

Leisure and Tourism Data and Decision Analytics for Experience Management



Hoong Chuin LAU
Singapore Management University

Analytics for User's Dynamic Experience in Leisure and Tourism

- YouTube Link
 - <http://youtu.be/v8NM6E96s1g>

Overview

Partner:



Research:



Our Research Playground 1



- Universal Studios Singapore (USS) welcomed its 10 millionth visitor in Apr 2013[^]
- USS drawing an average 9,500 visitors daily*
- USS consists of 7 Zones with more than 20 attractions and shows, along with more than 30 F&B outlets and Merchandise shops

*- Based on Genting Singapore's Annual Report 2012

[^] - Extracted from Straits Times – Universal Studios Singapore Hits 10 Million Visitor Mark dated 18 Apr 2013

Motivation

- Visitor's Perspective:
 - Dynamic Guidance (experience maximization)

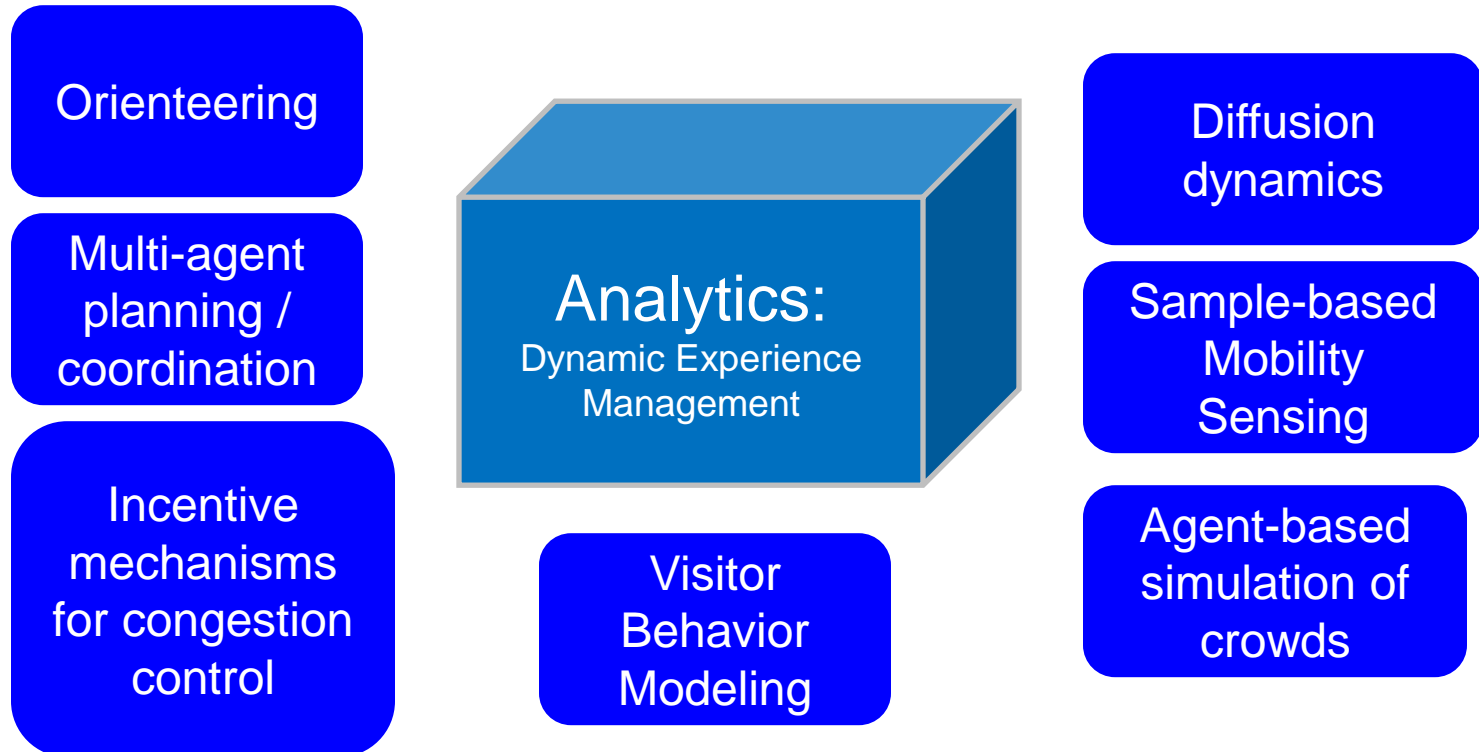


- Operator's Perspective:
 - Crowd Coordination (better facility utilization)

Research Overview

Data: Attraction wait times, visitor trajectories from ground surveys

Theme: Experience management via real time tracking, route guidance and incentive-based coordination in a dynamic network environment



Real-time Guidance and Intervention



Visitor Personal Info

Real-time Ride Status,
Queue Times,
Show Schedules



Replanning

Home Attraction **Monitoring** Intervention Weather Setting

Home > Attraction > Queue Wait-Time Monitoring

Name: TRANSFORMERS The Ride: THE ULTIMATE 3D BATTLE

Intervention

Attraction : TRANSFORMERS The Ride: THE ULTIMATE 3D BATTLE

Current Intervention Status :

Action :

StartTime : to

Attraction Operational Statistics

Total In Operation Time : 173 mins (100.00%)

Total Attraction Down Time :

- Closed : 0 mins (0.00%)
- Incident Weather : 0 mins (0.00%)
- Maintenance : 0 mins (0.00%)

Time Statistics

35 mins

~ / 120 mins

Wait-Time Statistics

31 mins

5 mins / 50 mins

Queue Statistics

12 mins

5 mins / 50 mins

Next Statistics

12 mins

5 mins / 50 mins

Current Status

Current Queue Wait-Time : 10 mins

Average Queue Wait-Time : 18 mins

Min/Max Queue Wait-Time : 5 mins / 30 mins

Operational Status : On Operation 173 mins

Intervention Status : Normal

Last Updated: 6/15/2013 12:58:00 PM



Operator Monitoring and Intervention

Full Itinerary

Recommended Time: 12:30 PM

- Donkey LIVE**
Show starts at 1:00 PM
- Accelerator®**
Recommended Time: 1:30 PM
- TRANSFORMERS The Ride: THE ULTIMATE 3D BATTLE**
Recommended Time: 1:45 PM
- Sesame Street Spaghetti Space Chase**
Recommended Time: 2:00 PM
- WaterWorld™**
Show starts at 3:30 PM

Next Attraction

Sci-Fi City™

Accelerator®
Reward: 500 Points

Wait Time : 5 min

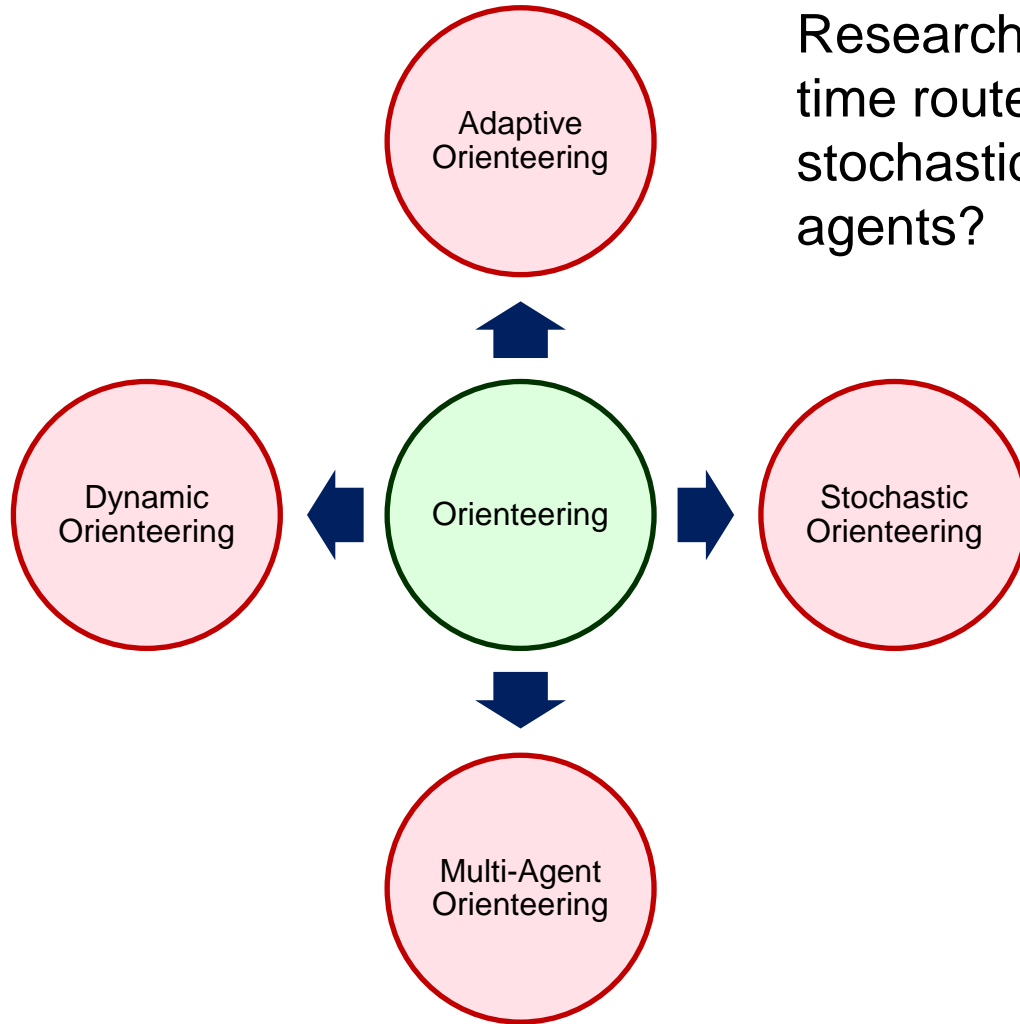
Recommended Time : 1:40 PM

Next Up

- WaterWorld™**
Show starts at 3:30 PM
- Sesame Street Spaghetti Space Chase**

Real-time visitor guidance and incentives

Orienteering



Research Question: How to provide real-time route guidance in a dynamic and stochastic environment involving multiple agents?

H. C. Lau, W. Yeoh, P. Varakanham. Dynamic Stochastic Orienteering Problems for Risk-Aware Applications. Conf. on Uncertainty in AI (UAI), August 2012.

P. Varakantham and K. Akshat. Chance-constrained Stochastic Orienteering Problem. Algorithmic Decision Theory (ADT), November 2013.

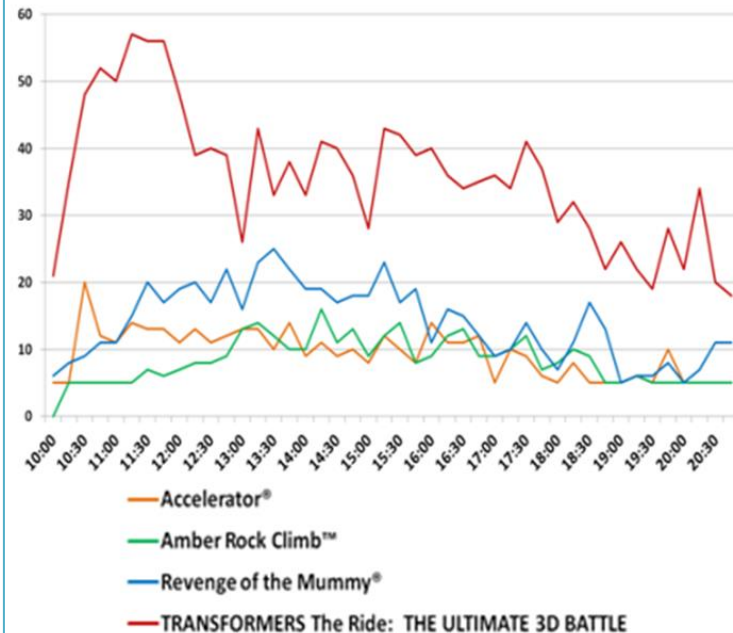
Chen Cen, S. F. Cheng, and H. C. Lau. Multi-Agent Orienteering Problem. Web Intelligence and Agent Systems Journal. Conditionally Accepted.

Incentives for Congestion Smoothing

Research Question: Given

- Agents and their Utility Functions
- Resources
- **Budget (incentives)**
- **Desired Resource Congestion Thresholds**

Find **Nash Equilibrium** (allocation of incentives to agents at different time points) that meets **desired congestion thresholds**

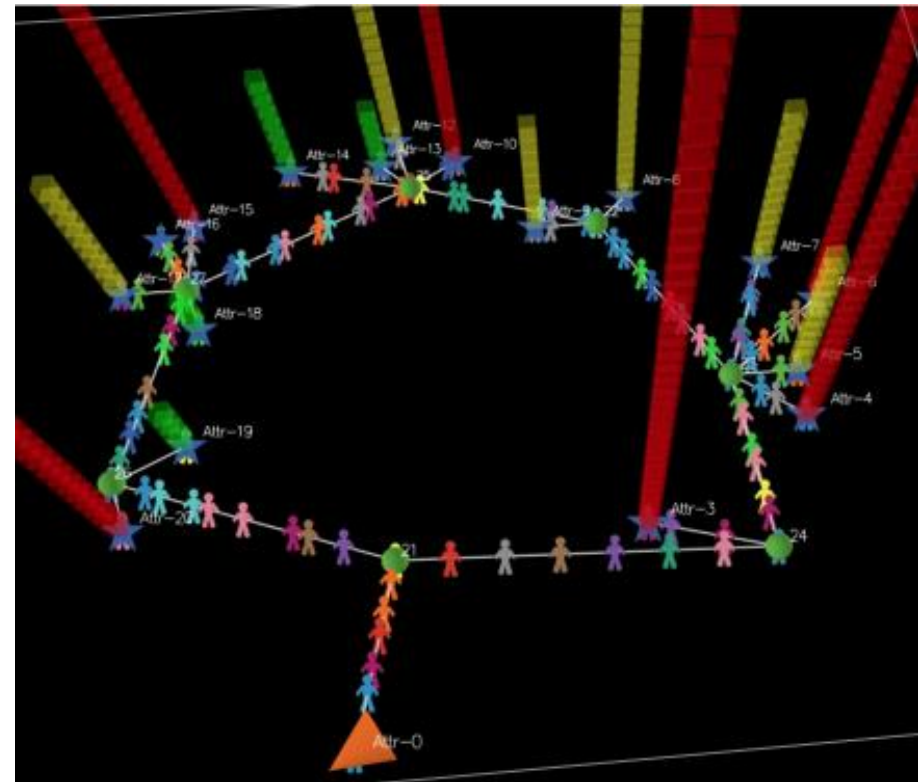
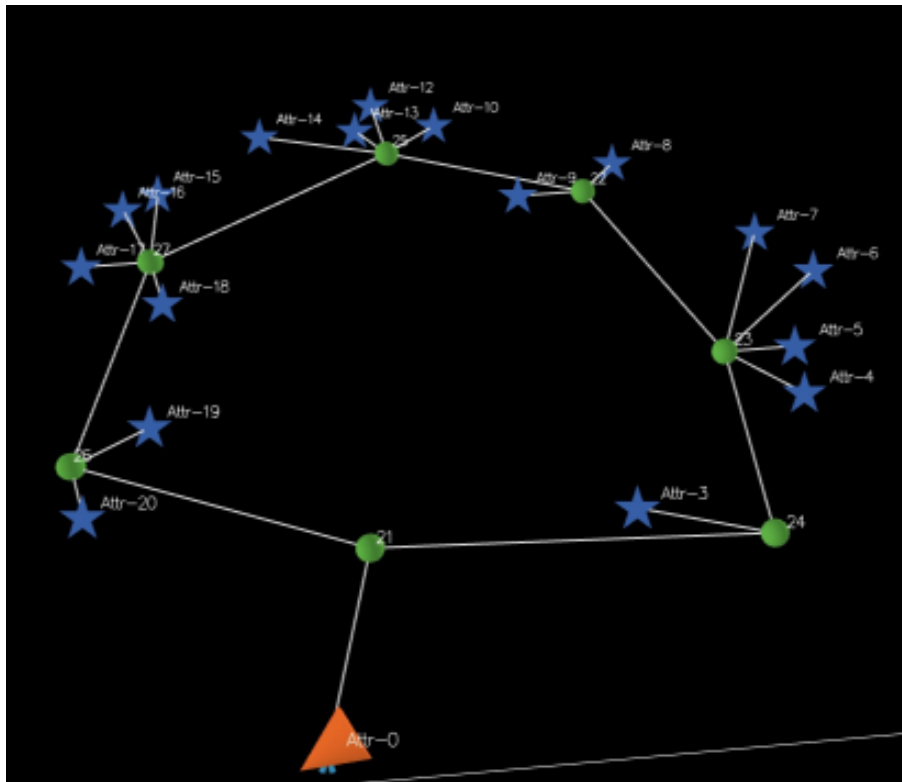


G. Gordon, P. Varakantham, W. Yeoh, H. C. Lau, A. Aravamudhan and S. F. Cheng. "Lagrangian Relaxation for Large-Scale Multi-Agent Planning". International Conference on Autonomous Agents and Multiagent Systems (AAMAS), May 2012.

P. Varakantham, N. Fu, W. Yeoh, S. Cheng and H. C. Lau. Budgeted Personalized Incentive Approaches for Smoothing Out Congestion in Resource Networks. Algorithmic Decision Theory (ADT), November 2013.

Agent-based Simulation

- Features:
 - Populated with 10,000 visitor agents with preferences.



S.-F. Cheng, L. Lin, J. Du, H. C. Lau, and P. Varakantham. An Agent-Based Simulation Approach to Experience Management in Theme Parks. Winter Simulation Conference (WSC), December 2013.

Our Research Playground 2



Motivation

- Visitor's Perspective:
 - Dynamic Guidance (experience maximization)
- Operator's Perspective:
 - Bundle design (revenue management)

DAY PLAY PASS		CHOICE PLAY PASS	
Play up to 16 attractions! Valid for 1 day from 9am – 7pm [^]		Play 4 out of 16 attractions! Valid for 1 day from 9am – 7pm [^]	
ADULT \$69.90 (U.P. \$212.90)	CHILD \$53.90 (U.P. \$187.90)	ADULT \$44.90 (U.P. \$75.00)	CHILD \$38.90 (U.P. \$63.00)

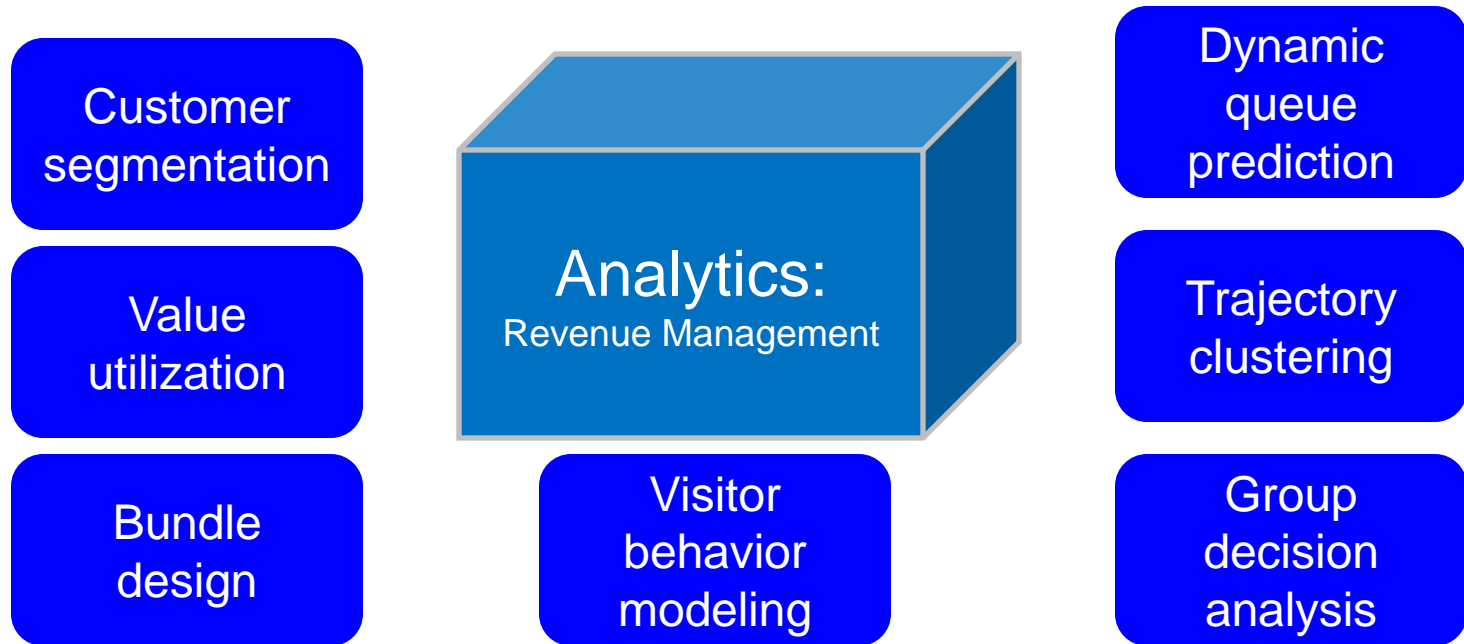
Attractions included in the passes:

- 4D AdventureLand: Desperados in 4D (Last Entry 7PM)
- 4D AdventureLand: Extreme Log Ride (Last Entry 7PM)
- 4D AdventureLand: Journey 2: The Mysterious Island (Last Entry 7PM)
- Bi-Pedal Bicycle (1 Hour) (Last Rental 7PM)
- Butterfly Park & Insect Kingdom (Last Entry 8:30PM)
- Fort Sisoa Combat Skirmish: Indoor Maze (Last Entry 8:30PM)
- Images of Singapore (Last Entry 8:30PM)
- MegaBounce (Last Bounce 8:05PM)
- Port of Lost Wonder (For child 12 and below) (Last Entry 8PM)
- Segway Fun Ride (Last Ride 7PM)
- Singapore Cable Car (Board at Imbiah only) (Last Boarding 7PM)
- Skyline Luge Sentosa (1 Luge & 1 Skyride) (Last Ride 7PM)
- The Flying Trapeze (Last Swing 6PM 06:00-Thu 8:30PM (Weekends & Pk))
- Sentosa Merlion (Last Entry 7PM)
- Tiger Sky Tower (Last Entry 7PM)
- Wave House Sentosa - Catch-A-Wave (1 Try) (Last Entry 7PM)

Research Overview

Data: Playpass redemption records

Theme: revenue management through better understanding of consumer behaviour and market segmentation

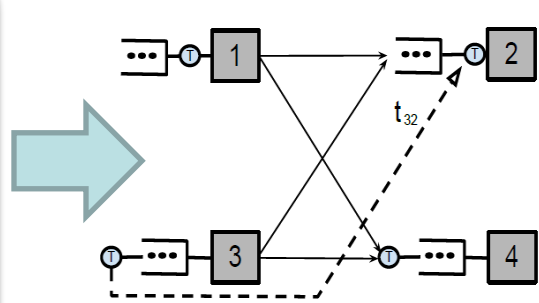


Dynamic Queue Prediction

Scope of Work

- Using Playpass data entry times to *infer* "queuing delays" at different attractions.
- Depart from classical queuing theory approach and provide a data-driven and online approach for estimating the time-varying queuing delays experienced at different attractions in a theme park
- Modeled via a statistical technique of Expectation Maximization (EM) applied to a "network" problem

Key Idea



Problem modeled as heterogeneous network of "queues"

$$\begin{pmatrix} 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 \\ 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 \end{pmatrix} \begin{pmatrix} q_1 \\ q_2 \\ q_3 \\ q_4 \\ \tilde{d} \end{pmatrix} = \begin{pmatrix} \tilde{t}_{12} \\ \tilde{t}_{13} \\ \tilde{t}_{14} \\ \tilde{t}_{21} \\ \tilde{t}_{23} \\ \tilde{t}_{24} \\ \tilde{t}_{31} \\ \tilde{t}_{32} \\ \tilde{t}_{34} \\ \tilde{t}_{41} \\ \tilde{t}_{42} \\ \tilde{t}_{43} \end{pmatrix}$$

"Mixture model" solved by a novel combination of EM+ linear regression

Outcome

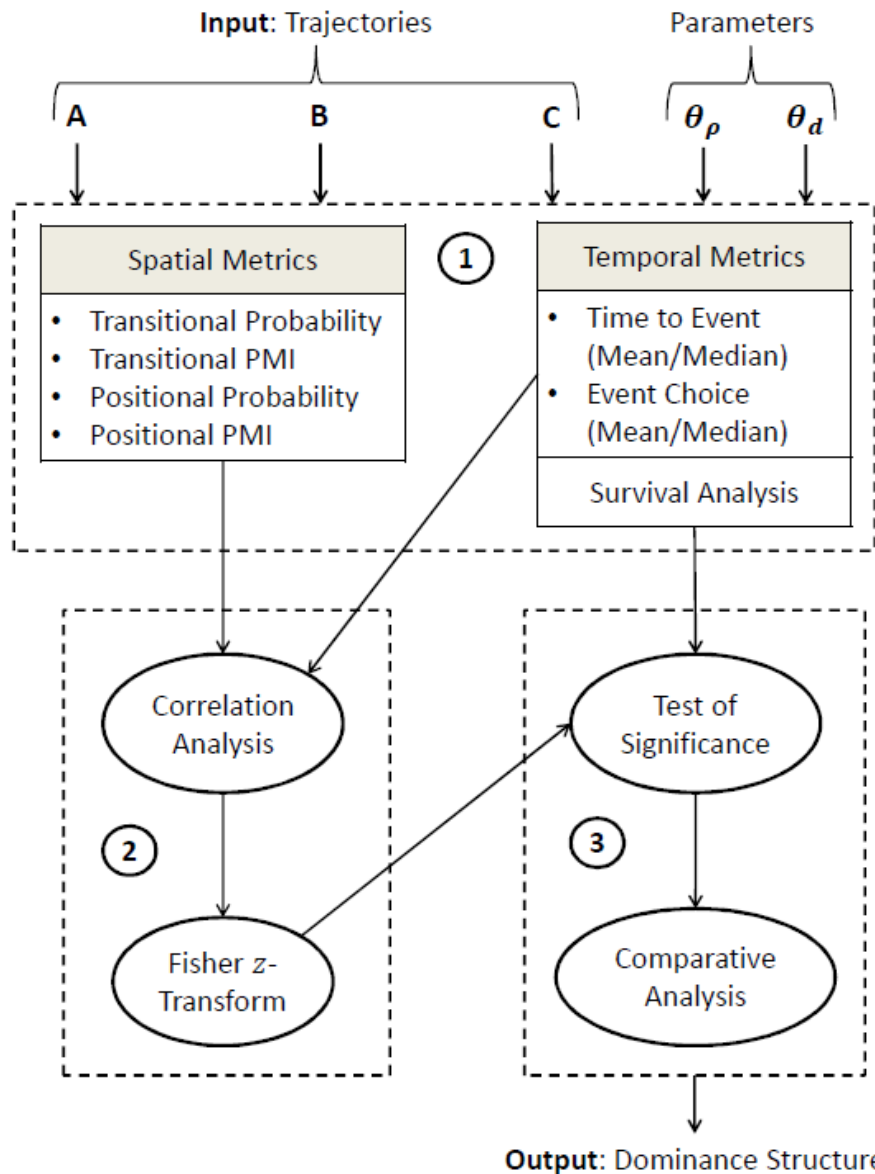
Experiments on simulated network data shows that our approach can predict queuing delays with estimation errors of less than 10% for queues with medium to long delays.

Variable	Mean Delay	30%-70%	50%-50%	70%-30%
q_1	4.00	3.67	3.88	4.24
q_2	8.00	6.56	8.15	9.14
q_3	12.00	10.67	12.19	13.27
q_4	16.00	14.56	15.92	17.69
q_5	20.00	17.61	20.07	22.02
q_6	24.00	21.79	24.07	26.16
d_1	15.00	15.59	14.86	16.01
d_2	35.00	34.04	34.96	34.64

TABLE VI: Effect of change in mixture composition (ratio of $d_1 : d_2$ observations) on queuing delay estimates

A. Aravamudhan, A. Misra and H. C. Lau. "Network-Theoretic" Queuing Delay Estimation in Theme Park Attractions. IEEE Conf. on Automation Science & Engineering, 2013.

Group Decision Analysis



• **Input:** *Trajectories* of different group types

• **Scope of work:** Compare each type's influence on the decision outcomes based on a number of spatio-temporal criteria. Comparisons are aggregated into a final score to make inference.

Outcome: Adult is the dominant decision-maker in the Family groups

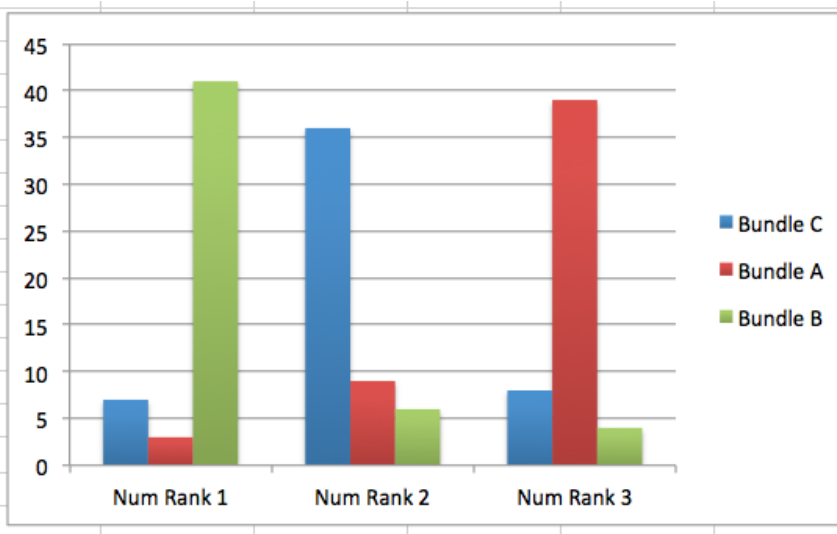
T. Le, S. Liu, H. C. Lau, and R. Krishnan. A Quantitative Analysis of Decision Process in Social Groups Using Human Trajectories. International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 2014.

Bundle Design Optimization

- Problem: Select K items from a set of N based on customer profile that maximizes Expected Revenue while keeping bundle attractive
- Stochastic Interacting Knapsack Problem: p_i and w_i are functions on the selected bundle

• Outcome:

Bundle A	a	
Num Rank 1	Num Rank 2	Num Rank 3
3	9	39
Bundle B	b	
Num Rank 1	Num Rank 2	Num Rank 3
41	6	4
Bundle C	c	
Num Rank 1	Num Rank 2	Num Rank 3
7	36	8
Ground Truth		
Bundle A	Bundle B	Bundle C
3	1	2



H. Nguyen, P. Varakantham, H. C. Lau and S. F. Cheng. Heuristics for Generalized Knapsack with Application to Theme Park Revenue Management. Metaheuristics International Conf. (MIC), 2013.



Tools Developed

Agent-based Simulation Model



Visitor Tracking and Heatmap

LARC Participant Monitor

Controllers

- Get Distinct List of All Participants
- Get Last Known Positions of All Participants
- Who will we focus on?
- Get Participant Location History
- Get Participant Activity History
- Get Audit Log

Data

S/N	Device ID	Push Notification Token	Latitude	Longitude	Time
1	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:34:14 PM
2	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:35:08 PM
3	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:36:09 PM
4	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:37:08 PM
5	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:38:10 PM
6	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:39:08 PM
7	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:40:09 PM
8	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:41:09 PM
9	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:42:09 PM
10	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:43:09 PM
11	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:44:09 PM
12	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:45:09 PM
13	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:46:09 PM
14	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255873	103.82209	3/11/2014 5:47:09 PM
15	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.255448	103.82227	3/11/2014 5:48:09 PM
16	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	1.254461	103.82132	3/11/2014 5:49:09 PM
17	android@testing.com	d9eeb0c-b519-44cd-9ee0-87b51ee334c	0.924193	103.92927	3/11/2014 5:50:09 PM

GPS Track Plot

GPS Location Data of Visitor

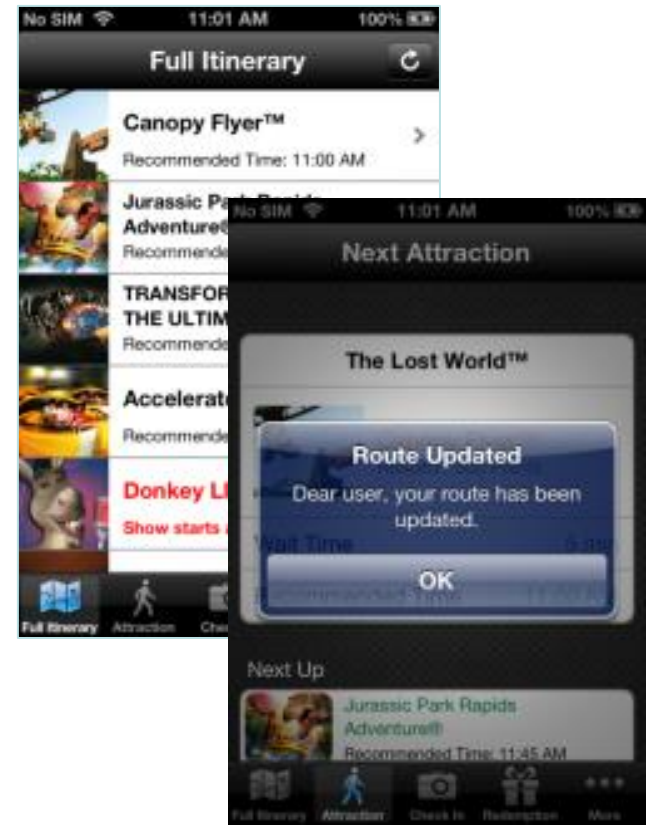


Tools Developed

Attraction Queue Monitoring & Intervention Portal (Web)

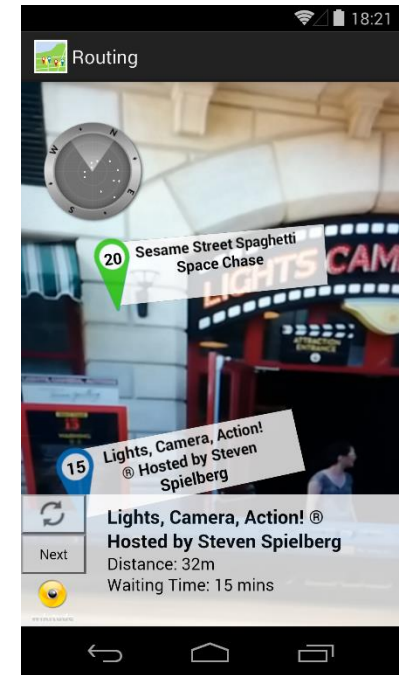
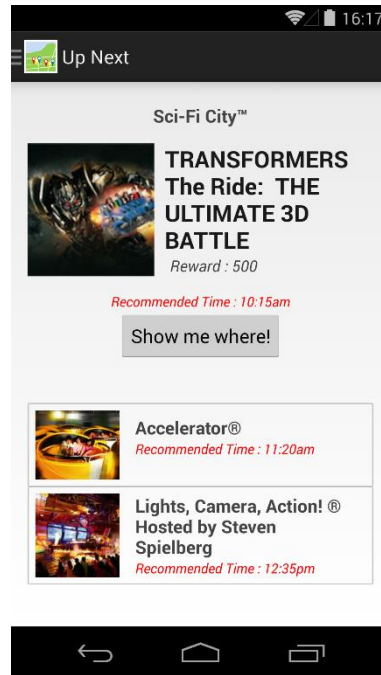
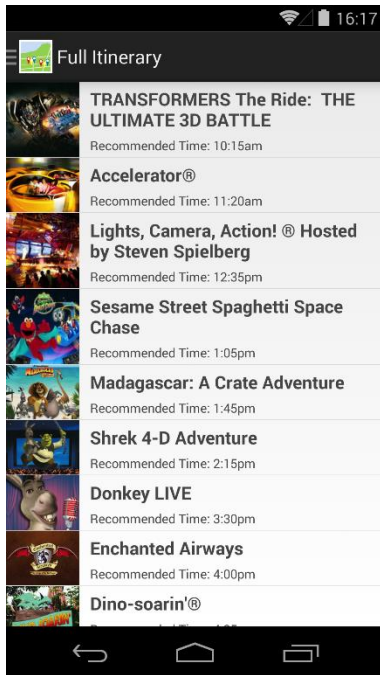


Personalized Dynamic Route Planning (iOS)



Tools Developed

Theme Park Navigation with Augmented Reality (Android)



Questions and Comments

Hoong Chuin LAU

Professor of Information Systems

Deputy Director, Living Analytics Research Center

Singapore Management University

<http://www.mysmu.edu/faculty/hclau>