Food Truck Parking Location Assignments

Siamak Khaledi
Ankit Shah
Matt Shoaf

Sponsor: Karen Wrege

Agenda

- Problem Domain
- Analysis of Existing System
- Proposed Solution
- Prototype
- Validation
- Conclusions

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Problem Domain

Background

- DC, Maryland and Virginia Food Truck Association (DMVFTA)
  - Mobile food vending zones
  - Limited parking spaces for food trucks
  - “Lottery-based” assignment has been used in DC

- Licensed trucks vs Spaces available (Jan 2015)
  - 250 licenses
  - 104 parking spaces

Current System Overview

- Lottery System
  - Receives vendor preferences as input
  - Provides location assignment as output
  - **Black Box**
- Online, Web-Based Interface
  - Interface design is cumbersome
  - Time consuming process
  - System does not maintain user preference data
- Under-Utilization and Lack of Vendor Buy-In
  - Assignments are static for 1 month, upon receipt by vendors
  - Low sign up fee

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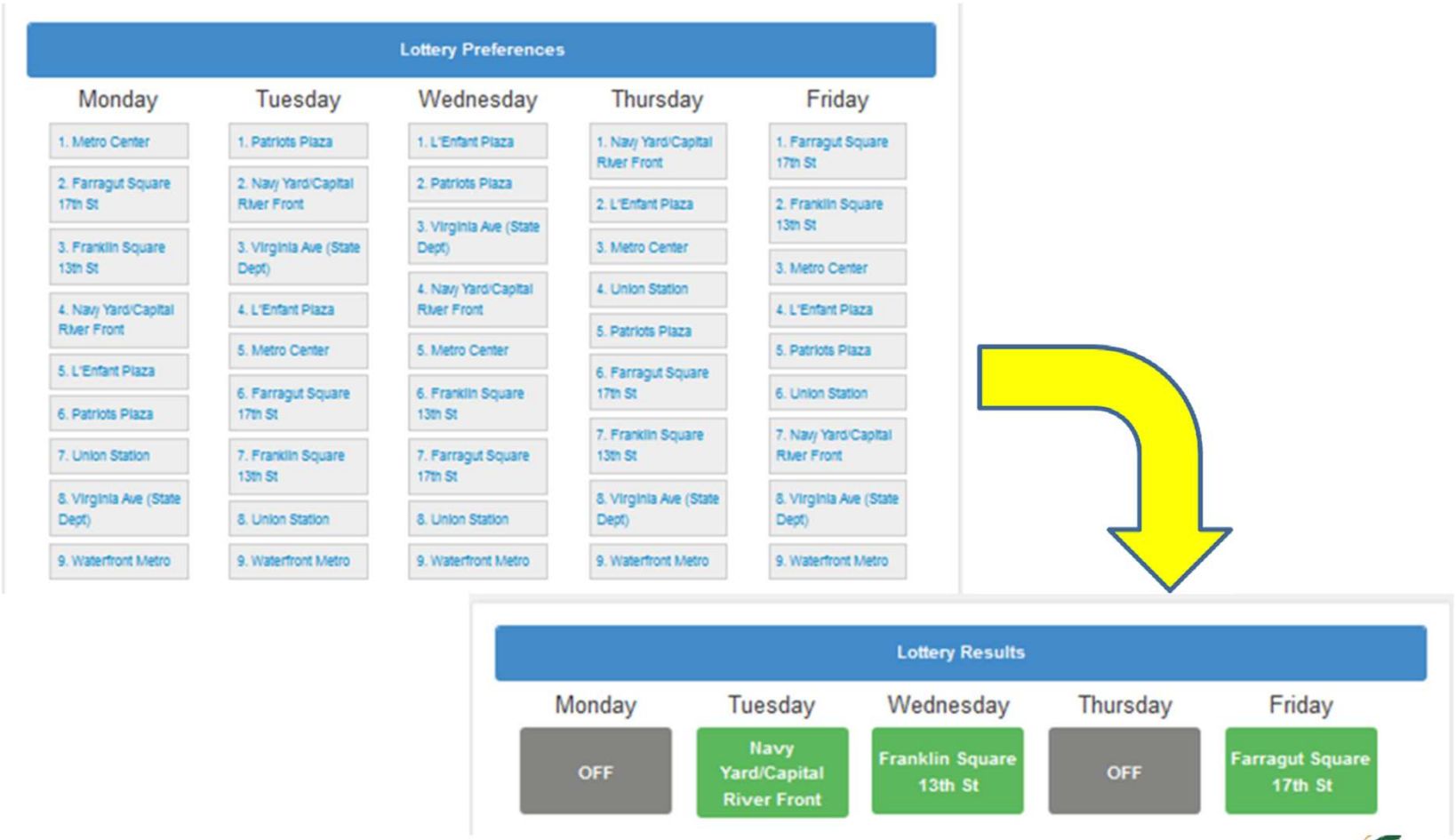
Current System Input/Output



Stakeholders

- Primary Stakeholders
  - DMVFTA – Implement more efficient assignment mechanism
  - Vendors – Concerns over current system fairness
  - DCRA – Safety, quality of service, utilization level

- Stakeholder Tensions
  - Vendors look for more popular locations to park their trucks
  - DCRA wants to avoid confrontations and fights on the streets
  - **DCRA concerned about low utilization**
  - **DMVFTA looking to find the solution to assign spaces fairly to vendors**
  - Lottery system fails to utilize available spaces

*DCRA: Department of Consumer and Regulatory Affairs

Problem Statement

- DCRA is concerned with:
  - Under-utilization of assigned spaces.
  - Strategic gaming and even abandonment of the lottery system.

- Truck vendors do not perceive the system to be fair.

- DMVFTA wants to develop and prototype alternative primary mechanism to assign parking spaces to the food truck vendors.

- ***The central issue: How do we define and measure "fairness" in this problem domain and develop a system that is superior to the existing one?***

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Analysis of Existing System

Data Collection

Qualitative:

- **Surveys and discussions with vendors**
  - Prefer to avoid distant assignments for consecutive days
  - Not willing to commit to monthly assignments
  - Concerns over current system fairness/transparency

Quantitative:

- **Preference/Assignment data**
  - 8 months of data
  - 17 licensed trucks

	A	B	C							
1188	VSP-00259	Carnivore	7/14							Farragut
1189	VSP-00259	Carnivore	7/14						nt	Franklin
1190	VSP-00259	Carnivore	7/14						Yard	Union
1191	VSP-00259	Carnivore	7/14							Metro
1192	VSP-00259	Carnivore	7/14						gt	State
1193	VSP-00259	Carnivore	7/14							L'Enfant
1194	VSP-00259	Carnivore	7/14						lin	Navy Yard
1195	VSP-00259	Carnivore	7/14		8	GW	GW	GW	GW	GW
1196	VSP-00259	Carnivore	7/14	A		Off	Navy Yard	Off	Union	Off
1197	VSP-00259	Carnivore	8/14		1	Patriots	L'Enfant	Metro	Metro	Farragut
1198	VSP-00259	Carnivore	8/14		2	Franklin	Farragut	Farragut	Farragut	Metro
1199	VSP-00259	Carnivore	8/14		3	Union	State	L'Enfant	L'Enfant	Franklin
1200	VSP-00259	Carnivore	8/14		4	Metro	Navy Yard	Union	Union	Union
1201	VSP-00259	Carnivore	8/14		5	Farragut	Metro	State	Navy Yard	State
1202	VSP-00259	Carnivore	8/14		6	Navy Yard	Patriots	Navy Yard	Franklin	Patriots
1203	VSP-00259	Carnivore	8/14		7	State	Union	Franklin	State	Navy Yard
1204	VSP-00259	Carnivore	8/14		8	L'Enfant	Franklin	Patriots	Patriots	L'Enfant
1205	VSP-00259	Carnivore	8/14		9	Waterfront	Waterfront	Waterfront	Waterfront	Waterfront
1206	VSP-00259	Carnivore	8/14	A		Off	L'Enfant	Off	Metro	Off
1207	VSP-00259	Carnivore	9/14		1	Patriots	L'Enfant	L'Enfant	Metro	Farragut
1208	VSP-00259	Carnivore	9/14		2	Union	State	State	L'Enfant	Metro
1209	VSP-00259	Carnivore	9/14		3	State	Union	Metro	Farragut	Franklin
1210	VSP-00259	Carnivore	9/14		4	Navy Yard	Navy Yard	Farragut	Union	Union
1211	VSP-00259	Carnivore	9/14		5	Franklin	Farragut	Navy Yard	State	State
1212	VSP-00259	Carnivore	9/14		6	Metro	Metro	Union	Navy Yard	L'Enfant
1213	VSP-00259	Carnivore	9/14		7	Farragut	Patriots	Patriots	Franklin	Patriots
1214	VSP-00259	Carnivore	9/14		8	L'Enfant	Franklin	Franklin	Patriots	Navy Yard
1215	VSP-00259	Carnivore	9/14		9	Waterfront	Waterfront	Waterfront	Waterfront	Waterfront
1216	VSP-00259	Carnivore	9/14	A		Patriots	Off	L'Enfant	Off	Metro
1217	VSP-00259	Carnivore	10/14		1	Patriots	L'Enfant	L'Enfant	L'Enfant	Farragut
1218	VSP-00259	Carnivore	10/14		2	State	Metro	Metro	Farragut	Metro
1219	VSP-00259	Carnivore	10/14		3	Union	Navy Yard	Farragut	Metro	Franklin
1220	VSP-00259	Carnivore	10/14		4	Navy Yard	State	Union	Union	Union
1221	VSP-00259	Carnivore	10/14		5	Metro	Farragut	Navy Yard	State	State
1222	VSP-00259	Carnivore	10/14		6	Farragut	Union	State	Franklin	L'Enfant
1223	VSP-00259	Carnivore	10/14		7	Franklin	Franklin	Franklin	Navy Yard	Navy Yard
1224	VSP-00259	Carnivore	10/14		8	L'Enfant	Patriots	Patriots	Patriots	Patriots

Additional Information

Location space capacities

- Farragut Square 17 spaces
- Franklin Square 17 spaces
- L'Enfant Plaza 18 spaces
- Metro Center 13 spaces
- Navy Yard 8 spaces
- Patriots Plaza 4 spaces
- Union Station 14 spaces
- Virginia Avenue (State Dept) – 10 spaces
- Waterfront Metro 3 spaces

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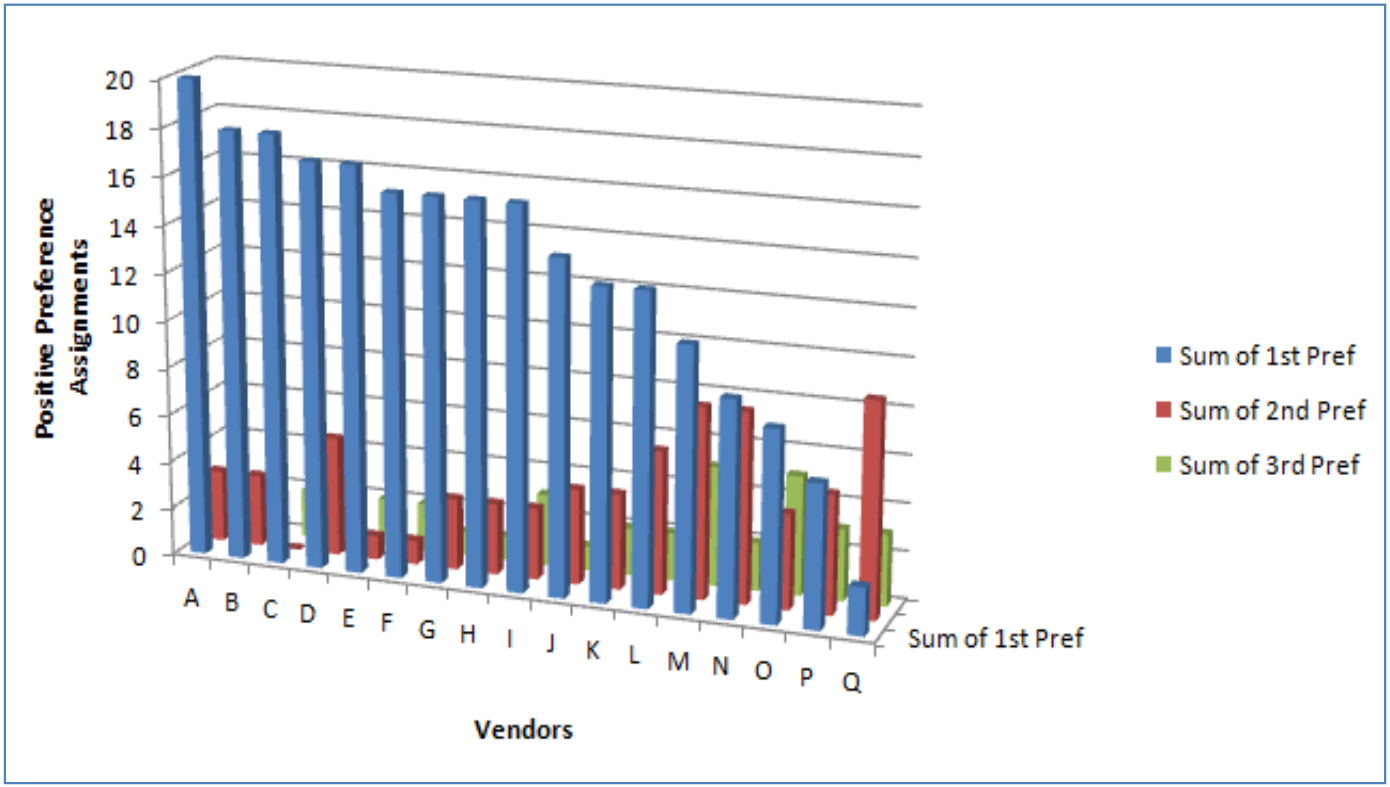
Data Analysis – Current Algorithm Behavior

- 8 months of assignment data (what they wanted, what they got)
- Vendors A-Q
- Number of times each vendor got their 1st-3rd preferences
- ***This is how we measure fairness!***



Hot Locations
(Total Preferences: 1st, 2nd 3rd Choice)

Preference Totals *Location*	*1st Preference*	*2nd Preference*	*3rd Preference*	*Total*
Farragut Square 17th St	195	177	191	563
Franklin Square 13th St	66	78	125	269
Union Station	91	84	155	330
L'Enfant Plaza	162	133	120	415
Metro Center	228	292	183	703
Waterfront Metro	22	16	16	54
Navy Yard/Capital River Front	38	39	33	110
Patriots Plaza	67	60	60	187
Virginia Ave (State Dept)	75	59	91	225

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First Preference					
Location	*Monday*	Tuesday	Wednesday	Thursday	Friday
Farragut Square 17th St	4.76%	6.35%	13.23%	12.17%	66.67%
Franklin Square 13th St	6.35%	16.93%	3.17%	4.76%	3.70%
Union Station	10.58%	13.76%	8.99%	13.76%	1.06%
L'Enfant Plaza	17.46%	26.46%	25.40%	13.23%	3.17%
Metro Center	19.58%	15.87%	37.04%	35.98%	12.17%
Waterfront Metro	7.41%	1.59%	1.06%	1.06%	0.53%
Navy Yard/Capital River Front	9.52%	4.23%	1.06%	5.29%	0.00%
Patriots Plaza	14.29%	10.05%	2.12%	8.47%	0.53%
Virginia Ave (State Dept)	10.05%	4.76%	7.94%	5.29%	11.64%

Farragut Fridays!

- A little history lesson . . .

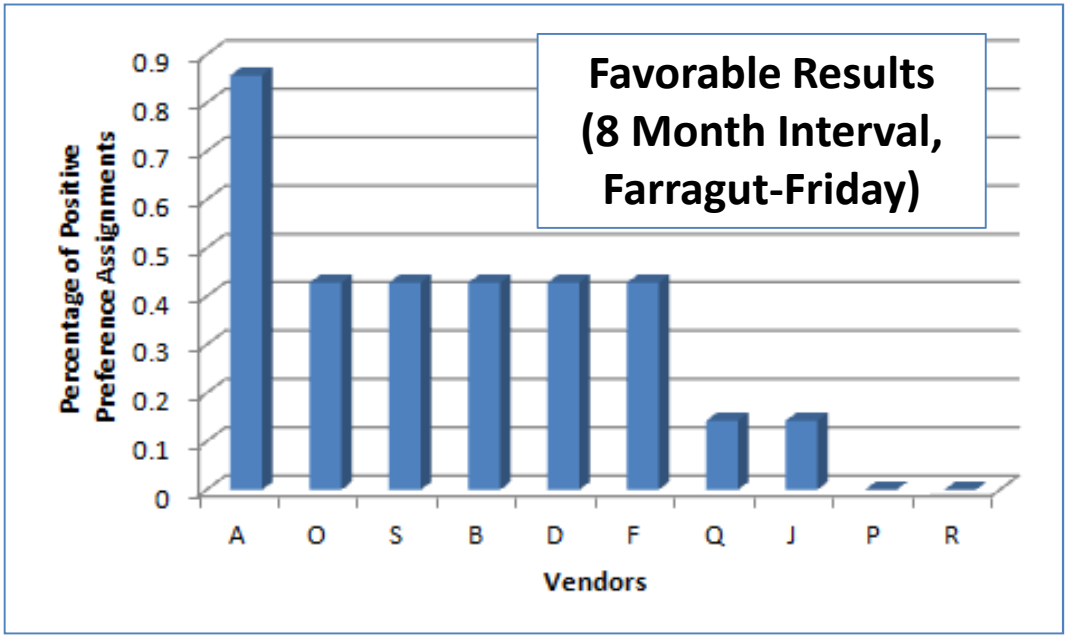
Two Variable Analysis of Location Value

- Number represents percentage of requests for a given spot on each day

Preference Matrix: 2nd Choice					
Location	*Monday*	Tuesday	Wednesday	Thursday	Friday
Farragut Square 17th St	3.09%	2.24%	3.84%	5.44%	4.26%
Franklin Square 13th St	1.39%	1.17%	1.39%	1.71%	2.67%
Union Station	4.05%	2.35%	0.96%	0.85%	0.75%
L'Enfant Plaza	1.07%	1.71%	3.94%	4.58%	2.88%
Metro Center	4.05%	7.04%	6.72%	5.54%	7.78%
Waterfront Metro	0.75%	0.43%	0.21%	0.32%	0.00%
Navy Yard/Capital River Front	2.13%	1.17%	0.21%	0.53%	0.11%
Patriots Plaza	1.71%	1.81%	1.60%	0.43%	0.85%
Virginia Ave (State Dept)	1.92%	2.24%	1.28%	0.75%	0.11%

Farragut Square on Fridays

- Focus on most popular pick
- Clearly unbalanced results



Requirements

- Input/Output
  - Receive parking location preferences from food truck vendors.
  - Output location assignments to vendors.
  - **Assign parking spaces to vendors based on user preferences.**

- Functional
  - **Provide equal opportunities to vendors to pick their preferences across all days of the week.**
  - Utilize a structured query database to store user profile information and process user requests.

- System Wide
  - **Maintain historical location preference data.**
  - Provide web access.
  - Include a user interface for vendors.
  - Provide secure access.

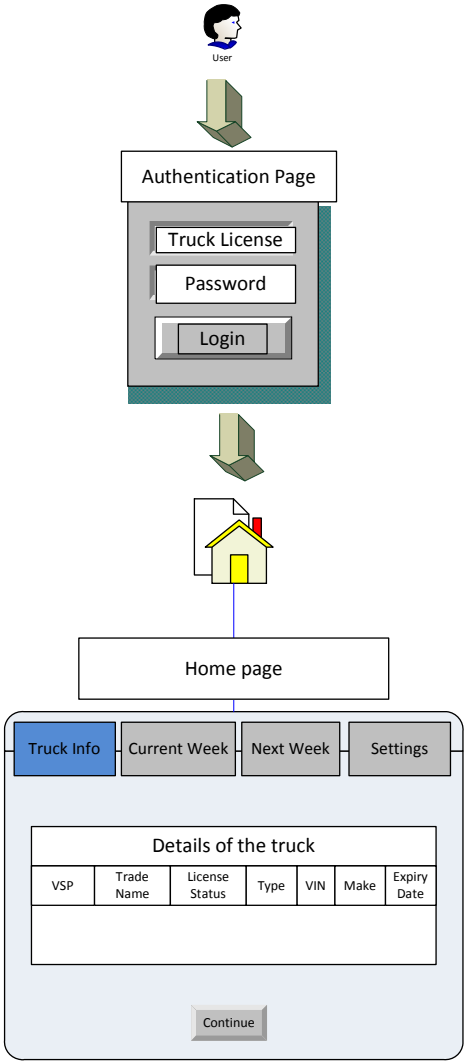
Proposed Solution

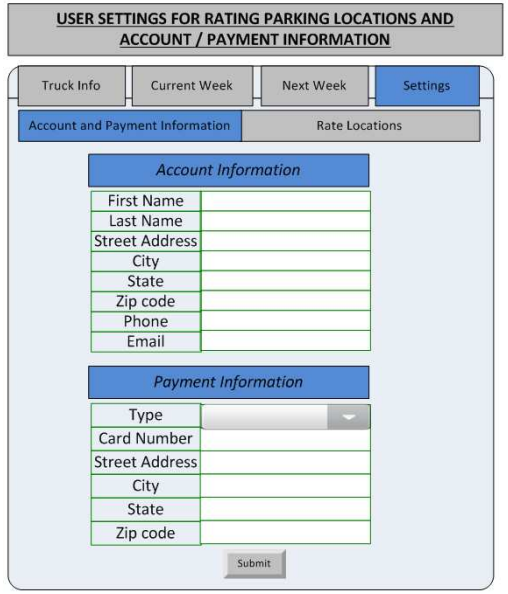
Proposed Solution

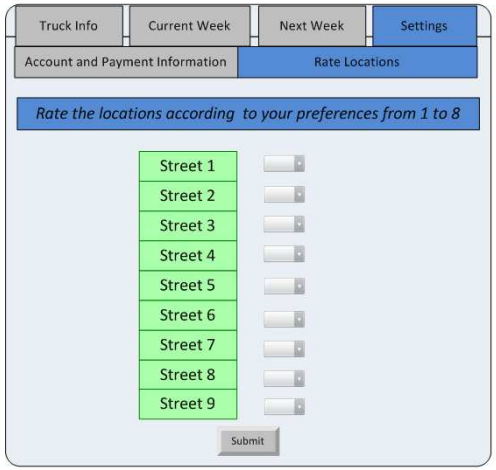
- Improved Interface
  - Ability to change and maintain preferences
  - Weekly assignment schedule

- New Algorithm
  - Based on proposed NBA Wheel Draft
  - Designed to address both **actual** and **perceived** fairness

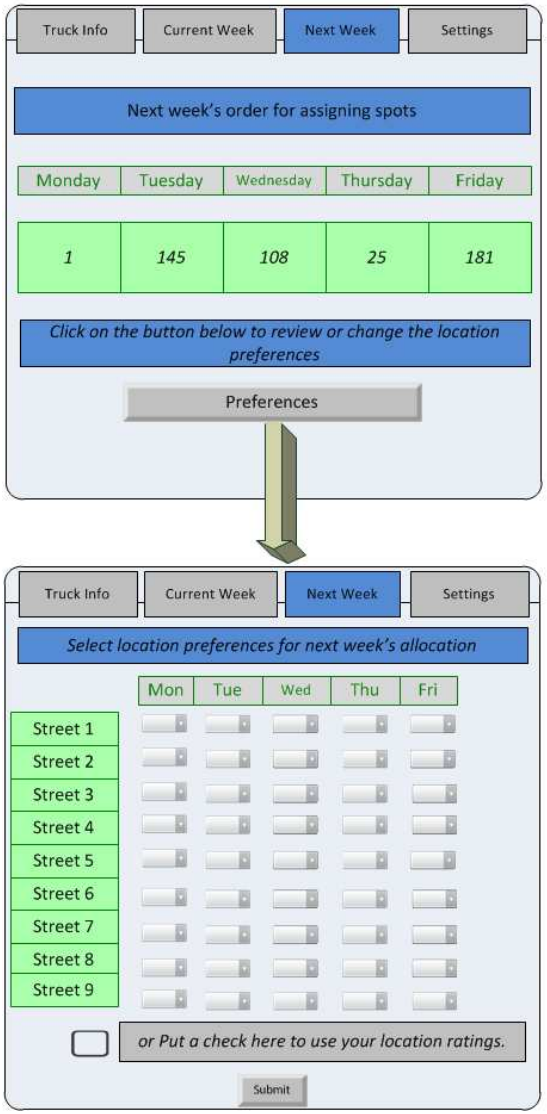
Proposed Design







NEXT WEEK'S SYSTEM ALLOCATED ORDER AND PREFERENCE SETUP



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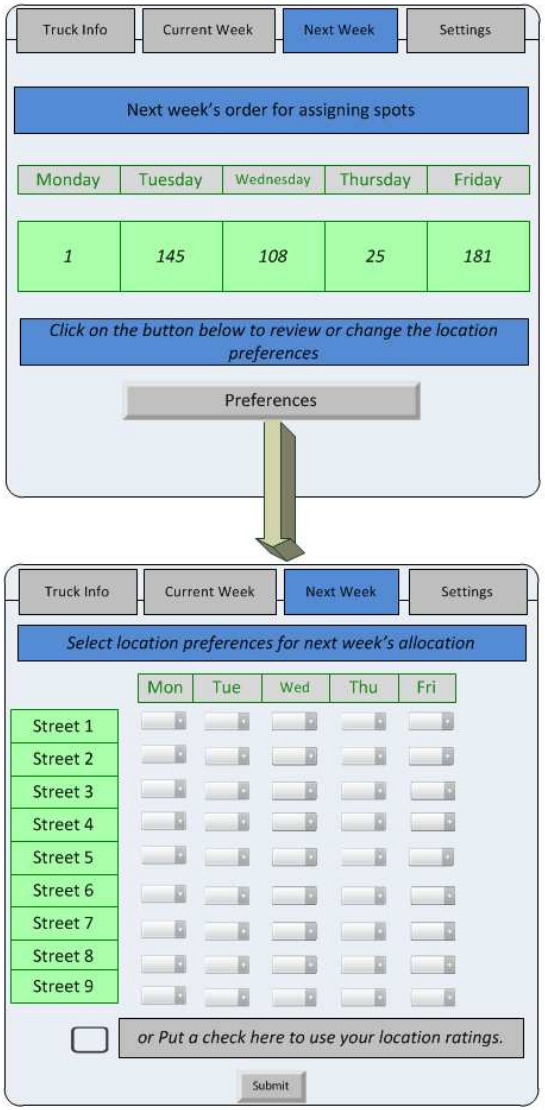
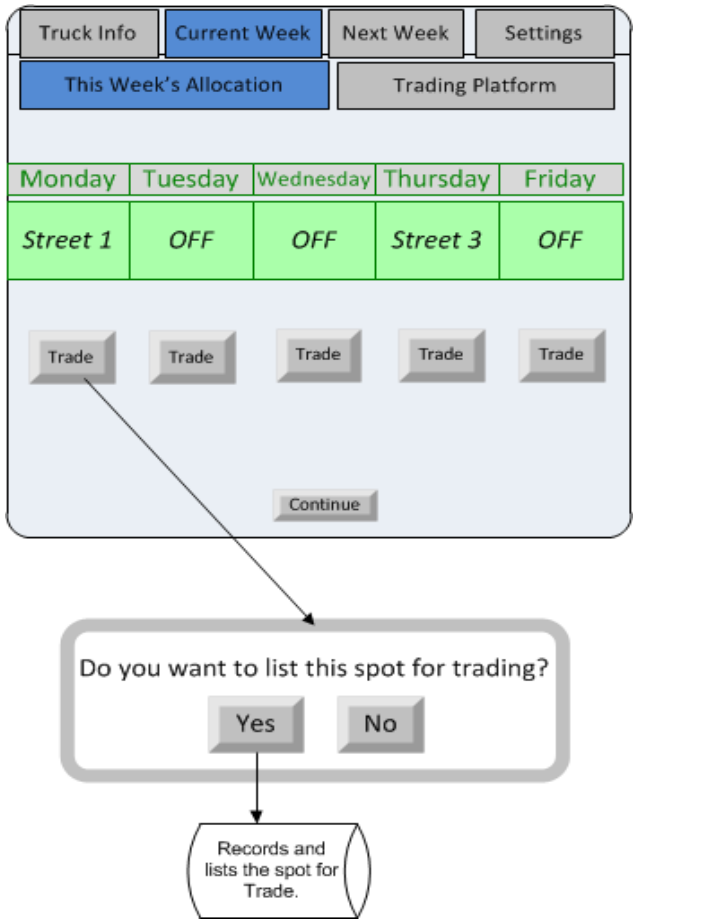


CURRENT WEEK'S PARKING SPACE ASSIGNMENT AND TRADING PLATFORM



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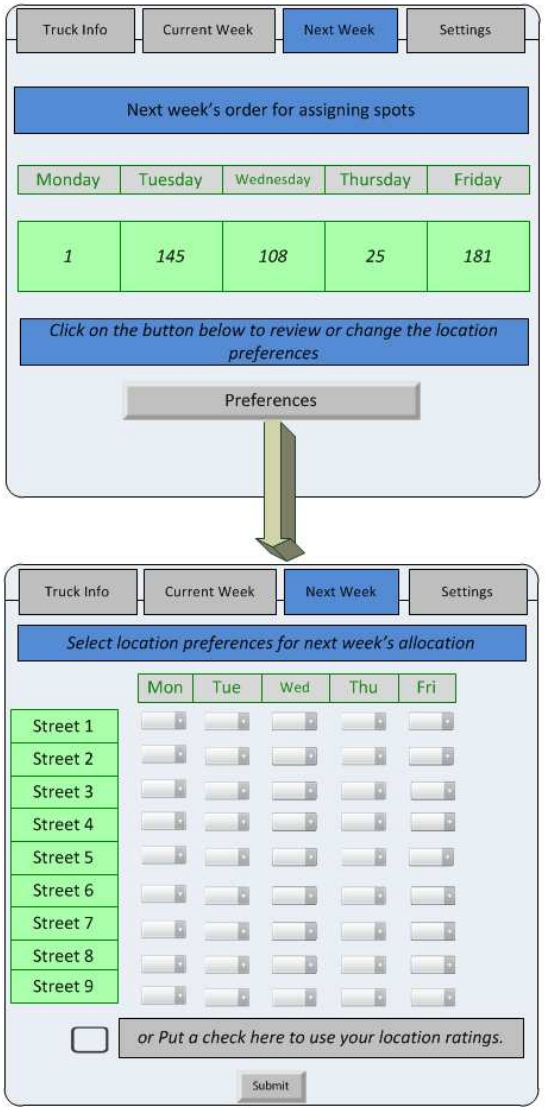

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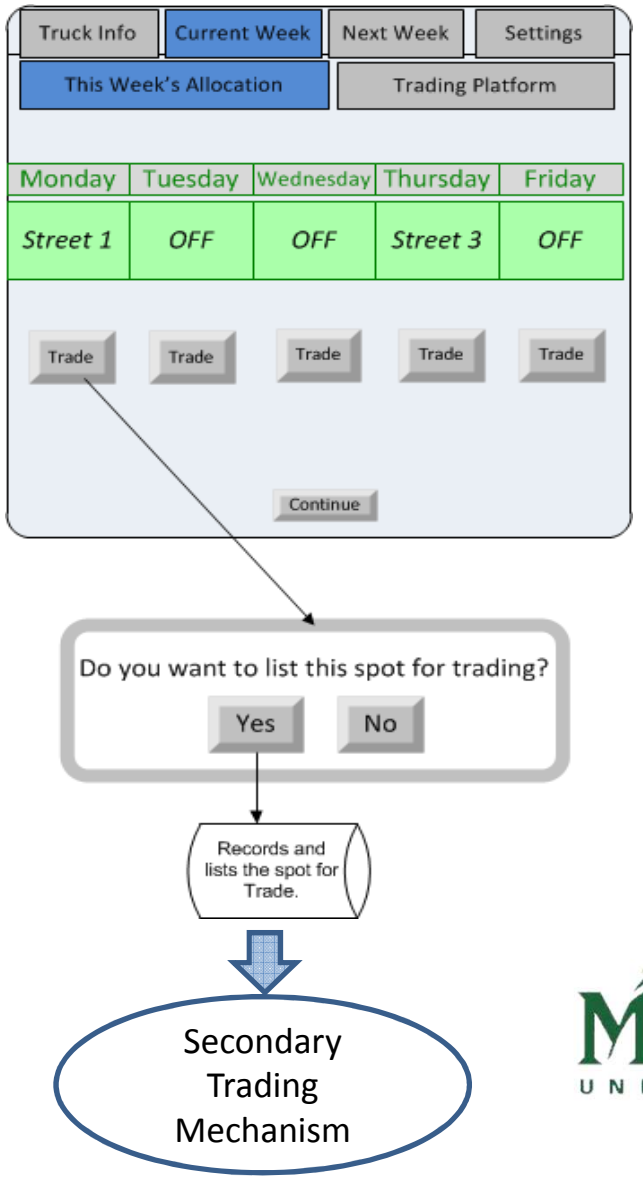
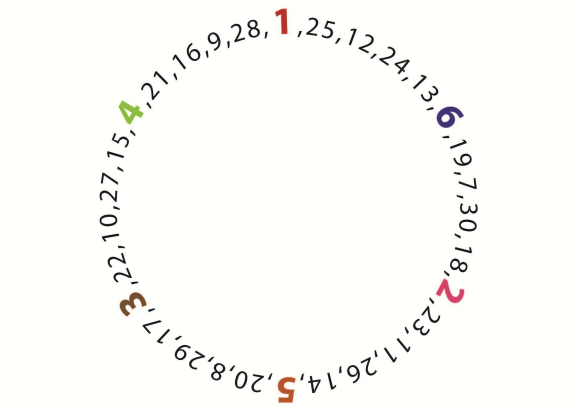


Draft Algorithm

- **Wheel draft proposal for NBA** [1]
  - **30 teams / 30 draft numbers**
  - **1-6 considered equally valuable**
  - **5 groups of 6**
    - **1-6**
    - **25-30**
    - **19-24**
    - **13-18**
    - **7-12**



[1] http://www.celticsblog.com/2014/5/20/5735850/the-nba-draft-lottery-wheel-a-proposal-to-solve-the-leagues-draft-zarren-fixed-solution

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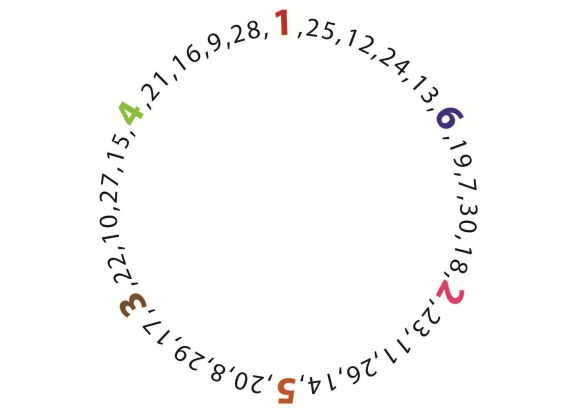

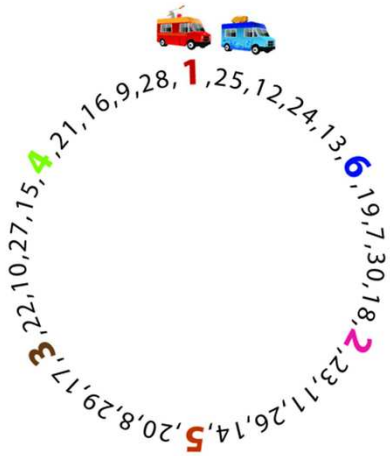

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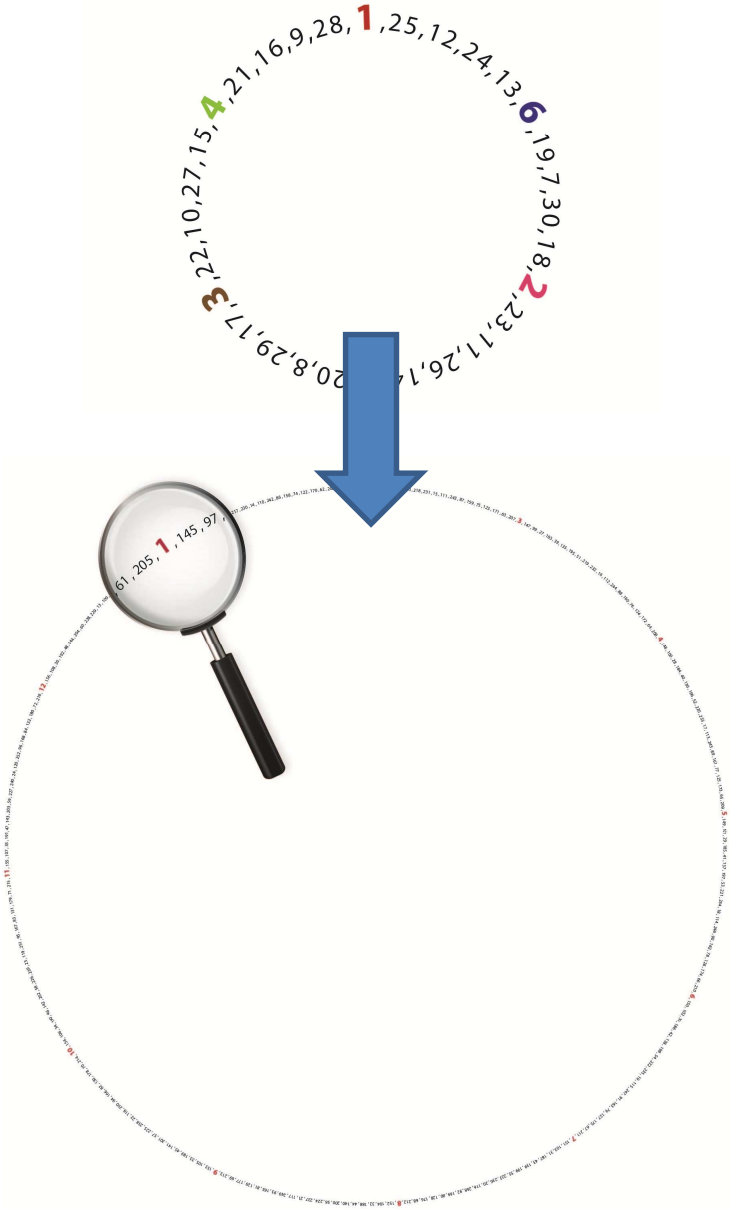
DC Problem Dimension

- Based on the data analysis, the top 3 popular streets are
  - L'Enfant Plaza
  - Farragut Square
  - Metro Center
- Draft ticket 1-12 are considered equally valuable
- 1-100 guaranteed a space
- Above 100 gets an off day
- 21 groups of 12 would give every vendor equal chances on each day of the week



Expanded Wheel

- Due to the limited capacity (252 trucks vs 100 locations) it is inevitable to have several off days
- Insert working days in a way to equally space the days off, avoid consecutive off days as much as possible

1	2	3	4	5	6	7	8	9	10	11	12
145	146	147	148	149	150	151	152	153	154	155	156
97	98	99	100	101	102	103	104	105	106	107	108
25	26	27	28	29	30	31	32	33	34	35	36
181	182	183	184	185	186	187	188	189	190	191	192
37	38	39	40	41	42	43	44	45	46	47	48
133	134	135	136	137	138	139	140	141	142	143	144
193	194	195	196	197	198	199	200	201	202	203	204
49	50	51	52	53	54	55	56	57	58	59	60
217	218	219	220	221	222	223	224	225	226	227	228
229	230	231	232	233	234	235	236	237	238	239	240
13	14	15	16	17	18	19	20	21	22	23	24
109	110	111	112	113	114	115	116	117	118	119	120
241	242	243	244	245	246	247	248	249	250	251	252
85	86	87	88	89	90	91	92	93	94	95	96
157	158	159	160	161	162	163	164	165	166	167	168
73	74	75	76	77	78	79	80	81	82	83	84
121	122	123	124	125	126	127	128	129	130	131	132
169	170	171	172	173	174	175	176	177	178	179	180
61	62	63	64	65	66	67	68	69	70	71	72
205	206	207	208	209	210	211	212	213	214	215	216

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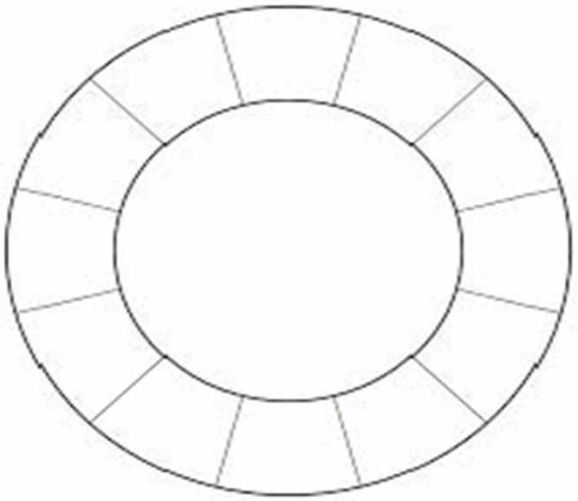

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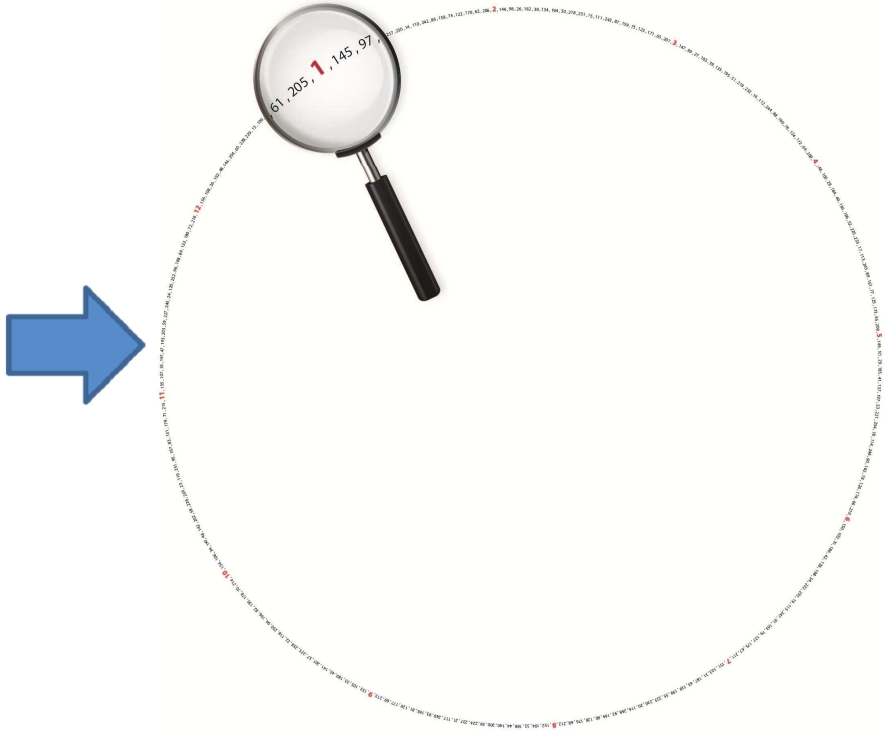
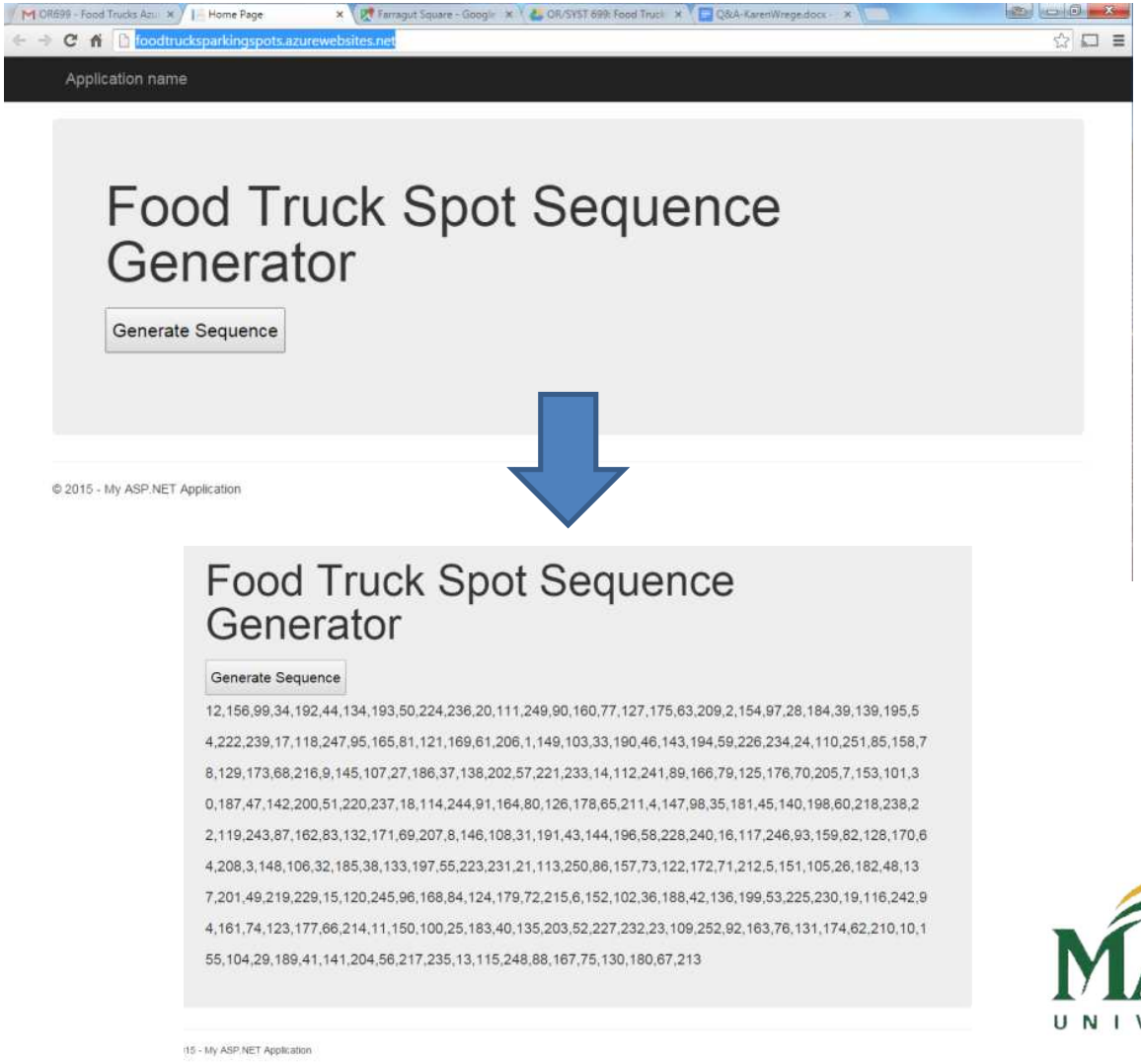


Demonstration

Prototype

- Visual Studio Express
- SQL Server Express
- Microsoft Azure Cloud Computing



http://foodtrucksparkingspots.azurewebsites.net/

Validation

Validation

Recall: New algorithm needs to be

- Fair in giving all vendors same chances to get their top preferences
- Fair in distribution of days of the week for the top preferences

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	Group	Mon	Tue	Wed	Thu	Fri
	1-12					
	13-24					
	25-36					
	37-48					
	49-60					
	61-72					
	73-84					
	85-96					
	97-108					
	109-120					
	121-132					
	133-144					
	145-156					
	157-168					
	169-180					
	181-192					
	193-204					
	205-216					
	217-228					
	229-240					
	241-252					

Validation (month 1)

	Group	Mon	Tue	Wed	Thu	Fri
month 1	1-12	1				
	13-24		1			
	25-36				1	
	37-48	1				
	49-60				1	
	61-72					1
	73-84		1			
	85-96					1
	97-108			1		
	109-120			1		
	121-132			1		
	133-144		1			
	145-156		1			
	157-168	1				
	169-180				1	
	181-192					1
	193-204			1		
	205-216	1				
	217-228					1
	229-240	1				
	241-252				1	

Validation (month 2)

	Group	Mon	Tue	Wed	Thu	Fri
month 2	1-12	1	1			
	13-24		1	1		
	25-36				1	1
	37-48	1	1			
	49-60				1	1
	61-72	1				1
	73-84		1	1		
	85-96	1				1
	97-108			1	1	
	109-120			1	1	
	121-132			1	1	
	133-144		1	1		
	145-156		1	1		
	157-168	1	1			
	169-180				1	1
	181-192	1				1
	193-204			1	1	
	205-216	1	1			
	217-228	1				1
	229-240	1	1			
	241-252				1	1

Validation (month 3)

	Group	Mon	Tue	Wed	Thu	Fri
month 3	1-12	1	1	1		
	13-24		1	1	1	
	25-36	1			1	1
	37-48	1	1	1		
	49-60	1			1	1
	61-72	1	1			1
	73-84		1	1	1	
	85-96	1	1			1
	97-108			1	1	1
	109-120			1	1	1
	121-132			1	1	1
	133-144		1	1	1	
	145-156		1	1	1	
	157-168	1	1	1		
	169-180	1			1	1
	181-192	1	1			1
	193-204			1	1	1
	205-216	1	1	1		
	217-228	1	1			1
	229-240	1	1	1		
	241-252	1			1	1

Validation (month 4)

	Group	Mon	Tue	Wed	Thu	Fri
month 4	1-12	1	1	1	1	
	13-24		1	1	1	1
	25-36	1	1		1	1
	37-48	1	1	1	1	
	49-60	1	1		1	1
	61-72	1	1	1		1
	73-84		1	1	1	1
	85-96	1	1	1		1
	97-108	1		1	1	1
	109-120	1		1	1	1
	121-132	1		1	1	1
	133-144		1	1	1	1
	145-156		1	1	1	1
	157-168	1	1	1	1	
	169-180	1	1		1	1
	181-192	1	1	1		1
	193-204	1		1	1	1
	205-216	1	1	1	1	
	217-228	1	1	1		1
	229-240	1	1	1	1	
	241-252	1	1		1	1

Validation (month 5)

	Group	Mon	Tue	Wed	Thu	Fri
month 5	1-12	1	1	1	1	1
	13-24	1	1	1	1	1
	25-36	1	1	1	1	1
	37-48	1	1	1	1	1
	49-60	1	1	1	1	1
	61-72	1	1	1	1	1
	73-84	1	1	1	1	1
	85-96	1	1	1	1	1
	97-108	1	1	1	1	1
	109-120	1	1	1	1	1
	121-132	1	1	1	1	1
	133-144	1	1	1	1	1
	145-156	1	1	1	1	1
	157-168	1	1	1	1	1
	169-180	1	1	1	1	1
	181-192	1	1	1	1	1
	193-204	1	1	1	1	1
	205-216	1	1	1	1	1
	217-228	1	1	1	1	1
	229-240	1	1	1	1	1
	241-252	1	1	1	1	1

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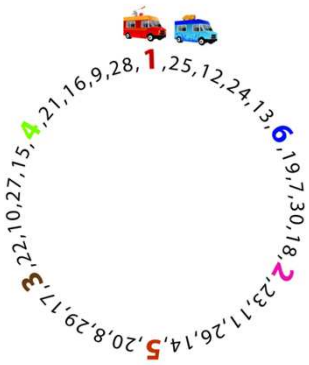
Validation (month 5)



	Group	Mon	Tue	Wed	Thu	Fri
month 5	1-12	1	1	1	1	1
	13-24	1	1	1	1	1
	25-36	1	1	1	1	1
	37-48	1	1	1	1	1
	49-60	1	1	1	1	1
	61-72	1	1	1	1	1
	73-84	1	1	1	1	1
	85-96	1	1	1	1	1
	97-108	1	1	1	1	1
	109-120	1	1	1	1	1
	121-132	1	1	1	1	1
	133-144	1	1	1	1	1
	145-156	1	1	1	1	1
	157-168	1	1	1	1	1
	169-180	1	1	1	1	1
	181-192	1	1	1	1	1
	193-204	1	1	1	1	1
	205-216	1	1	1	1	1
	217-228	1	1	1	1	1
	229-240	1	1	1	1	1
	241-252	1	1	1	1	1

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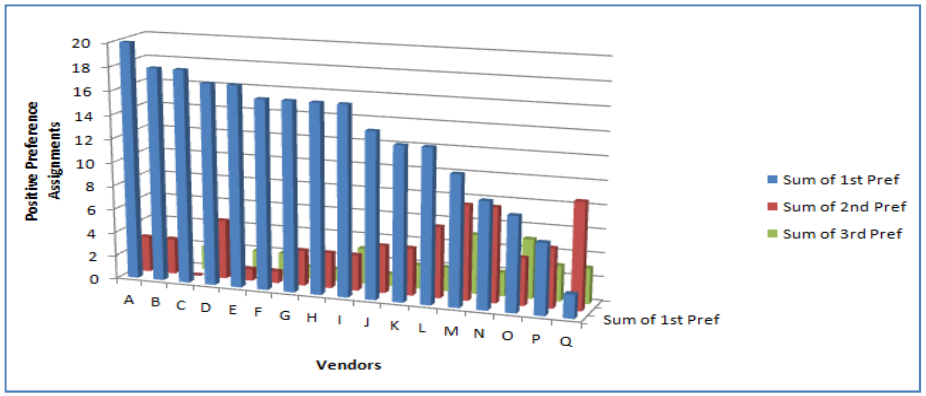
Validation (summary)

- Proposed algorithm provides
  - Equal chances to get preferences
  - Equal chances to get all weekdays
- Cycle completion length is 105 days
- A new wheel generation after cycle completion

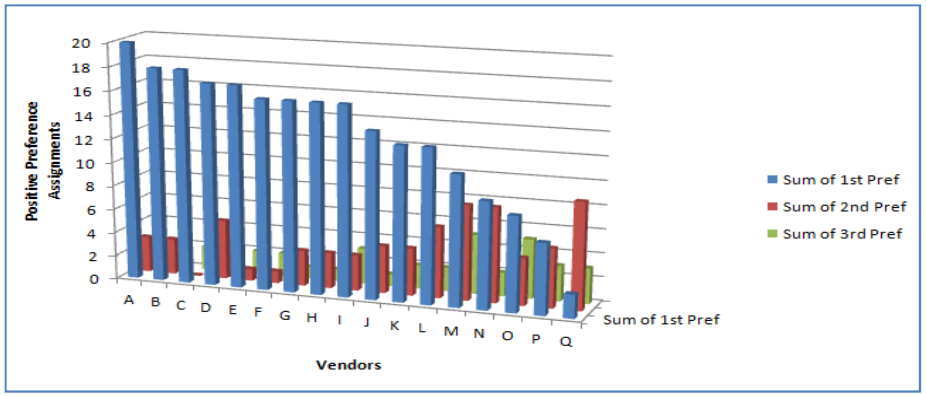
Conclusions

Fairness Comparison



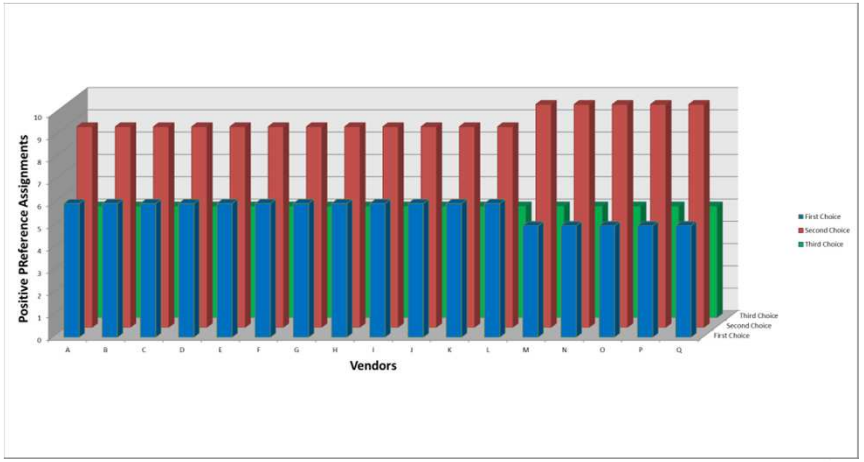
- Current System
  - Recap: Unfair after 8 months
  - Data on a sample of 17 trucks

Fairness Comparison



- Current System
  - Recap: Unfair after 8 months
  - Data on a sample of 17 trucks

- Proposed Algorithm
  - Simulated: Fair after 5 months
  - 17 trucks, assumed to choose most popular locations



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Conclusions

Proposed system

- Mathematically guaranteed to give everyone equitable assignments after ~ 5 months (105 working days) in *worst case*
- May provide equitable assignment *sooner*, depending on vendor preferences

Comparison

- Proposed Algorithm: **Fair after 5 months**
- Current Algorithm: Unfair after 8 months

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Recommendations/Future Work

- Integration of primary and secondary assignment mechanisms
- Machine learning
- Increased capacity (DCRA tension)

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Back-up Slides

Previous Research

- Snake algorithm
  - http://www.aaai.org/ocs/index.php/IAAI/IAAI14/paper/download/8341/8657

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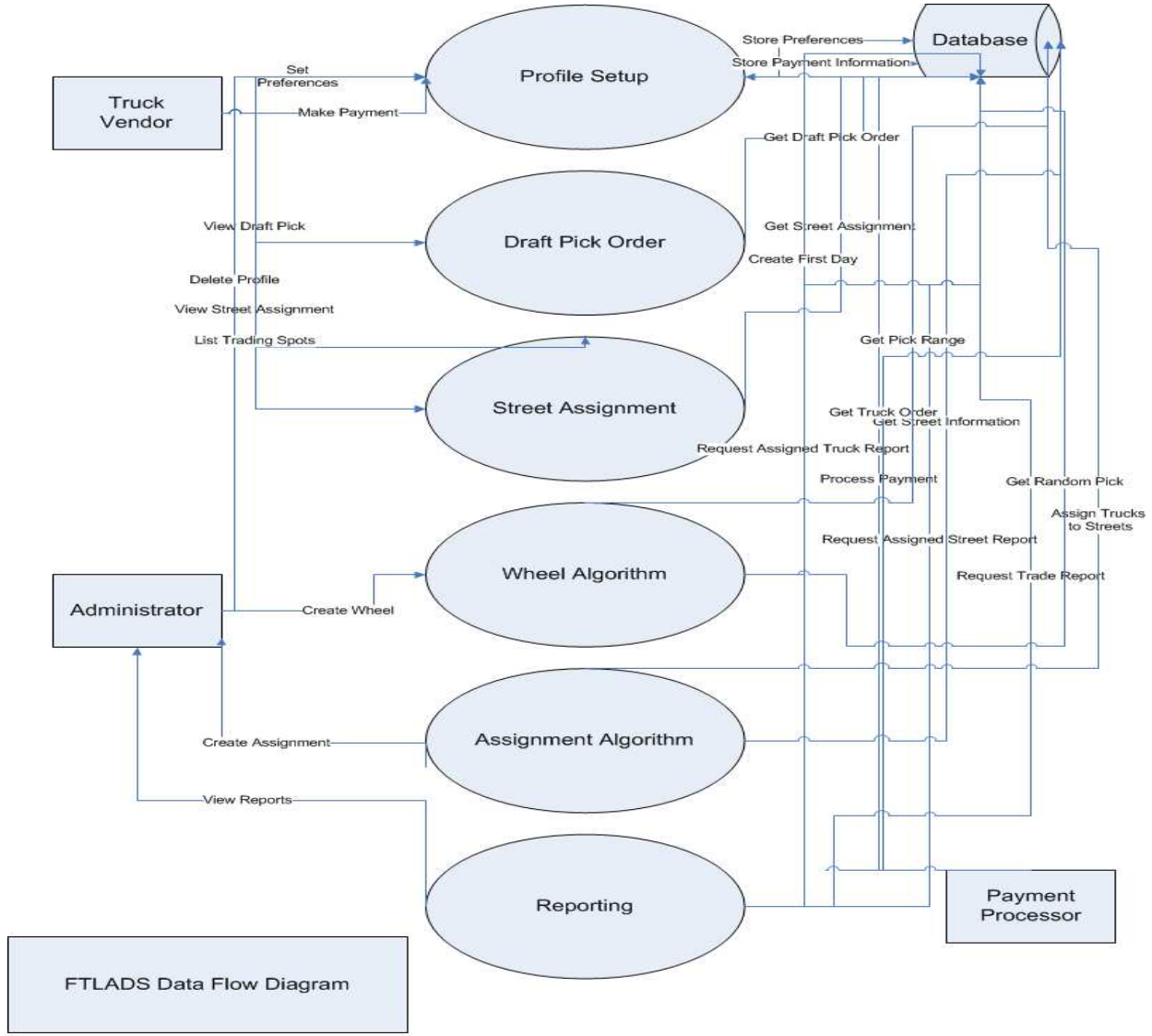
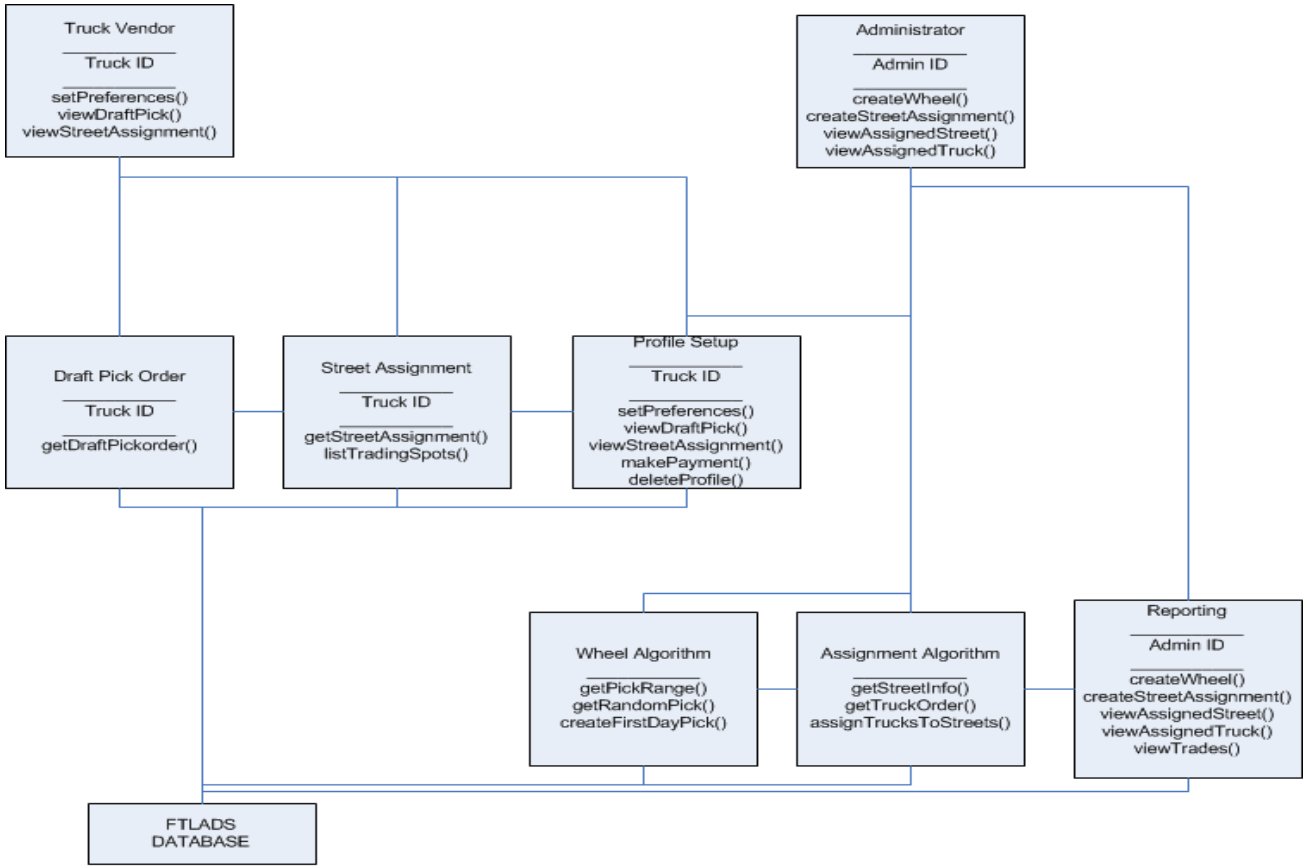
Data Flow Diagram (detailed)

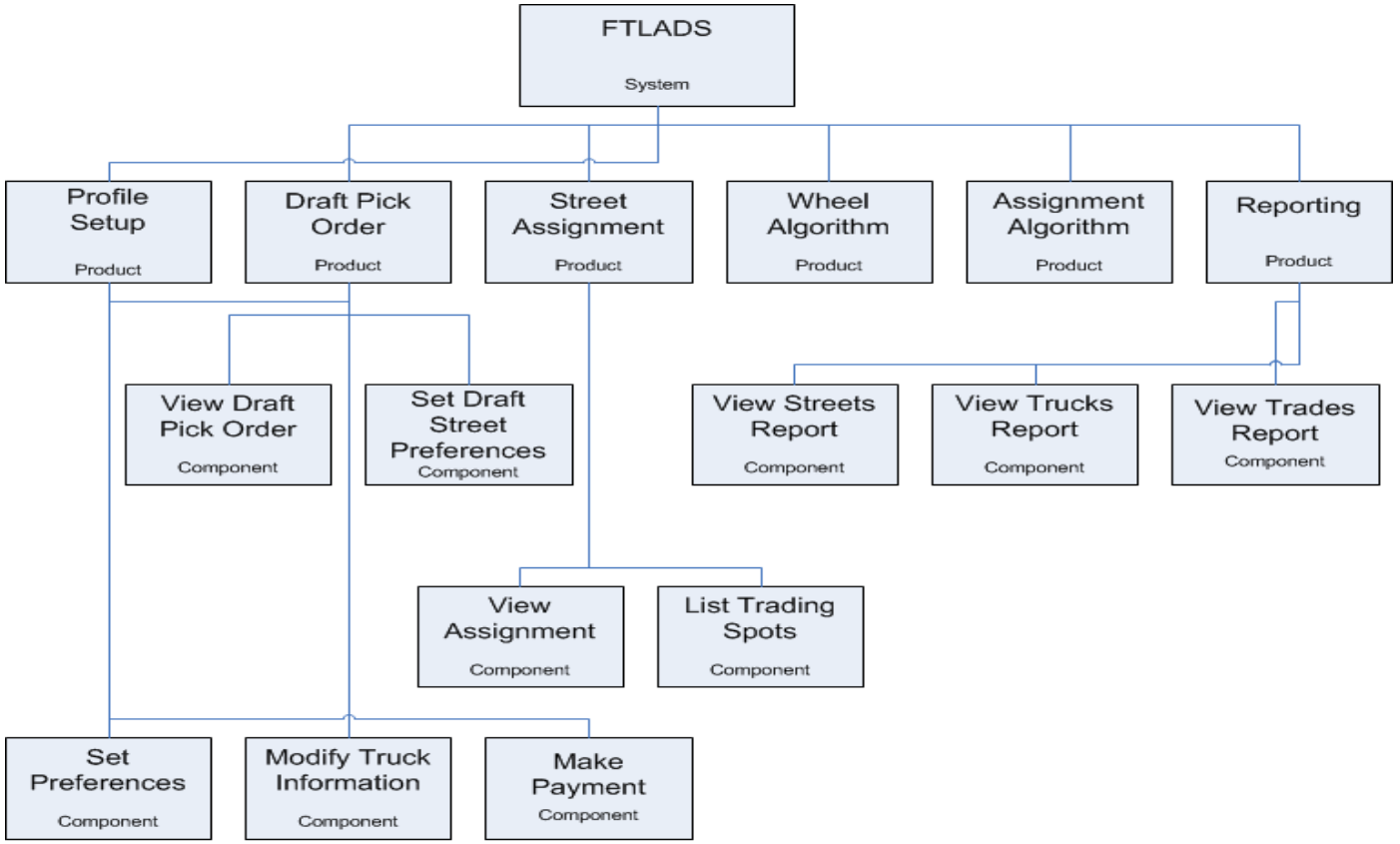


Object Model



FTLADS Object Model

System Architecture



FTLADS System Architecture