



DC Food Truck Vending Location Trading Platform

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TRUCK



TOP

Agenda



2

- Background
- Problem Definition
- Objective
- Research
- Current System
- System Concept
- Use Case
- Approach One: Linear Optimization
- Approach Two: Customized Matching Algorithm
- System Inputs
- System Interfaces
- System Outputs
- Comparison of Approaches
- Future Direction

Background



Primary Sponsor - DMV Food Truck Association (DMV FTA)

Food Trucks in the DMV FTA are subject to a schedule defining where and when they can sell food in 9 Washington D.C. locations (182 food trucks were scheduled in Nov. 2014)

The schedule is administered by the Washington D.C. Department of Customer and Regulatory Affairs (DCRA)

Purpose of this schedule is to allow Food trucks to do business while maintaining traffic flow in D.C.

Stakeholders

- DMV FTA (and its members)
- DCRA
- D.C. government
- Food truck customers

DMVFTA DC, Maryland and Virginia Food Truck Association

Problem Definition



- Washington D.C. has limited supply of "prime" locations for Food Trucks
- Monthly schedule assigned by lottery is unsatisfactory for food trucks
- The current mechanism for trading monthly assignments is cumbersome and inefficient and trucks are not able to obtain their preferences

The solvable problem is the trading problem

Objective



 Create a new trading platform that is usable, abides by current regulations, and maximizes trades

- Maximize number of trades (client defined goal)
- Allow Food Trucks to enter preferences for location/day assignments they would like to trade
- Easy for both DCRA and Food Trucks to use

Derived Requirements

- The system shall not reassign food trucks to locations which they do NOT prefer
- The system platform shall maximize utilization of open source and freely available software.
- System shall output schedule in same format as initial schedule

Research: Food Truck Interviews



- Current method and frequency of trading assignments
- Insight into the assignment process
- General location preferences
- Interest in a Secondary Trading Platform



Food trucks expressed that they were:

- Dissatisfied with complexity of current system for initial assignment and trading
- Interested in <u>any improvements</u> in trading process
- Primarily focused on <u>simplicity</u> of system and <u>mobile</u> <u>accessibility (iPad etc)</u>
- Desired <u>consistency</u> in weekly assignments (already occurs per current schedule)

Research: DCRA Administrators



- The DCRA desires a system to facilitate food truck assignment trading after the lottery assignments to maximize mobile roadway vending utilization and associated revenue
- Goals
 - Easy to use for administrators (automated)
 - Easy to use for food trucks (increased participation)
 - Easy to implement (automated)
 - Low cost and affordable
 - Maintainable

Current System



Primary Assignment

- Assignments for each day of the week are done once a month by lottery assignment for 9 locations
- The location assignments for the week are replicated throughout the month (consistent weekly schedule)

Secondary Trading

 Currently, all trades are between only two trucks, and must be approved by DCRA via email. An email listserv is used to offer positions available for trades. The is no DIRECT multi-way trading.

System Concept



User Input

- Food trucks select:
 - 1. Day/ location combinations that they are already assigned and would like to trade
 - 2. Day/ location combinations that they want and do not own

Algorithm/MILP

• The algorithm identifies all potential trades re-assigns the day/location pairs





which is being considered for trading

Trading Concept-Two Approaches

1) Linear Optimization

- Optimize schedule based on preferences
- Solve as a mixed integer linear optimization (MILP) problem

2) Bipartite Matching

- Automated trading algorithm based on preferences
- Introduces multi-way trading capability

This project will compare the results of these two approaches

Assumptions



- By entering location preferences into secondary trading platform, food trucks agree to accept any potential trades identified (i.e. no reneging)
- System will ensure the new truck assignment is an improvement, or there is no change to the initial assignment
- Per DCRA regulation, for all trades, trucks must offer an assigned location/day to receive a prefered location/day
- Each truck is treated as single truck with no relation to other trucks (trucks owned by the same company treated as separate trucks)

Approach One - LP Optimization



Benefits of the LP approach:

- Provides a globally optimal solution
- Is maximally "informed"
 - Is aware of desired locations that are under-capacity

• Basic idea:

- Create two matrices
 - One that indicates just preferred spots (Pij)
 - The other indicates preferred + initially assigned spots (Rij)
- Maximize the number of assignments from this first maxtrix
- Make sure every truck has an assignment from the second matrix
- End with the same number of spots given

LP Optimization - Formulation



Formulation:

Objective Function:

Maximize
$$\sum_{i} \sum_{j} X_{ij} * P_{ij}$$

Subject to:

1. Each truck starts and ends with the same number of initially assigned spots and must be assigned according to their preferences:

$$\sum_{j} X_{ij} * R_{ij} = 1 \qquad \forall i$$

2. The number of trucks assigned don't exceed the MRV capacity:

$$\sum_{i} X_{ij} \le 17 \qquad j \in \{s_1\} \qquad \sum_{i} X_{ij} \le 17 \qquad j \in \{s_4\} \qquad \sum_{i} X_{ij} \le 15 \qquad j \in \{s_7\} \\ \sum_{i} X_{ij} \le 11 \qquad j \in \{s_2\} \qquad \sum_{i} X_{ij} \le 3 \qquad j \in \{s_5\} \qquad \sum_{i} X_{ij} \le 4 \qquad j \in \{s_8\} \\ \sum_{i} X_{ij} \le 10 \qquad j \in \{s_3\} \qquad \sum_{i} X_{ij} \le 8 \qquad j \in \{s_6\} \qquad \sum_{i} X_{ij} \le 19 \qquad j \in \{s_9\}$$
 14

LP Optimization - Results



15

- The sample data provided involved 32 of 182 trucks willing to trade a single spot, i.e. 32 trucks were dissatisfied with one of their assignments
 - For trucks willing to trade more than a single spot, a similar but extended formulation is used and not shown here (but is provided in the final report)
- Out of the 32 assignments the LP improved 30, over 93% improvement

Approach Two - Matching Algorithm 👰



Customized Matching Algorithm

- Customized Matching Algorithm allows traceable trades between 2 or more trucks
- Trucks can only potentially trade IF their preferences are available
 - Checks occurs before trading and after each trade so that trucks whose preferences are NOT available are eliminated from trade consideration
- Coded in PERL Script also reads in initial schedule and preference data, and outputs trade data and new schedule

Matching Algorithm Description



Checks Before Entering Algorithm:

- 1. For each truck, disallow preferences for location/day assignments that truck owns and is trading
- 2. For each truck, disallow preferences on days that truck has a location/day assignment that it is NOT offering to trade
- 3. Eliminate trucks whose preferences are not available (i.e. location/day assignments not being traded by other trucks)

One Dimensional Arrays needed before entering algorithm 1. "Location/Days to be Traded" array

2. Corresponding "Trucks that are Trading" array

NOTE: The indices in these arrays correspond to each other



Matching Algorithm Description



Example: Two-Way Trade, 1 Truck Eliminated

Available Positions: 11, 22, 33, 44, 55, 66, and 77 Trucks Trading: A, B, C, D, E, F, G



Result:

- Truck C trades position 33 and receives position 44
- Truck D trades position 44 and receives position 33
- Truck B eliminated because positions and 33 and 44 are no longer available (Trucks that prefer only position 22 would be eliminated as well)
- Algorithm goes back to looking for a trade, starting with Truck A

Matching Algorithm Description



20

Example: Four-way Trade

Available Positions: 11, 55, 66, and 77 Trucks Trading: A, E, F, G



Result:

- Truck A trades position 11 and receives position 55
- Truck E trades position 55 and receives position 66
- Truck F trades position 66 and received position 77
- Truck G trades position 77 and receives position 11

Matching Algorithm Results



21

- According to sample data, 32 trucks provided a location/day assignment that they were willing to trade and preferences for that location/day assignment
- From that data:
 - o 3 trucks eliminated before trading
 - o 6 trucks eliminated during trading
 - o 23 trucks received new, preferred positions
- Over 70% improvement

System Inputs



Inputs 1. MRV Lottery Assignment Schedule Format

November 2014 MRV Location Lottery				
Site Permit	Business Name	Monday	Tuesday	
VSP-00747	Adilmo	L'Enfant Plaza	Union Station	
VSP-00573	Ali Abdelghany	Farragut Square 17th St	OFF	
VSP-00160	Amorini Panini, Inc.	Union Station	OFF	
VSP-00161	Amorini Panini, Inc.	OFF	Union Station	
VSP-00048	Ana Olmos	Farragut Square 17th St	OFF	
VSP-00049	Ana Olmos	OFF	L'Enfant Plaza	
VSP-00626	Arepa Zone	OFF	Farragut Square 17th St	Fra
VSP-00743	Asian Delight	Franklin Square 13th St	OFF	Fan
VSP-00732	Azn Eata	Union Station	OFF	Fra
VSP-00559	Baba's Big Bite	Navy Yard/Capital River Front	OFF	
VSP-00219	Basil Thyme LLC	OFF	Virginia Ave (State Dept)	
VSP-00220	Basil Thyme LLC	L'Enfant Plaza	OFF	Fan
VSP-00157	BBQ Bus	Metro Center	L'Enfant Plaza	
VSP-00249	Beirut Delights, LLC	OFF	Virginia Ave (State Dept)	Navy Y
VSP-00690	BiBi Ja	OFF	Farragut Square 17th St	
VSP-00739	Big Robs Good Eats	Franklin Square 13th St	OFF	

2. Truck requested trades and associated preferences

System Interfaces

Web Based Interface

- www.foodtrucktrade.com
- Web interface created to allow preference inputs from Food Trucks
- Mobile device compatible

Features

- Login authentication
- Dynamic reference to initial lottery assignment
- Flexible input format
- Input confirmation provided

Member Login DMV FTA Link

VSP-00747

Current Assignment Reference

#	Day	Location	
Location 1	Monday	LEnfant Plaza	
Location 2	Tuesday	Union Station	
Location 3	Thursday	Waterfront Metro	



System Interfaces (Cont'd)



- Trucks can select multiple locations on a given day or multiple days for a given location
- Data is then forwarded to the algorithm for trade consideration

What Location would you consider trading for? *

Click or hold left mouse button to mark cells. Hold SHIFT to mark areas instead of single cells.

	Monday	Tuesday	Wednesday	Thursday	Friday
Farragut Square					
Franklin Square					
L'Enfant Piaza					
Metro Center					
Navy Yard					
Patriots Pieza					
Union Station					
Virginia Ave					
Waterfront Metro					

Agreement *

I agree that if available locations identified which match my submitted preferences will be re-assigned and replace the indicated location I am offering to trade.

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System Outputs



• New schedule in same dimensions as input schedule

Site Permit	Business	Monday	Tuesday	Wednesday	Thursday	Friday
VSP-00747	Adilmo	LEnfant Plaza	Union Station	Virginia Ave (State Dept)	OFF	OFF
VSP-00573	Ali Abdelghany	Farragut Square 17th St	OFF	Union Station	OFF	Franklin Square 13th St
VSP-00160	Amorini Panini Inc.	Union Station	OFF	L'Enfant Plaza	OFF	Virginia Ave (State Dept)
VSP-00161	Amorini Panini Inc.	OFF	Franklin Square 13th St	OFF	LEnfant Plaza	OFF
VSP-00048	Ana Olmos	Farragut Square 17th St	OFF	Metro Center	OFF	Union Station
VSP-00049	Ana Olmos	OFF	LEnfant Plaza	OFF	Virginia Ave (State Dept)	OFF

System Outputs



26

#===#Beginning of Trading Events for Trade ID 9#===#
###Beginning of Trade ID 9###
There are 2 trucks involved in this trade:
Truck VSP-00150 traded [Union Station on Tuesday] and received [Virginia Ave (State Dept)
on Monday]
(Rebecca Cuisine)
Truck VSP-00023 traded [Virginia Ave (State Dept) on Monday] and received [Union Station
on Tuesday]
(Feelin' Crabby)
###End of Trade ID 9###

After the last trade, Trade ID 9, this truck/owned position was eliminated from trading because its preferences are no longer available: VSP-00370/[Waterfront Metro on Wednesday] (DC Ballers) After the last trade, Trade ID 9, this truck/owned position was eliminated from trading because its preferences are no longer available: VSP-00142/[Union Station on Monday] (DC Empanadas LLC) #===#End of Trading Events for Trade ID 9#===#

.....Trading Completed! Final Statistics..... Total Trucks with new positions = 23 Total Trucks eliminated before trading = 3 Total Trucks eliminated during trading = 6

Only available on Matching Algorithm

Comparison



Linear	Matching
Optimization	Algorithm
 More trucks obtained preferred positions (93% as opposed to 70%) Will look to fill all available capacity 	 Shows trades that occur Single script capable of reading input, performing algorithm, and providing new schedule

Both approaches are usable, expandable, and available via free software

Future Direction



- Test and Integration of algorithm and preference entering
- Incorporate scoring/ranking of preferences per location/day assignment to be traded





Conclusion



- Lottery assignments can be significantly improved from food truck perspective
- Found matching algorithm, linear optimization, and associated processes to effectively allow trucks to trade
- A prototype capable of outputting a new schedule was built

What we Learned

- Systems Engineering Principles are very important
 - Design change occurred in November

What we Contributed

 As far as we know, our matching algorithm and associated process is NEW*

Thank You - Questions?



