

Lab 1 – Load.In Product Description

Chris Miller

Old Dominion University

CS 411

Professor Janet Brunelle

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1. Introduction

The average American moves 11.7 times in their lifetime. In 2019 nearly 31 million Americans moved, which was 9.8 percent of all Americans. The average cost of an interstate move is \$4,100 and an in-state move is \$980. This average cost includes both do it yourself (DIY) movers and Americans who hired professional movers. For many, this means that hiring professional movers is just not feasible because of the high cost (Wood, 2020). Moving comes with many obstacles in addition to just the cost—from packing boxes and safely loading them onto the truck to the potential loss or misplacement of important items when a move is finished.

All these problems culminate in two major issues for Americans: moving is expensive and tedious. To help solve these issues, an application for planning a DIY move is a solution that saves the cost of hiring professional movers and saves time by making the planning more efficient. Load.In solves these problems by providing a smartphone application for DIY movers to plan, catalogue, and gain expert knowledge on how to move more efficiently. Load.In allows the user to take pictures of their boxes and through photogrammetry produce 3D models of those items, access expert tips and tricks on how to pack and load a variety of items, and view a step-by-step packing solution to guide the mover through every step of the process—all while keeping track of where each item is during the move.

2. Load.In Product Description

Load.In is a mobile application that can be used by any person or group of people to plan and execute a move. Load.In reduces the cost of a user's move as well as increase their efficiency. By loading pictures of their items, Load.In generates 3D plan of both loading and unloading their truck. This plan also contains suggestions on what rental truck sizes, box sizes, and packing materials are the most efficient for moving the user's items. Load.In provides expert

tips on how to pack items into boxes to help the user begin packing for their move. Whether a user needs help with packing fine china or a ceramic vase, Load.In has different tips and tricks how to pack. The user takes pictures of their items to be packed which Load.In uses to generate 3D models of the items and create a plan on how to load them based on the size, shape, weight, and fragility. Another key component is that because all the boxes are being catalogued, a user will know where important items are. Load.In maintains an inventory of where each item or box is located inside the truck including the contents contained within a given box.

Load.In acts as a powerful ally to rental truck companies through analytics gathering and providing deals to the customers. By tracking data such as truck sizes and move distances, Load.In can provide rental truck companies with data on how large a fleet should be at a given location. In addition to analytics gathering, Load.In can provide a platform for these companies to advertise directly to users who need their service. When the user's load plan is generated, an advertisement for the local rental company that has the exact truck size the user needs.

Load.In is an all-in-one solution to a DIY move. Keeping track of items, generating a plan to load and unload the truck, and providing tips on how to pack makes the move much more efficient. Load.In provides DIY movers an efficient move without the cost of hiring professional movers.

2.1 Key Product Features and Capabilities

Load.In provides several capabilities for users to plan their move. The biggest feature is the 3D load plan generated on the app. This works through photogrammetry— converting images of a user's items into 3D models. With each picture the app determines whether an accurate model can be generated based on the item's dimensions, and if not, it has the user take another picture from a different angle. Once unique items are photographed and modeled, the

algorithm takes these 3D models and prepares the loading plan. This algorithm considers the fragility of items as well as weight and size to determine the safest and most effective way to load the items. This generally means that items like furniture are packed first and other items stacked on top of them. The load plan suggests a truck size and directs the user to where such a truck can be rented. If the user specifies a truck size or chooses a different truck, the plan is regenerated for that new vehicle. The load plan is meant to be a step-by-step manual on how to load and unload the truck. It specifies a location and order of how to pack items to keep them safe. This also means the load plan keeps track of a user's inventory displaying where items are within the truck.

With the user taking pictures of all their items, Load.In maintains a log of all the items. This means that the user will have a list of which box has which items. The utensils the user packed are labeled as designated by the user—meaning they can take that box straight to the kitchen in their new home. This inventory means the important items that users may need right away, such as a computer, will be easy to find and unpack.

In addition to the inventory, Load.In has a cost estimation feature generated from the information the user provides. By taking the load plan, the truck size, and start and end locations of the move, the app calculates an estimated total cost for the move. Load.In works with rental truck vendors to provide the best estimates and deals to its users. This is done through scraping the web and pulling in data from the rental companies to gather truck sizes, costs, and availability. This allows Load.In to show users the best options that are closest to them, and update in real-time as more trucks become available. With all of these factors, Load.In shows a tangible cost benefit to the user over hiring professional movers.

In order to help a user begin boxing their items, Load.In provides expert tips and has a live chat. These two services help with packing heavy, oddly shaped, and fragile items to keep them safe. The chatbot and live help are used to either guide a user to articles about the topics they want help with or provide live interactive service to the user. This is for questions as to how the app itself works or something as simple as removing the legs of a couch. The tips and chatbot are there to improve the user experience with quick helpful tricks.

Load.In uses user data to generate analytics on DIY moves throughout the country. The important pieces of information that Load.In gathers include location data, meaning a move's start and end locations, and the total amount of trips and time it took a user to complete that move. Data on the move itself is collected including the cost of gas, the cost of renting the truck, the cost of any other supplies such as boxes, as well as the time spent loading and unloading the truck. The specifics on a user's inventory are kept until the move is completed, and the less sensitive data will continue to be stored. Data such as how many fragile items were packed, the weight of the entire move, and the dimensions of the different items or boxes are stored. Data will be used to generate predictive analytics about the overarching meaning of these statistics. Generating predictions on where people are moving from and to, how far they are moving, and how much they are moving are valuable assets that can be either sold or used to make a more efficient service to Load.In users.

The final functions of Load.In are to gather feedback from the user. This is rating their experience with Load.In and how it helped their move. Giving feedback on the move helps give a direction to improve Load.In for future users. Another way in which Load.In works to improve the application is using a heat map to track what users are accessing the most. It tracks taps on

the app as well as when the app is closed so Load.In knows exactly what features are being used the most or the least and what needs to be improved upon.

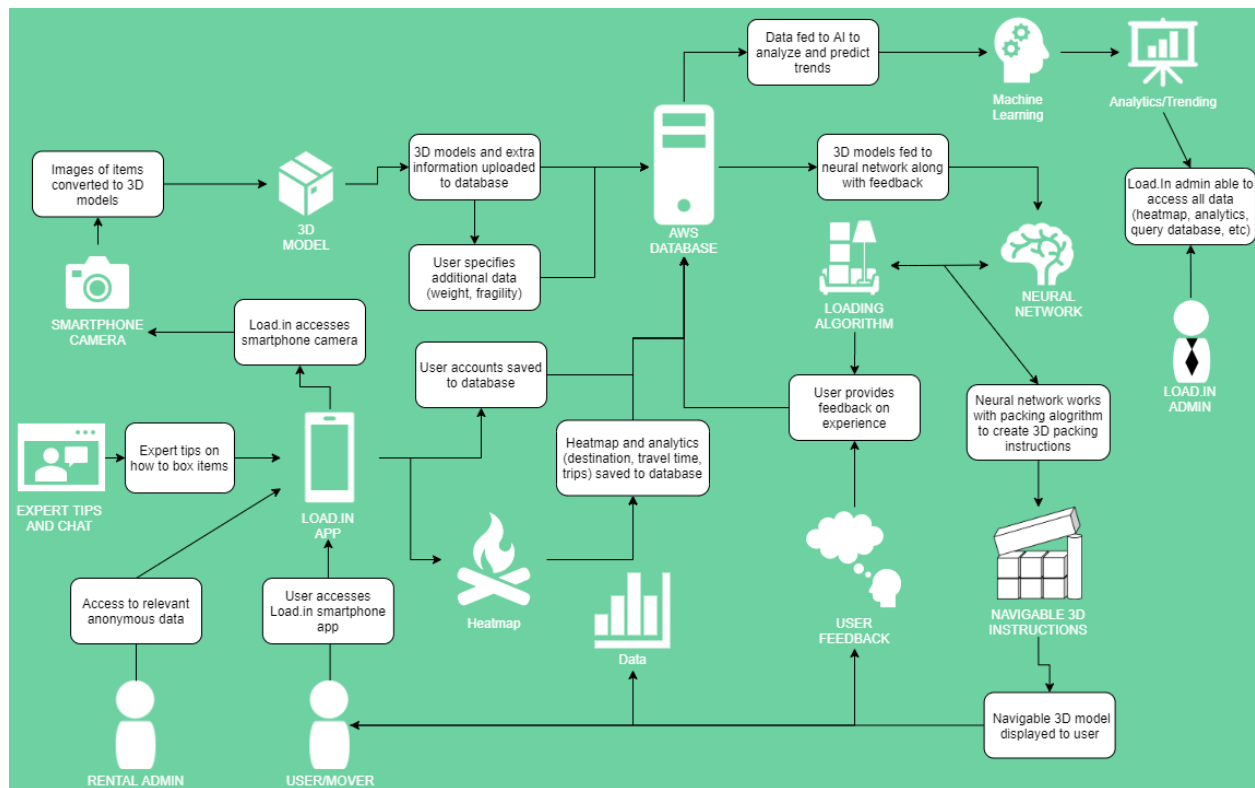
2.2 Major Components (Hardware/Software)

The Load.In application functions by using a mobile device that displays a GUI to interact with specific functions. Each function in turn communicates with a remote AWS Database and produces an output which is presented to the user. Most of these functions are accessible through the Load.In app; however, some are reserved for administrators to access functions such as analytical data on the website rather than the app itself.

Load.In functions off of a relational database known as Amazon RDS. This is compatible with MySQL and Amazon Lambda which is used for connections on the back end of the system. The software is composed of a back-end API, user authentication, data storage, and algorithms in order to get the Load.In app to function for each user. The data storage and algorithms are a large part of the components as there is both a large amount of data to be collected as well as many different algorithms being used to generate all of the information Load.In hopes to provide to the users.

Load.In is an application on Android smartphone. Many of the important hardware requirements are fulfilled by most Android Smartphones. The goal is for the application to perform the majority of its functions locally on a user's smartphone as possible. This means storing the photos locally—requiring more memory from the smartphone. The other components needed to run Load.In include a stable internet connection, either through Wi-Fi connectivity or cellular.

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Figure 1*Load.In Major Functional Component Diagram*

The Load.In website client is needed for applications outside of the specific move plan solution that is intended for the customer. The web API is written in Java and takes advantage of both AWS Elastic Beanstalk and Spring MVC with Tomcat. The vendor synchronization is also written in Java and take advantage of AWS Lambda. The goal is to have the vendor synchronization work on a timed schedule so that it brings data from vendor sites in a timely manner.

The most important part of the Load.In system is the database. This runs on the cloud and needs to store large amounts of data including user profiles, analytics on the moves of the user, rental company information, and cost estimates. The database is the foundation of Load.In; much

of the functionality and value comes from the database correctly interfacing with the web API and Android application.

3. Identification of Case Study

Load.In is being developed for DIY movers in America. The goal is for the app to be useful for a move just across the street or a move 3,000 miles across the country. The case study for Load.In will be a single family of 3 with a dog moving less than 20 miles across town. They need to move the contents of an approximately 2,200 square feet household which is the average house size US Census Bureau (2019). This move will also need a rental vehicle as it has too many items for just the family vehicles. A few of the mandatory items involved in the move will be furniture, books, and silverware to get a more accurate picture of a typical move. Load.In will need to accurately tell the costs of this move and allow friends or family to collaborate through the app on the move. Really tricky or odd shaped items will be left out of this case study. The final goal for the Load.In case study is to have the app work well for a common local move but be able to see that it is scalable. This means determining if the application is just as effective with a variety of different move sizes.

4. Product Prototype Discussion

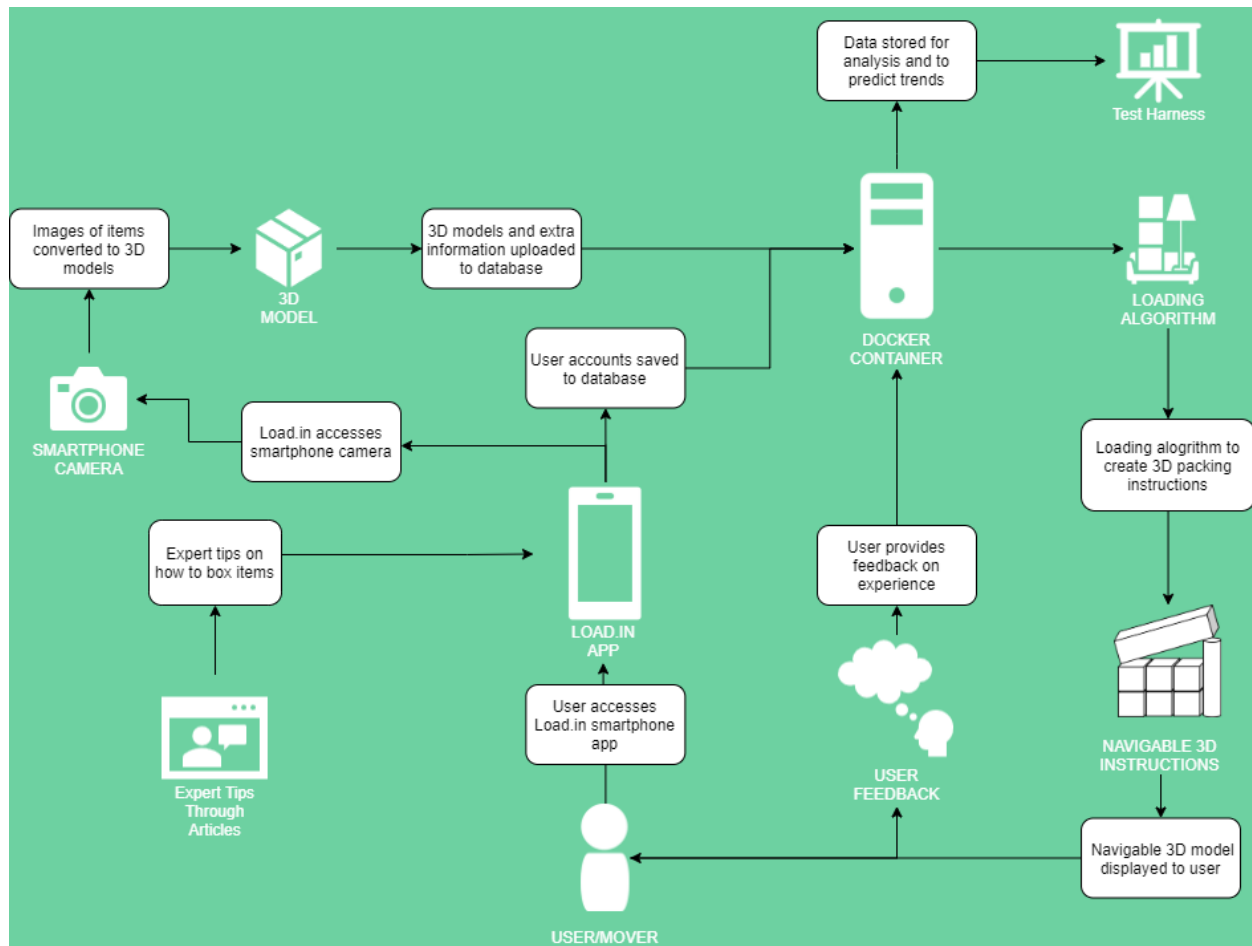
The prototype for Load.In will have some reduced functionality from the overall vision of the application. The features that are being developed for the prototype are as a proof of concept and are meant to help show what the app can potentially do. This means changing functionality of features such as the expert tips so that it merely shows the application can produce these tips rather than the implementation of real and valuable tips for a DIY mover. This model will be used to show how Load.In will work through demonstrating functionalities that are key to the success of the application.

4.1 Prototype Architecture (Hardware/Software)

The Load.In prototype is being developed on a virtual machine using the Ubuntu Linux operating system. The application will make use of Docker containers that include Apache Tomcat, CFX for the web API, and MySQL. The user interface will be an Android application, and the prototype will also have a Test Harness interface. Tomcat is going to be used as the platform for the web API, and MySQL will be the platform for maintaining data. The app itself will be an Android application which is how fake clients will interact with the other systems. The test harness will be a built-in way to create many different testing features as to ensure the functionality of the application. The Test Harness will include moves of different sizes, including one based around the case study. It will be useful in demonstrating the scale and scope of Load.In.

Due to the differences between the Load.In prototype and the real world product, the Major Functional Components Diagram shown in Figure 1 has been cut down to reflect those changes. Many of the functions have either been fully removed or will be implemented in a limited fashion in order to show a proof of concept and nothing more. This includes the removal of some functions such as the heatmap and the reduction of other functions such as the expert tips. The components that are being included in the prototype are shown in Figure 2.

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Figure 2*Load.In Prototype Major Functional Components Diagram*

One of the major goals of the prototype is to demonstrate its effectiveness against the case study mentioned in section 3. Being able to demonstrate a move plan for this family will be a great proof of concept showing that Load.In will be effective in its mission of helping the DIY mover.

4.2 Prototype Features and Capabilities

The Load.In prototype will have specific features in order to demonstrate a proof of concept that a full version of the application would be feasible. The prototype will demonstrate the ability to measure an item through photogrammetry and generate that item into a 3D model.

The data will be kept in an inventory that the user can access to add, delete, or edit items. The load plan is generated from these models and keeps track of where the items are located within the truck. The load plan which will guide the user step-by-step through loading the boxes properly onto a truck. The prototype will also include an estimation for how many trips a user will need based upon the inventory and truck space available. The last two features the prototype will include are expert articles and a feedback feature. The changes from the real-world product to the prototype are demonstrated Table 1 mapping how the functionality has changed.

Table 1*Load.In Prototype Features Table*

Feature	Description	Implementation
	UI	
Login Page	Create a landing page for the login screen.	Full Functionality
Guest User Interface	Ability for a new user to view the application without being logged in.	Full Functionality
Admin User Interface	Ability to have super user privileges when interaction with the application.	Full Functionality
DIY User Interface	Create a user role for the end user with normal privileges.	Full Functionality
	Authentication	
User Registration	Create an account inside of the load.in application.	Full Functionality
User Login	Authenticate with the server that an account exists.	Full Functionality
Reset Login	End user to be able to reset his/her own password inside of load.in application.	Partial:
	Move Inventory	
Furniture/Item Measurement	Ability to measure items using the phone camera.	Partial: Ability to manually type in dimension of boxes.

3D Model Generation	Generate a 3D Model based on item measurements	Partial
Box Locator Search Feature	Ability for the user to find the location of a box via search	Full Functionality
	Move Plan	
Load Plan	Generate a plan that will show users where and how to load boxes	Partial: Preloaded data inside of the database
	Logistics Planning	
Estimated Number of trips	Calculate the number of trips one will take based on the truck size.	Full Functionality
	Expert Help	
Packing Tips and suggestions	A list of tips will be suggested to the user on how to load the truck properly.	Full Functionality
Tips Search	Ability to search items a end user need additional help loading.	Full Functionality
Move expert articles	Expert level tips written by professionals.	Full Functionality
	Analytics	
Feedback data	Ability for the end user to provide feedback for a move.	Partial: User can only give a thumbs up or down.

These are the core features to what makes Load.In a unique solution to the problems of DIY moving. Some of these features, such as the expert tips, will be more of a proof of concept rather than fully fleshing out the function. Load.In will have features that are meant to mitigate some of the risks involved in developing such an application. The feedback feature is meant to

mitigate the risk of customers being unsatisfied with the aspects of the app from how it measures items to how it plans a user's move. Another risk is the user not following the guidelines of the application. Loading boxes out of order or leaving items behind intentionally can alter how a user interacts with Load.In. To mitigate issues that could arise from such, changes Load.In will be able to alter a plan based on changes a user makes. The security risks such as the pictures taken by the user and the security of the user's data will be mitigated by the prototype storing photos locally on the phone. The data will also only contain information for the purpose of the move. A user's data will also be able to be deleted at any time through the Test Harness.

The goals of the Load.In prototype are to prove that the application can work in a real-world setting by providing expert tips and a plan to move from one location to another. This will be done through capturing a move inventory, generating a load plan based on that inventory, being able to change truck sizes, generating and searching for expert tips, and the ability to search for items within a load plan. In order to test many of the features, the prototype will be able to generate a random inventory so there can be a variety of test cases.

4.3 Prototype Development Challenges

The main development challenges involved with Load.In specifically involve the many variables that will go into a move. This includes the Test Harness changing values in the database, changing the truck sizes, changing the move inventory, prioritizing results for the expert tips search, determining and setting multiple trips, and the handling of edge cases. The handling of edge cases is probably the most difficult when it comes to this application. This involves ensuring a user cannot overpack a truck or have boxes that are too large for the truck itself. There are potentially problems with the boundaries of each variable and without careful implementation, the prototype could fail to run correctly. Other development challenges are

balancing the use of already existing open-source software versus development from the ground up. Balancing these is the key to keeping Load.In innovative, and also keeping development on schedule.

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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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