% of moves occur over a distance less than 50 miles (Yale, 2019), so this case study models 50 mile moves where travel time does not prohibit multiple trips during 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). In addition, this case study will only model moves that utilize a moving truck and do not employ professional movers. The number of participants in the move will also be considered, while extremely unusual items may be disregarded when judging the effectiveness of Load.In.

In order to gauge the effectiveness of Load.In, moves matching the description above will be simulated with and without the use of Load.In. Truck loading time, unloading time, and number of trips will be measured in order to quantify the time savings that Load.In provides. In addition, qualitative data regarding the moving families' experience moving with and without Load.In will be collected through a series of interviews.

In the future, Load.In may be adapted for extremely small moves such as loading the back of a pickup truck or even extremely large moves – assisting the professional movers Load.In seeks to emulate today. As the product matures, Load.In will need to be adapted to support packing and loading of unusual items. Overall, Load.In's technology has potential for productization wherever space optimization is necessary.

4 Load.In Prototype Description

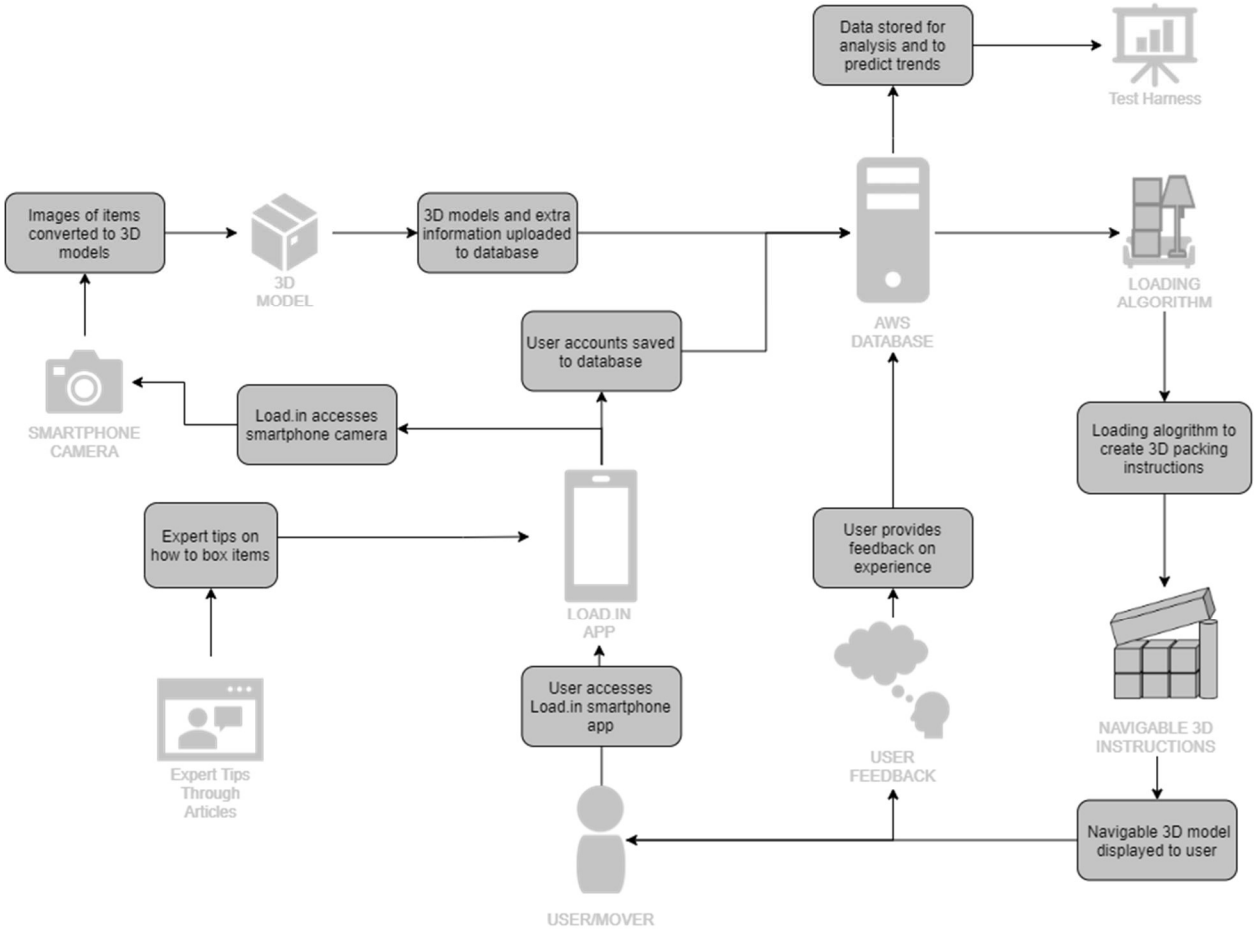
A prototype version of Load.In with limited capabilities will be developed in order to prove the feasibility of the innovative aspects of the solution. This prototype version will feature a simplified set of features, with some real world product features cut entirely, and will also be produced with a smaller architecture.

4.1 Prototype Architecture (Hardware/Software)

The Load.In prototype will be produced using an Ubuntu 16.04 Virtual Machine development environment. The user will interact with an Android App GUI. This GUI will also contain Test Harness elements which are used for testing and demonstration purposes. The Load.In database will be contained in a Docker container and accessed using MySQL. A second Docker container will contain the Load.In Web API which will utilize Apache Tomcat as a platform. Figure 5 shows the major functional components of the Load.In prototype.

Figure 5

The Major Functional Components of the Load.In Prototype



4.2 Prototype Features and Capabilities

The prototype will feature simplified Photogrammetry and load plan generation capabilities due to the complexity of those features and will not support numerous aspects such as analytics, truck rental company integrations, and the live Chatbot.

Figure 6 compares the features of the real world product and prototype.

Figure 6

A Comparison of the Prototype and Real World Product Feature Sets

Feature	Real World Product	Prototype
Move Inventory:		
Furniture/Item measurement	Fully Functional	Partial
Photogrammetry	Fully Functional	Partial
Item Weight	Fully Functional	Eliminated
Item Fragility	Fully Functional	Eliminated
Box Locator	Fully Functional	Fully Functional
Move Plan:		
Load Plan	Fully Functional	Partial
Truck Unloading Instructions	Fully Functional	Eliminated
Logistics Planning:		
Estimated Number of Trips	Fully Functional	Fully Functional
Estimated Move Time	Fully Functional	Eliminated
Estimated Truck Costs	Fully Functional	Eliminated
Expert Help:		
Packing Tips and Tricks	Fully Functional	Fully Functional
Search Feature	Fully Functional	Fully Functional
Expert Articles	Fully Functional	Fully Functional
Chatbot	Fully Functional	Eliminated
Live Expert	Fully Functional	Eliminated
Vendor Integration:		
3rd Party Vendor Web Scraper	Fully Functional	Eliminated
3rd Party Vendor Web API Reader	Fully Functional	Eliminated
Box Dimension Finder	Fully Functional	Eliminated
Truck Size Finder	Fully Functional	Eliminated
Truck Availability Finder	Fully Functional	Eliminated
Analytics:		
Location Data	Fully Functional	Eliminated
Move Data	Fully Functional	Eliminated
Feedback Data	Fully Functional	Partial
Usage Heatmap	Fully Functional	Eliminated
Rental Statistics	Fully Functional	Eliminated

The Load.In prototype will demonstrate a simplified version of the real world product. While the real world product will create and utilize 3D representations of any object, the prototype will only support boxes. The prototype will have the ability to view a Move Inventory, which will provide information about each box input into the application. The prototype will also feature a simplified Load Plan that does not support weight, fragility or unloading priority.

Because of the information generated by the Load Plan and Move Inventory, the number of trips required to finish a move will be available in the prototype. In addition, packing tips and expert articles will be available in the prototype version. A basic feedback feature will be included in the prototype.

Together, these features represent the core workflow of Load.In. While the prototype version will not be as fully featured or sophisticated as the real world product, it will still serve as a valid proof of concept for the unique combination of features that make Load.In an innovative and unique offering in the market.

One of the greatest risks Load.In faces is not properly collecting user feedback. The Load.In prototype will feature some feedback mechanisms to ensure that users have an opportunity to provide their feedback. The second risk concerns the Load Plan. If a user chooses not to follow the instructions of the Load Plan, it ceases to be valuable to the user. To mitigate this risk effectively, the Load.In prototype will include a feature to go back to previous steps in the Load Plan to correct any packing mistakes. In order to mitigate any security risks involving personal data, the Load.In prototype will store all data locally on the user's phone, rather than store it on offsite servers, and will additionally provide an option to delete the data.

In summary, the Load.In prototype will serve as a proof of concept for the Real-World Product. In doing so, it will implement basic versions of the Move Inventory and Load Plan features. It will also contain expert tips and the necessary search features to find them inside the app. The Test Harness will include tools to adjust truck dimensions and create randomized lists of box sizes in order to demonstrate how Load Plan generation performs in different scenarios.

4.3 Prototype Development Challenges

Several challenges have been anticipated for the prototype stages of development. The ability to adjust critical data such as truck size and move inventory from the Test Harness is necessary but may prove difficult. Calculating the number of trips is possible within the scope of the prototype but will require careful design of Load.In's internal systems to accomplish. Creating a feature that allows the user to search for tips and tricks is possible at a basic level, but optimizing that search to be as useful as possible may be challenging. Most importantly, because Load.In is an application that depends heavily on Computer Vision algorithms, there may be several edge cases in those algorithms that need to be considered, and each may require unique solutions – complicating and lengthening the development process.

5 Glossary

3D – A three-dimensional form or appearance.

Administrator – Someone who will access elevated features of the Load.In system in order to maintain and detect issues.

Amazon Lambda – A serverless compute service that allows code to be run without the need for provisioning or managing servers.

Amazon RDS – A distributed relational database service provided by Amazon Web Services.

AWS – Amazon Web Services: a cloud platform on which Load.In's databases are hosted. **Android** – A mobile operating system based on a modified version of the Linux kernel and other open-source software.

Android Client App – The client-side application for Load.In which runs on the Android platform.

API – Application programming interface: an interface for programs to share information and functionality with one another through a series of calls or connections.

AWS Elastic Beanstalk – An orchestration service offered by Amazon Web Services for deploying applications which orchestrates various AWS services including EC2, S3, Simple Notification Service, CloudWatch, autoscaling, and Elastic Load Balancers.

AWS Elastic File Storage – An AWS service that provides file storage with the ability to auto scale up with increased demand.

Apache CFX – A popular library for hosting web APIs.

Apache Tomcat – An open-source implementation of the Java Servlet, JavaServer Pages, Java Expression Language, and WebSocket technologies. Tomcat provides a "pure Java" HTTP web server environment in which Java code can run.

Chatbot – A feature within Load.In that provides information to users and guides them towards helpful articles and other resources interactively.

Cloud – A term used to describe several computing models such that a company or individual can purchase resources for hosting a variety of things in a centralized location accessible from anywhere in the world.

Computer Vision – a subclassification of artificial intelligence that involves computing information about the world from various sensory data such as images. Techniques of this classification are used throughout Load.In to observe real world objects.

Container Loading Algorithm – A type of algorithm that attempts to optimally fill a three-dimensional space with physical objects. Load.In uses this kind of algorithm to generate Load Plans.

CPU – Central processing unit: the primary component of a computer that processes instructions.

CSS – Cascading style sheet: a style sheet language that is used for formatting the layout of Web pages.

Do-It-Yourself (DIY) Mover – Non-professional movers who rent a truck for their move, and handle all packing, unpacking, and manual labor themselves. This is the primary end user of Load.In.

Expert Tips – Feature of Load.In that allows for a mover to search for helpful articles pertaining to a variety of useful information on how to accomplish various tasks during a move.

GHZ – Gigahertz: a commonly used unit when measuring computer processing speeds.

Guest – Someone who is accessing the Load.In system anonymously and has not registered for an account or someone who has registered but has not authenticated to the system at the time of access.

GUI – Graphical user interface: the aspect of a software program that the end user interacts with. **HTML5** – Hyper Text Markup Language version 5: a markup language used for structuring and presenting content on the Web.

Heatmap – A data visualization technique that shows magnitude of a phenomenon as color in two dimensions.

Java – A set of computer software and specifications that provides a system for developing application software and deploying it in a cross-platform computing environment.

JavaScript – A scripting language that runs in the browser and performs one or more functions to animate an otherwise static HTML document.

Linux – An open-source and community-developed operating system for personal computers and workstations.

Load Plan – A set of instructions on how to optimally load a container – generated automatically by Load.In from the boxes and furniture input into the system by the user.

Logistics Planning – A feature of Load.In that assists the mover with determining what rental trucks cost, how many trips the truck might need to take and whether the truck is available to rent based off proximity to the mover.

Mbps – Mega-bits per second: a unit of measurement for network speeds.

Megapixel – One million pixels: typically used to measure the size and quality of images.

Move Analytics – A feature of Load.In in which information gathered from previous moves are used to determine estimations for future moves as well as predict market trends for Rental Companies.

Move Inventory – A feature of Load.In that catalogs all boxes and items the mover intends to move.

MySQL – An open-source relational database management system.

MacOS – An operating system used on Apple's MacIntosh line of personal computers and workstations.

OS – Operation system: a collection of programs designed to provide a platform on a device to run other applications and typically provides a layer of abstraction from the hardware it interacts with.

Pixel – A small square of color that is part of a larger display screen or image.

Photogrammetry – A computational method of deriving three-dimensional information from images. This method is used in Load.In to construct 3D models of boxes, furniture, and other items from pictures taken from the end user's cell phone camera.

PNG – Portable Network Graphics: a common image file format that Load.In uses.

Professional Mover – Professionals who handle the physical labor of loading and unloading a moving truck as well as driving the truck to the destination.

Rental Administrator – A representative of a rental company who will access the Load.In system on behalf of the rental company.

Rental Company – Any company that rents moving vehicles for a Do-It-Yourself Mover to assist them with their move.

Rental Estimate – A feature provided by Load.In that pulls data from the internet to determine the cost of renting a moving truck.

Smartphone – A device, typically handheld, that can act as both a cellular phone and a computer by running one or more applications typically through a touch screen interface.

SPRING MVS – An application framework and inversion of control container for the Java platform.

Test Harness – A set of special features used during the development of Load.In to enable testing and demonstration of the application.

Vendor Synchronization – A feature of Load.in that brings in truck sizes and availability of rental information from third party moving company websites.

Windows – An operating system developed by Microsoft for use on personal computers and workstations.

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