Freight Advanced Traveler Information System (FRATIS) – Dallas-Fort Worth

Software Architecture Design and Implementation Options

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This document describes the Software Architecture Design and Implementation Options for FRATIS system. The demonstration component of this task will serve to test the technical feasibility of the FRATIS prototype while also facilitating the collection of baseline and performance data related to the operation and impact of the system. The FRATIS prototype in Dallas will consist of three components: Optimization algorithm, Terminal wait time, and route specific navigation/traffic/weather. This document describes the technical options that were considered for each component. An analysis of the options is followed by a recommendation for each component. The high level architecture is described for each of the recommended component options.</td></tr>
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1 Introduction

1.1 System Purpose

The United States Department of Transportation (USDOT) Dynamic Mobility Applications (DMA) program, undertaken in 2009, consistently sought to take advantage of the increasing volume of data generated within the transport system and to build on recent success stories in using these data to improve mobility and efficiency. Through the DMA Program - the FRATIS Concept Development and Functional Requirements task order was undertaken to further engage the freight transportation community in the process of documenting the concept, user needs and high-level requirements for the next generation freight advanced traveler information system (FRATIS) system. The DMA program is currently entering the demonstration phase. The FRATIS Prototype and Small-Scale Demonstration effort will assess the effectiveness and impacts of a regional implementation of the FRATIS solution.

The demonstration component of this task will serve to test the technical feasibility of the FRATIS prototype while also facilitating the collection of baseline and performance data related to the operation and impact of the system.

1.2 Primary Components

In Dallas the FRATIS system will consist of 3 components.

Optimization algorithm

This component will be used by individual carriers to create a daily load plan for each of their drivers that will ensure they perform their work in the most efficient manner. This will have the overall impact of increasing the efficiency of the carrier's entire fleet.

Terminal queue

This component will measure queues at intermodal facilities and communicate that information to carriers so that they may plan their arrivals at the facility in the most efficient manner. This will result in better resource and time management.

Routing, navigation, traffic and weather

This component will provide drivers and dispatchers with the most efficient route to their destination taking into account characteristics of the truck, traffic conditions, and weather conditions.

2 System Views

2.1 Optimization algorithm

The optimization algorithm will take the scheduled moves for the next day from a single carrier and create a load plan for each driver that minimizes the number of trucks needed and the number of bobtail moves required.

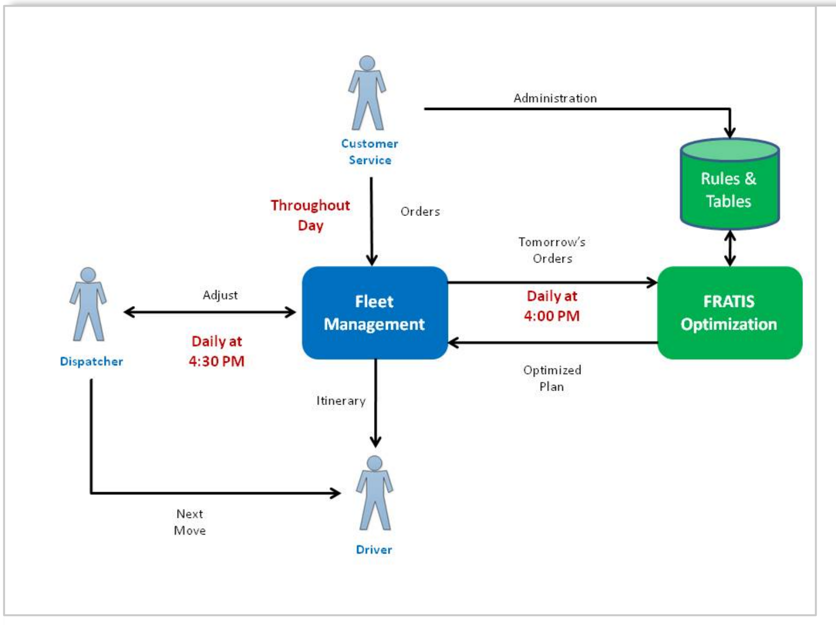

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Figure 1. Optimization Process

2.2 Terminal queue

The terminal queue component will be deployed at intermodal facilities in the Dallas area. These could include railroad yards, container freight yards, steamship yards and distribution centers. The objective of this component is to provide various users with the current expected time to enter a facility and to complete container drop-offs or pickups within the facility. In addition the component will provide the expected time for those activities for the rest of the day.

Technology will be deployed at the facility that is capable of measuring the current time for each activity. That information will be forwarded to the FRATIS server which will make it available to authorized users. The information will be stored and used to predict expected times based on historical experience.

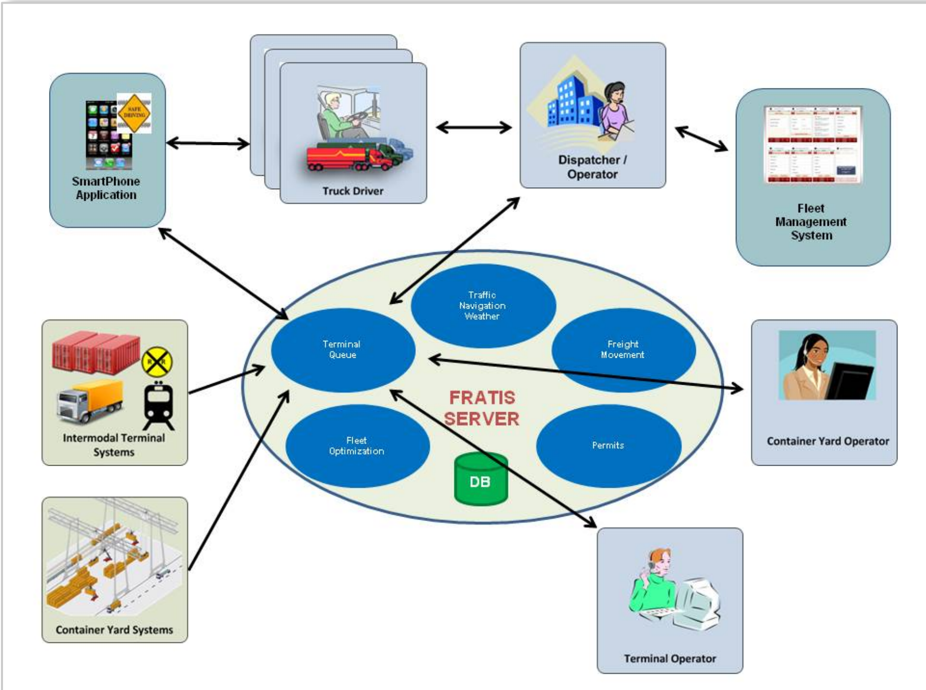

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Figure 2. Terminal queue

2.3 Routing, navigation, traffic and weather

A commercially available routing and navigation product will be purchased and deployed in each participating truck. The application will be able to route drivers on roads that can accommodate trucks of their size and weight. The application will be capable of receiving traffic and weather information and alerts for incidents along their current route. This information will come from various weather and traffic sources that are already existent within the application.

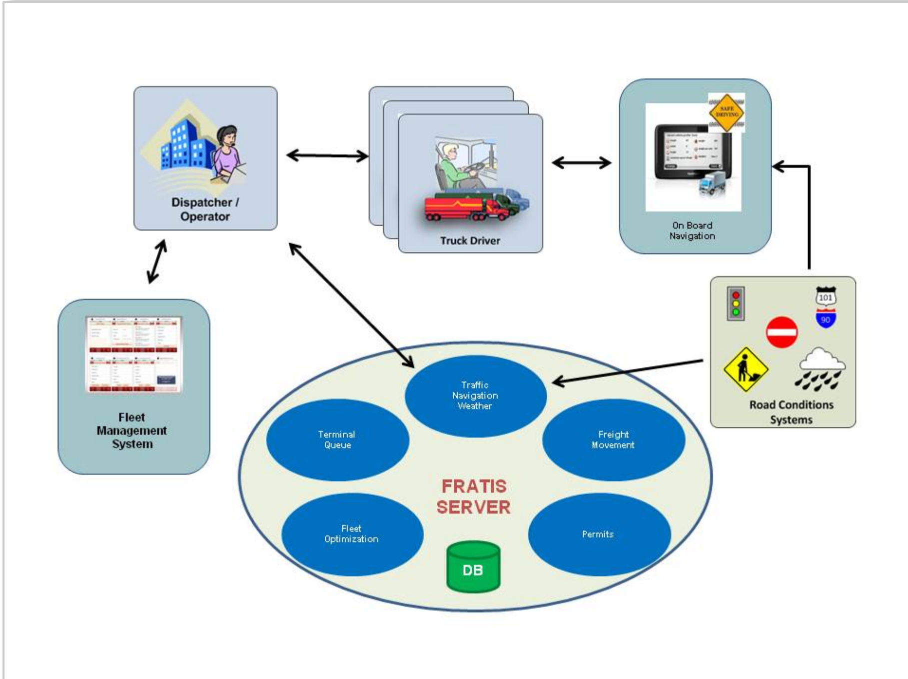

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Figure 3. Routing, navigation, traffic and weather

3 Assessment Findings

3.1 Optimization algorithm

Technology options

Options considered include:

- Productivity Apex – Productivity Apex has developed and deployed an optimization algorithm for a dray carrier in Memphis. They are making the source code available for use at other carriers. The application will need to be modified to meet the needs of different carriers in different locations.

Feature comparison

The features considered are:

- Optimization objectives – Values that are optimized by the technology
- Interfaces with fleet management – Can the technology interface with a fleet management application in use by the carrier?

- Source code available – Is the algorithm source code available to be modified?
- Source code language – Computer language used for the application source code
- Database – Database product used by the application
- Operating system – Operating system needed to run the application
- License – Does the application require a license?
- Cost – Cost for the application

Feature	Productivity Apex
Optimization objectives	1) Maximize completed moves for the day 2) Minimize number of trucks needed 3) Minimize bobtail miles
Interfaces with fleet management	Yes
Source code available	Yes
Source code language	C#
Database	None
Operating system	Windows
License	No
Cost	$0

Analysis

Productivity Apex's optimization algorithm was the only solution considered for carrier optimization. USDOT has required that we implement this solution in Dallas.

Recommendation

SAIC will install the optimization algorithm from Productivity Apex on a Windows FRATIS server at SAIC. The team will develop a process for the fleet management application used by each carrier that will send scheduled moves for the day to the FRATIS server. Scheduled moves will be submitted to the optimization algorithm which will produce a detailed load plan. The load plan will be transmitted back to the fleet management application to display to the dispatchers.

Testing

The system will be fully operational with the exception of loading plans into the fleet management systems. The load plans will be shared with the carriers to verify and calibrate the optimization results. That process will also serve as a test period to validate the reliability of the system and the quality of the results.

3.2 Terminal queue

Technology options

Options considered include:

- Video – Video cameras are mounted at locations that where they can scan the entire queue outside of a facility. The video is digitized and through special software the length of the queue can be measured. Once the length is known the wait time can be predicted.
- DSRC probe – Trucks are outfitted with DSRC radios that transmit position information to a DSRC antenna located within the facility. The position is passed to a server application that uses geo fencing to determine when the truck arrived at the facility, entered the facility, and exited the facility. This approach will only use the sample size of trucks that have an operating DSRC radio and application which at this time will be limited to trucks configured for this pilot.
- Bluetooth – An antenna and reader are placed at strategic locations within the facility that detect whenever a Bluetooth device passes those points. The information is passed to a server which correlates the passing times from the same device to calculate the desired metrics. This approach uses the sample size of trucks that have an operating Bluetooth device. It will need to identify and exclude devices that are not in a truck by eliminating any device that does not actually pass through a truck gate.
- Wi-Fi – This approach is identical to the Bluetooth with the exception that it recognizes Wi-Fi devices rather than Bluetooth devices.

Feature comparison

The features considered are:

- Measures queue to enter facility – Is the technology able to measure the time that a truck spends waiting from when it arrived in line to enter the terminal to passing through the in gate.
- Measures drop off time – Is the technology able to measure the time it takes to drop off a container once the truck has entered the facility.
- Measures pick up time – Is the technology able to measure the time it takes to pick up a container once the truck has entered the facility.
- Sample size available – The percent of trucks entering the facility that are included in the sample size used to compute statistics
- Capabilities beyond queue – Additional capabilities that the technology makes possible

- Cost per truck – The cost to equip a truck with any necessary devices
- Facility cost – The cost of all equipment and software that needs to be installed at the facility
- Total cost to achieve 20% sample size – The cost to implement at the facility and enough trucks to reach a sample size of 20%. At the test container yard facility (IMCG) this includes 80 trucks.

Feature	Video	DSRC Probe	Bluetooth	Wi-Fi
Measures queue to enter facility	Yes	Yes	Yes	Yes
Measures drop off time	No	Yes	Yes	Yes
Measures pick up time	No	Yes	Yes	Yes
Sample size available	100%	0%	5%	20%
Capabilities beyond queue	Video can be made visible to drivers and dispatchers	More accurate location in terminal. Data can be passed between facility and truck.	None	None
Cost per truck	$0	$750	$0	$0
Facility cost	$75,000	$10,000	$10,000	$10,000
Total cost to achieve 20% sample size	$75,000	$70,000	$10,000	$10,000

Analysis

With the exception of railroad yards the profit margin at intermodal facilities and carriers is small. Technology will not be adopted if the cost is too high. Bluetooth and Wi-Fi have the lowest to both the facilities and the carriers. This $10,000 cost to facilities is a price that facilities could realistically afford. The Wi-Fi readers are able to detect four times the number of devices, which gives a more statistically significant sample size than Bluetooth readers. DSRC probes would provide the most accurate results and could be enhanced to communicate additional information between the facility and the driver. However, at this time there are no trucks with this capability and the cost to install DSRC radios on a truck is prohibitive. This option will be more viable when a large population of trucks have the capability.

Recommendation

Install Wi-Fi readers on the approach road, in-gates and out-gates. Analyze time span between detection of the same Wi-Fi device at each reader to calculate current queue to enter yard, time to drop off a container once inside the yard, and time to pick up a container. Use historical data to predict the same times for the remainder of the day. Provide this information to dispatchers through a secure website.

USDOT has made specific requests regarding Bluetooth and DSCR. For research purposes we will install an antenna for Bluetooth at the out gate and approach road to compare the number Bluetooth versus Wi-Fi devices that can be detected. For research purposes we will install DSRC readers that cover the approach road and gates. Additionally, we will install a DSRC device in 5 trucks that transmit the Basic Safety Message and capture terminal queue from those trucks whenever they are at the facility.

Testing

Current and predicted wait times can be compared to other sources for the same information. Those sources will include the DSRC equipped probes and observations by the terminal manager. At various times and days the terminal manager can record when a truck arrived in the queue. That data can be combined with the records of when the truck went through the gate to determine the actual wait time for that truck. The data can then compared to both the current projection at that time and the predicted wait time from earlier in the day.

3.3 Routing, navigation, traffic and weather

Technology options

Options considered include:

- ALK CoPilot Truck – This is an application from ALK Associates that can be installed on a variety of devices that provides a routing and navigation application specific to truck drivers. For an additional fee real time weather and traffic can be integrated into the application.
- TomTom Pro 7150 Truck – This is an onboard device that contains a routing and navigation application specific to truck drivers. It includes real time weather and traffic information.

Feature comparison

The features considered are:

- Truck specific routing – Does the technology provide routing along roads that have the capacity for trucks of various sizes and weights?
- Driver interface conforms to safety regulations – Does the technology provide an interface for the driver that does not result in unsafe driving practices?
- Navigation – Does the technology provide turn by tune navigation advice?
- Real time weather – Does the technology provide real time weather information along the expected route?
- Real time traffic – Does the technology provide real time traffic information along the expected route?
- Includes hardware device – Does the technology include an on board device?
- Requires Smart phone – Does the technology require a Smart phone to run an application?
- Initial cost – The initial acquisition cost for one driver
- Recurring fees – Monthly or annual recurring fees for one driver
- Additional costs – Other costs that must be incurred as a result of selecting the technology
- Total cost per driver for 1 year – Total cost of the technology for one driver for one year
- Total cost for 100 drivers – Total cost of the technology for all drivers in the pilot for one year

Feature	ALK CoPilot Truck	TomTom Pro 7150 Truck
Truck specific routing	Yes	Yes
Driver interface conforms to safety regulations	Yes, but device may not	Yes
Navigation	Yes	Yes
Real time weather	Yes	Yes
Real time traffic	Yes	Yes
Includes hardware device	No	Yes
Requires Smartphone	Yes	No
Initial cost	$165	$300
Recurring fees	$10 per year for traffic	$0
Additional costs	Smartphone - $200 Phone service - $100/month	None

Total cost per driver for 1 year	$1575 if phone needed $175 if driver phone used	$300
Total cost for 100 drivers	$17,500 if all drivers use their own phone $157,500 if DOT provides phone	$30,000

Analysis

Features of both products are very similar. The major difference is that the TomTom is a self-contained device that only does navigation. ALK sells the software application and it must be hosted on a Smartphone. If the phones need to be purchased and supplied to the drivers the ALK option becomes cost prohibitive.

In reality some of the drivers may already have a similar device. If a driver is already using a similar device and we try to assess the before and after changes the results could be skewed. For those drivers the baseline scenario will be identical to the post implementation scenario. In that case we would expect to experience no change. However, that is not necessarily due to a lack of benefit in the system, but because the driver is already receiving all of the benefits that the system should provide.

Recommendation

We expect to deploy 50 TomTom 7150 devices to trucks at Southwest Freight and Associated Carriers. These devices include real time weather and traffic services. SAIC will configure the devices to contain the physical locations that a driver may need to go through in order to make it easy for the driver to see the recommended route.

The drivers chosen to receive a device should be limited to drivers that do not currently own their own device.

Testing

There are currently 60 million TomTom devices in use throughout the world. We can safely assume the devices have already been adequately tested. There may be quality issues with truck specific routing, traffic conditions and weather conditions. This can only be observed by the drivers during the pilot period.

4 Architecture

This section describes the high level architecture that we will utilize for each of the components.

4.1 Consolidated

Figure 4 illustrates how the three FRATIS components will interact with other components and with the primary users – drivers and dispatchers. The items shaded green are modules that will be developed specifically for this project and will be released as open source at the end of the pilot.

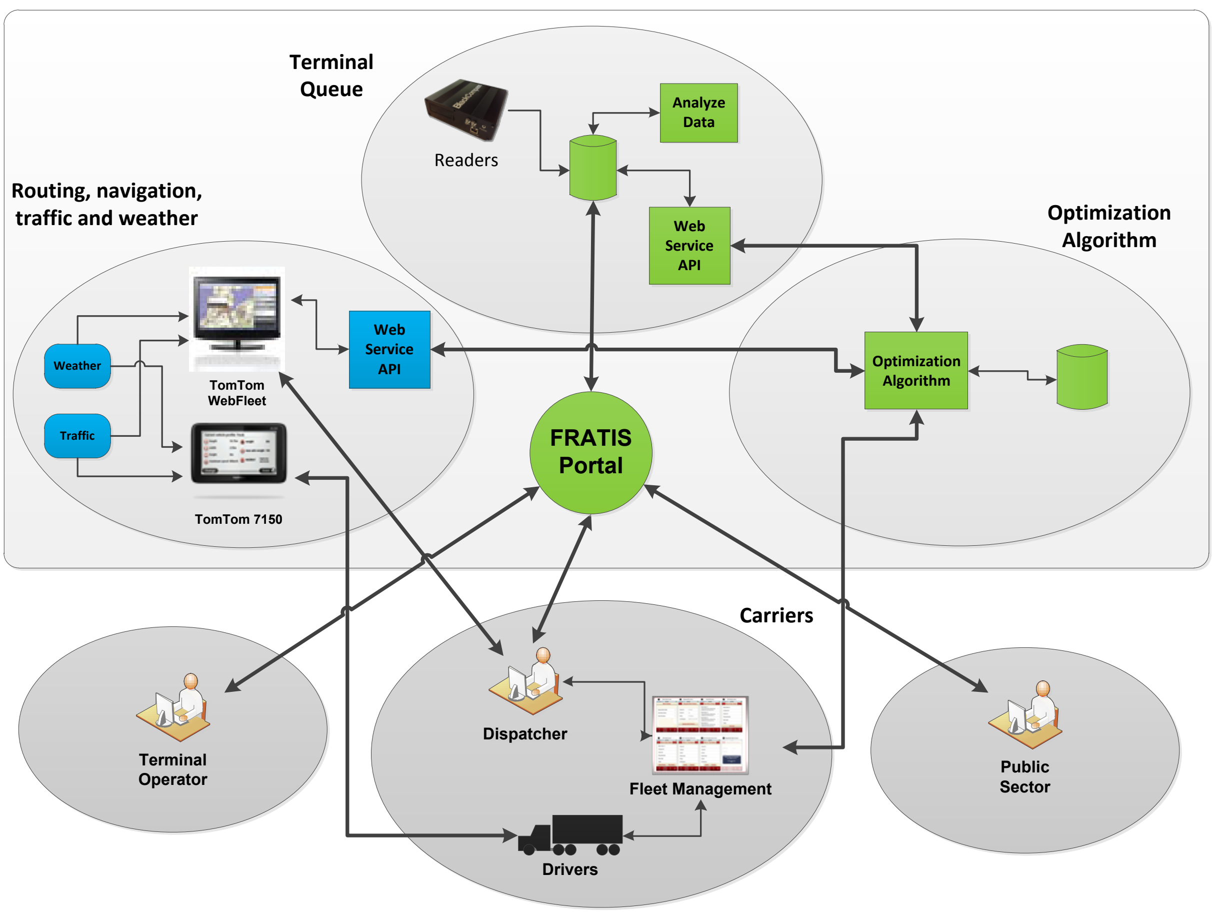

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Figure 4. Consolidated Architecture

The terminal queue component will include a website for dispatchers and a web service interface for the optimization algorithm, both of which will communicate current and predicted wait times.

The optimization algorithm will interact with the terminal queue web service for wait times. It will interact with the TomTom Web Service in the routing and navigation component for current and predicted travel time that takes traffic into account. It will interact with the carrier fleet management systems to receive orders and send load plans.

The routing, navigation, weather and traffic component will send current and predicted travel times to the optimization component through the TomTom Web Service. The WebFleet application will provide dispatchers with truck specific routing and current and predicted travel times adjusted for traffic conditions. The TomTom 7150 device will provide truck specific routing, traffic conditions, weather conditions and travel time to drivers.

We do not expect to integrate the 7150 device into the FRATIS portal to enable receipt of orders from the dispatchers. All carriers participating in the demonstration currently have a fleet management system and processes to communicate between drivers, dispatchers and their fleet management system. They have stated that they do not want to change that aspect of their operation. We are extracting scheduled moves from their fleet management system and returning an optimized load plan to import into their fleet management system. At that point they will use their existing processes to communicate with their drivers.

All components developed for the prototype will comply with current federal and USDOT security, data and web standards.

4.2 Optimization algorithm

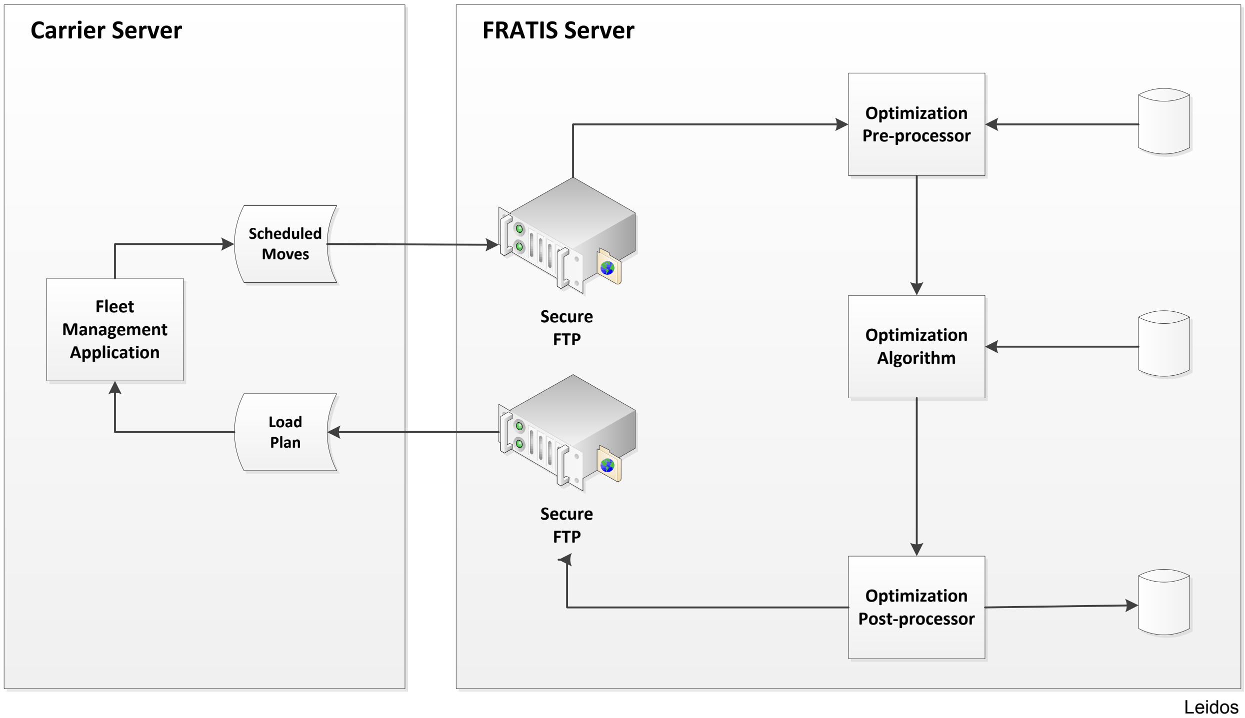

Figure 5. Optimization Algorithm Architecture

A scheduled process will extract a comma delimited file from the carrier's fleet management system and send it to a secure FTP site on the FRATIS server. This file will contain the following for each scheduled move:

- Move type
- Origin
- Destination
- Pickup window
- Drop-off window

Arrival at the FTP site will trigger the Algorithm pre-processor. The pre-processor will transform the file and add any additional information such as mileage that is required by the algorithm. The Optimization Algorithm will create the most efficient load plan by distributing the moves to drivers and specifying the sequence in which they should be moved. The post-processor will add estimated schedule times based on predictive travel time and terminal wait time. It will also store the load plan for future use.

The load plan will be placed on a secure FTP site where the carrier system can access it and load it into their fleet management application. The file will contain:

- Move ID
- Driver
- Sequence
- Estimated pickup time
- Estimated drop-off time

4.3 Terminal queue

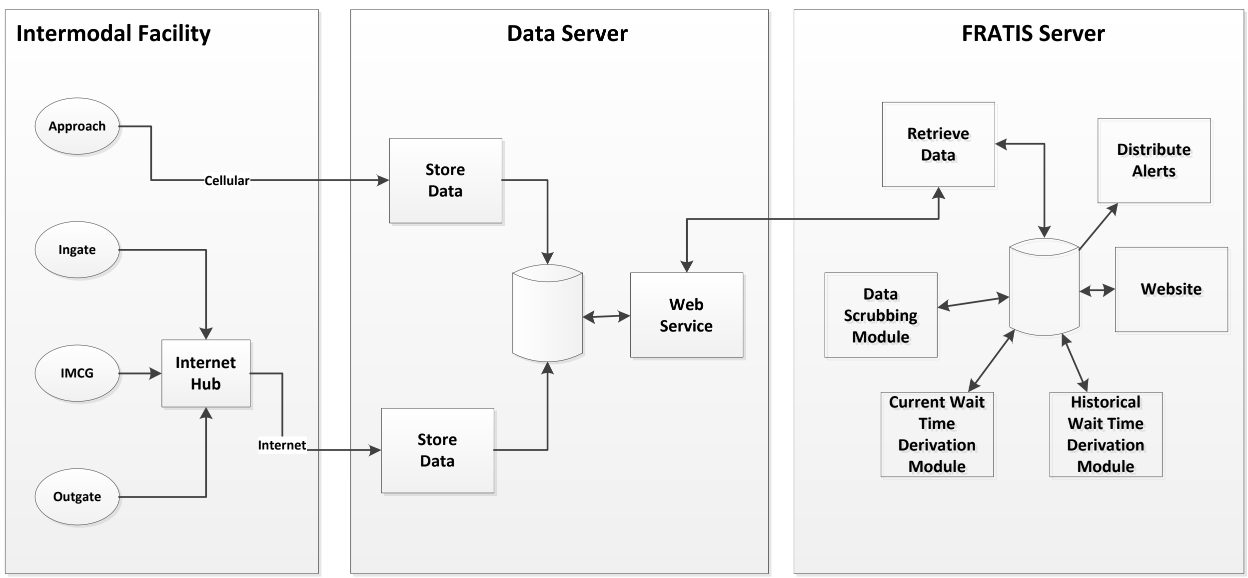

Figure 6. Terminal Queue Architecture

Antennas at the approach road, in-gate, IMCG gate and out-gate detect passing Wi-Fi devices. The MAC address and detection time is passed in real time to the device server. The approach road data is passed via a cellular call. The other locations are passed through an internet connection.

The data server does basic scrubbing and stores the MAC address and detection time. A scheduled process on the FRATIS server will retrieve any data since the last retrieval via a RESTful web service. The FRATIS server will analyze time between locations and calculate current time to in-gate, current time to in-gate for IMCG trucks, current time for a drop-off and current time for a pickup. The FRATIS server will store current times and calculate predicted times for each day of the week based on historical times.

The FRATIS server will provide a web site where authorized users can view current and predicted times. It will also distribute notifications of a change in conditions to an email distribution list of dispatchers and other authorized users.

4.4 Routing, navigation, traffic and weather

The TomTom 7150 solution is a commercial off-the-shelf product. For FRATIS in Dallas this product will be deployed as a standalone solution without any integration with other FRATIS components. Up to date maps, real time traffic and weather information are already integrated in to the product. As this is a proprietary system we do not have architectural details available.

TomTom updates their traffic information every 2 minutes. Their sources include:

- Real time flow data from their network of vehicles with TomTom devices
- Real time incident reports
- Historical traffic data

5 Pilot evaluation

During the pilot evaluation, actual mileage will be collected from a sample of trucks at each carrier. A vehicle tracking device will be installed in the trucks that periodically transmits location, time and odometer reading. For the FRATIS pilot we will use the LINK 10 device from TomTom in combination with WebFleet from TomTom. We have purchased 50 TomTom LINK 510 devices to be installed on trucks from Associated Carriers and Southwest Freight. The LINK will transmit location information to WebFleet. WebFleet will parse the location information into specific trips and calculate mileage, travel time and terminal time for each trip.

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