Using Smart-Phone Tracking Data to Predict and Reduce Delays in Airport Terminals

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Agenda

- Background and Motivation
- Potential for Predictive Analytics in Airport Operations
- Using Predictive Analytics to Mitigate Congestion and Delay
- Summary

Predicting and Reducing Delays in Airport Terminals

Background and Motivation

What is predictive analytics?

- Area of statistical analysis that deals with extracting information from data and using it to predict trends and behavior patterns.
  - Utilizes a variety of techniques from statistics, modeling, machine learning, and data mining.
  - Applied to any type of unknown whether it be in the past, present or future.
  - Accuracy and usability of results depend greatly on the level of data analysis and the quality of assumptions.

Does predictive analytics really work?

"Companies that systematically apply predictive analytics to operational decisions, especially those pertaining to customers, outperform their competitors."

- James Taylor

CEO, Decision Management Solutions

Notable Non-Aviation Successes

- How did the grocery cashier know to hand you a coupon for the whole-grain cereal you will need to buy next week?
  - Computers crunched terabytes and terabytes of historical purchasing data to determine that your favorite whole-grain cereal was missing from your shopping basket.
  - Further, the computer matches this finding to the ongoing promotions in the store, and determines that you should receive a coupon.

Notable Aviation Successes

- Predicting success of pilot trainees… identifying best candidates and reducing training costs.
  - David Hunter and Eugene Burke, "Predicting Aircraft Pilot-Training Success: A Meta-Analysis of Published Research," International Journal of Aviation Psychology 4(4)297-313

Notable Aviation Successes

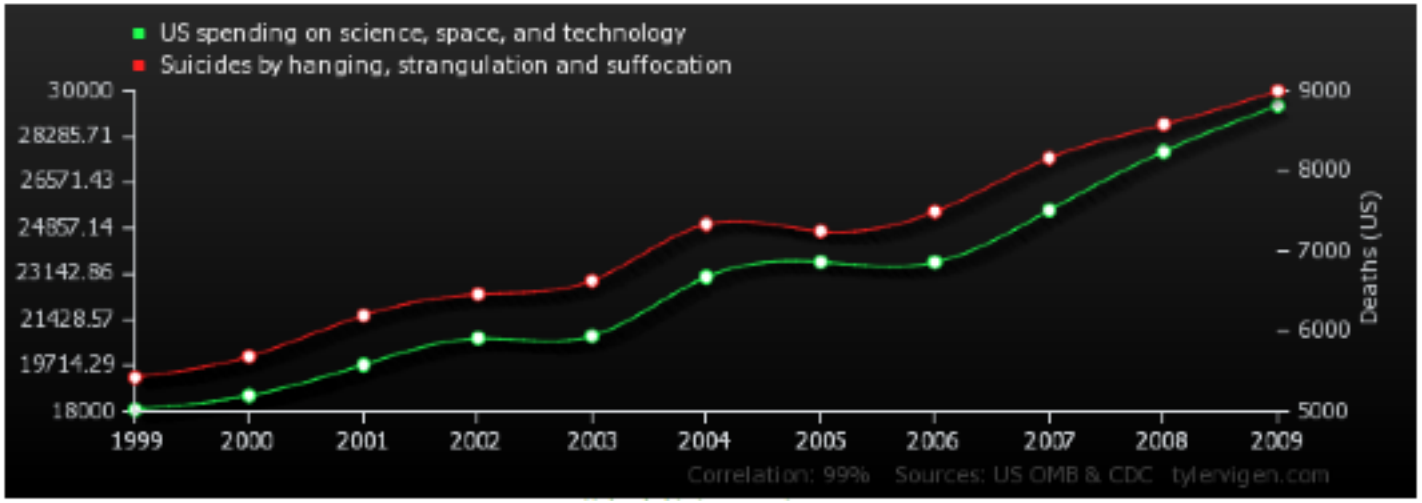
- Predicting parts failure… anticipating maintenance requirements.
  - Clockwork Solutions LLC, "Predictive Analytics in Aerospace and Defense: It's time Launching Modern Day Modeling and Simulation in the Defense Industry," 13 January 2013

Notable Aviation Successes (cont'd)

- Predicting the number of passengers who won't show up for a flight… reducing the number of overbooked flights and empty seats… increasing revenue and customer satisfaction.
  - Wayne Eckerson, "Predictive Analytics: Extending the Value of Your Data Warehousing Investment," TDWI Best Practices Report, 2007 Q1

A Word of Caution…

US spending on science, space, and technology
correlates with
Suicides by hanging, strangulation and suffocation



Correlation is NOT Causality!

US spending on science, space, and technology
correlates with
Suicides by hanging, strangulation and suffocation

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
US spending on science, space, and technology *Millions of todays dollars (US OMB)*	18,079	18,594	19,753	20,734	20,831	23,029	23,597	23,584	25,525	27,731	29,449
Suicides by hanging, strangulation and suffocation *Deaths (US) (CDC)*	5,427	5,688	6,198	6,462	6,635	7,336	7,248	7,491	8,161	8,578	9,000

Correlation:
0.992082

Predicting and Reducing Delays in Airport Terminals

Georgia Tech

Potential for Predictive Analytics in Airport Operations

Overview of Airport Operations

- Airports are the nodes of the air transportation system.
  - Capacity constraints and inefficiencies at airport entrances, parking, curbsides, security, immigration, customs, gates, ramps, runways are the primary drivers of congestion and delays.
- Passengers satisfaction is in large part governed by their experience at the airport.

Overview of Airport Operations (cont'd)

- Control of airport processes and procedures are distributed or shared between airlines, airport authorities, government, and third party suppliers.
  - No single entity able to predict consequences of decisions and initiate remedies.
- Critical need for a mechanism to predict the likely situation as well as the benefits / consequences of potential changes / decisions.

What are the right questions?

- From the passenger's viewpoint…
  - Why are there never enough ground / immigration / customs / check-in / security / gate personnel when I get there?

What are the right questions?

- From the provider's viewpoint…
  - Can we really improve airline and airport operations and enhance the passenger experience by modeling and predicting the movement of aircraft, baggage, and passengers and use our predictions to allocating resources (e.g. ground support equipment, staffing levels)?

What is the opportunity?

- Reality:
  - Airlines and airports collect a lot of data but mostly conduct retrospective analyses as opposed to using the data to predict what could happen and being proactive.

What is the opportunity?

- Hypothesis:
  - Significant operational benefits could be achieved by using data to predict where and when congestion and delay will occur and then using this information to re-allocate resources and mitigate potential congestion and delay.

Predicting and Reducing Delays in Airport Terminals

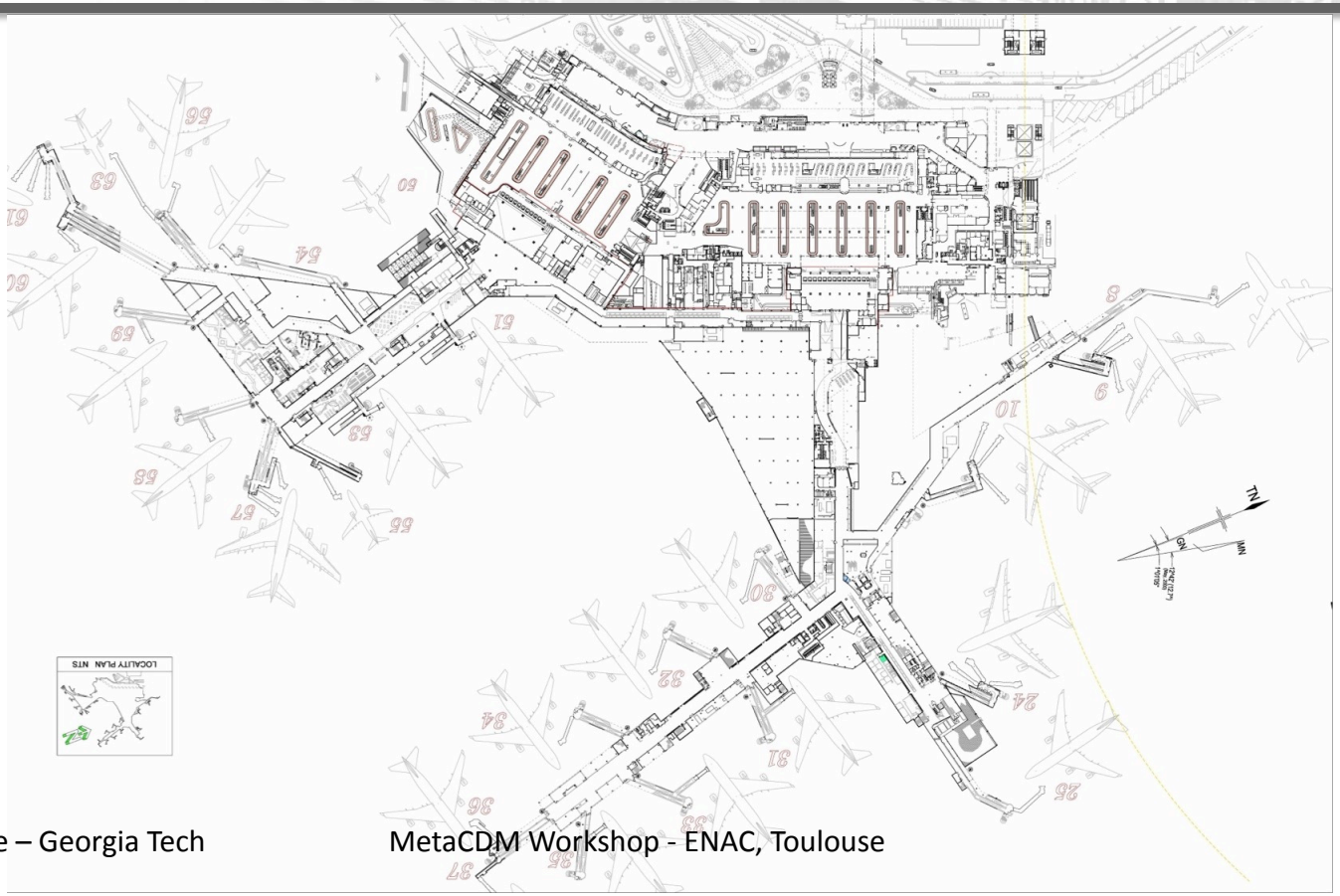
Using Predictive Analytics to Mitigate Delay – A Case Study of Sydney Airport

Case Study at Sydney Airport

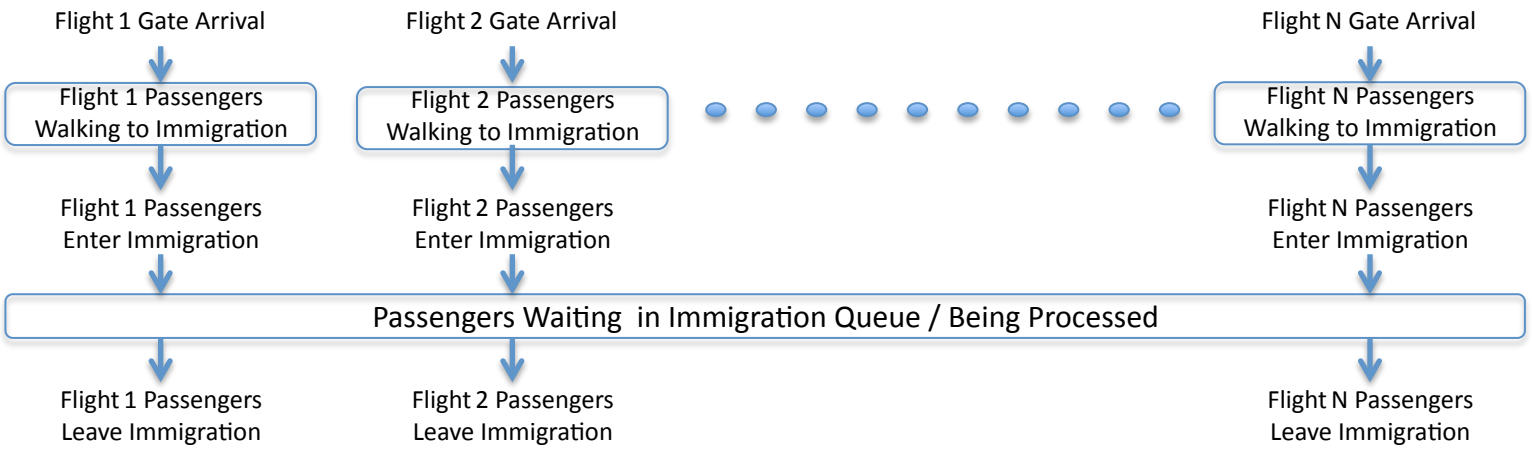
- Scenario:
  - Aircraft en route to Sydney but their estimated arrival times are off-schedule due to upstream factors.
- Questions:
  - Can we predict the queue sizes and delay in immigration for planned staffing levels?
  - How would these queue sizes and delay change if we changed the staffing levels?

Case Study at Sydney Airport

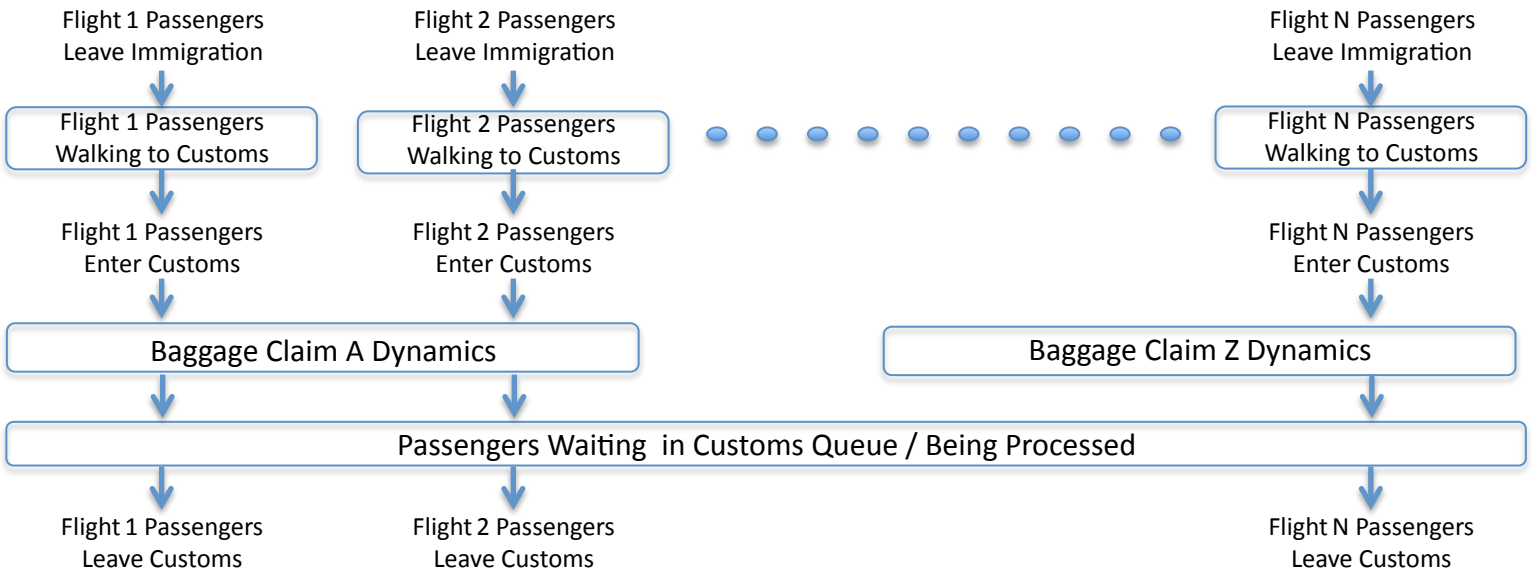
Sydney Airport Map



How should we model this scenario?



How should we model this scenario?



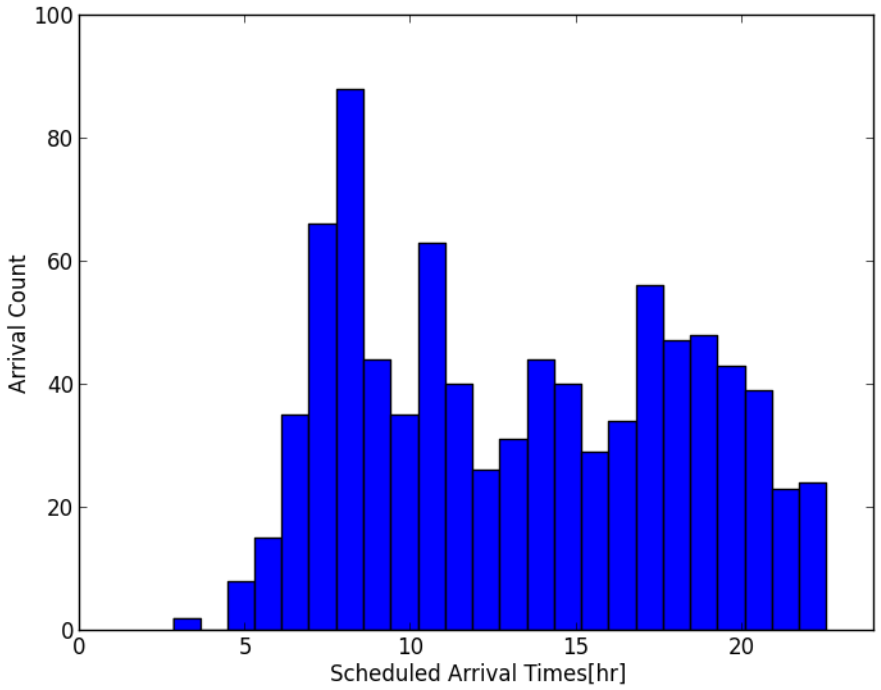
Model

- Service rate proportional to the number of open immigration desks
  - PDF for service rate per desk derived from historical data
- Passenger inter-arrival time (at immigration) dependent on predicted flight arrival time, flight-to-gate assignment, distance from gate to immigration
  - PDF for walk speed found to be more reliable than PDF for walk times

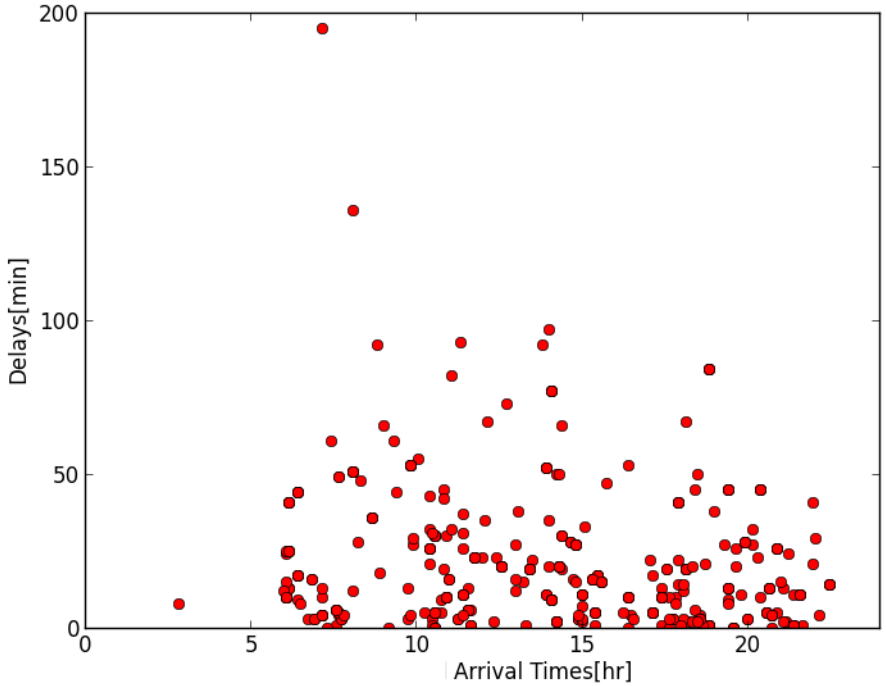
Data Available

- Data sources
  - FIDS flight information (Aug. 2012-Jan. 2013)
  - DIMIA passenger control time stamps (2012)
  - DWELL MAC address tracking* (2012)
- Data usage
  - FIDS -> predicted flight arrival times and gate assignments
  - DWELL -> number and attributes of passengers
  - Airport geometry + DWELL -> walk time
  - DIMIA -> service rate at immigration

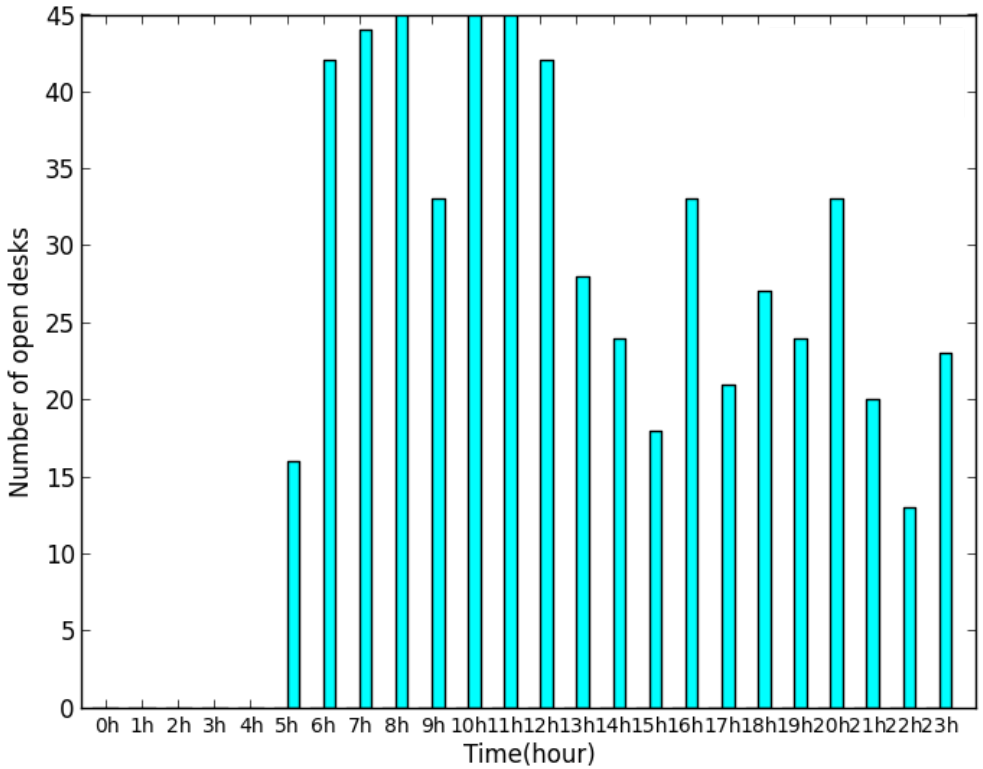
27 July 2012 – Arrival Schedule



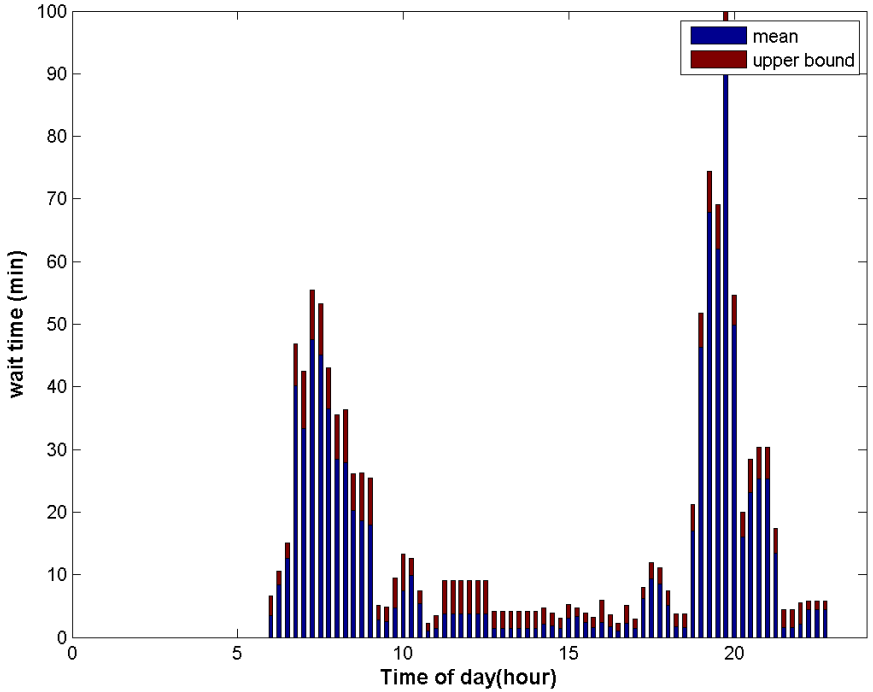
27 July 2012 – Flight Delays



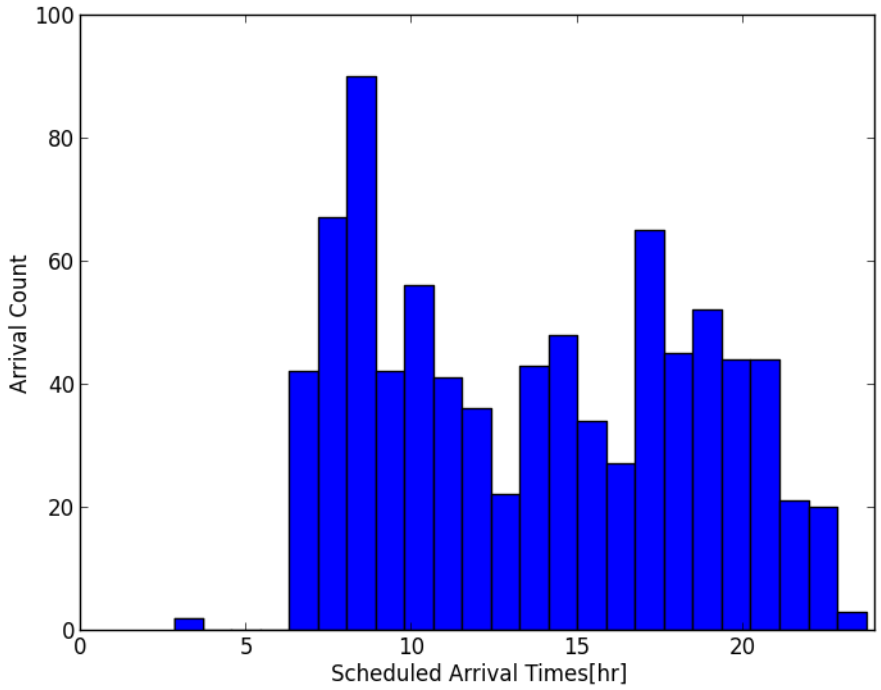
Nominal Staffing Schedule



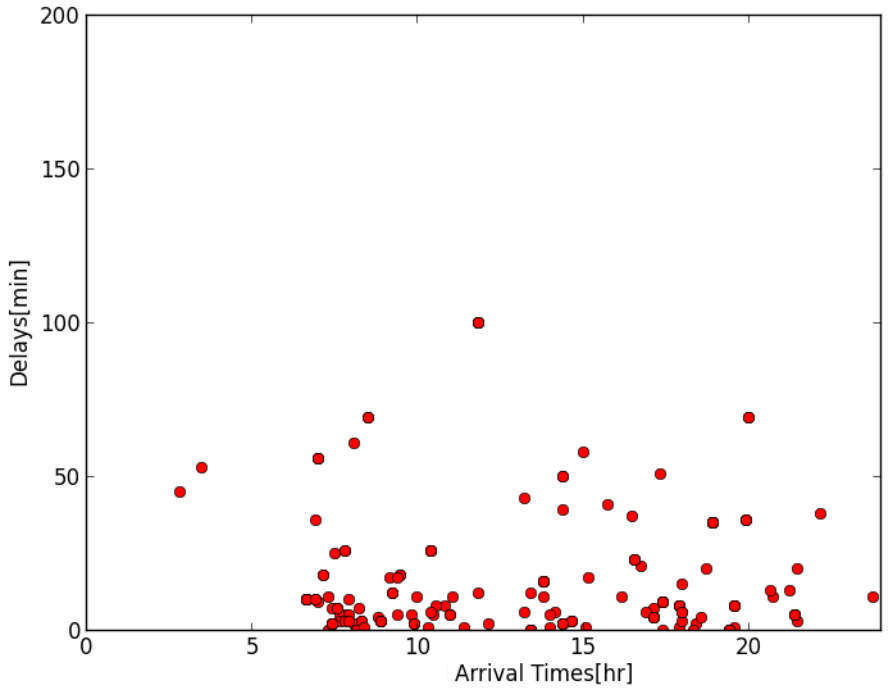
27 July 2012 – Wait Times



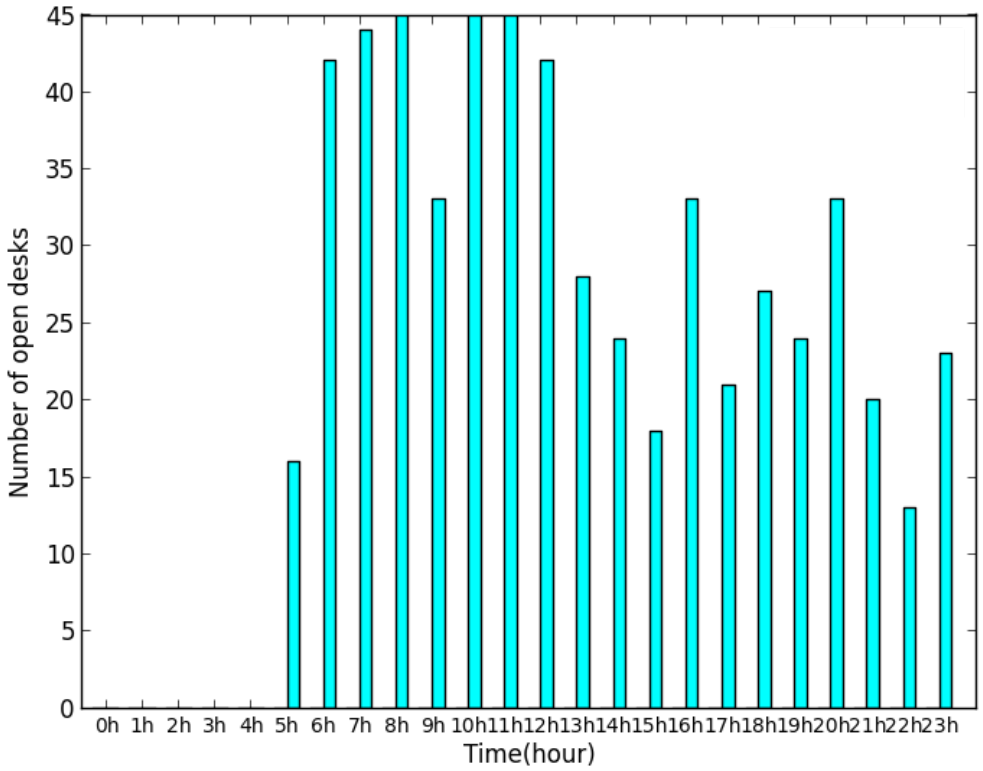
30 October 2012 – Arrival Schedule



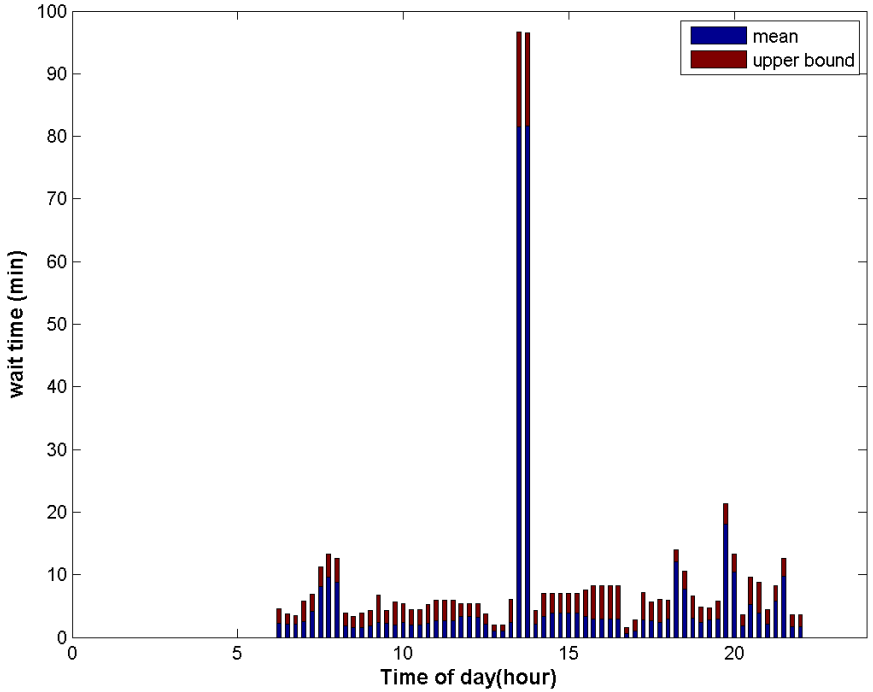
30 October 2012 - Flight Delays



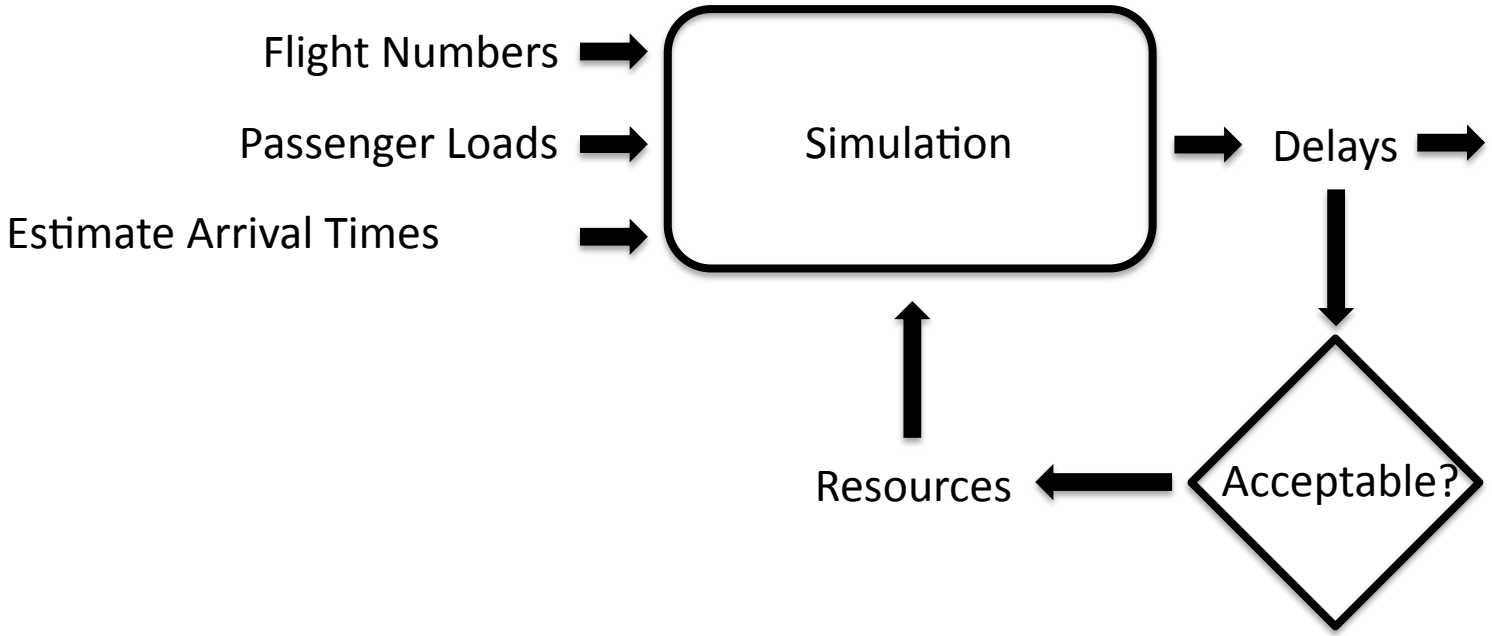
Nominal Staffing Schedule



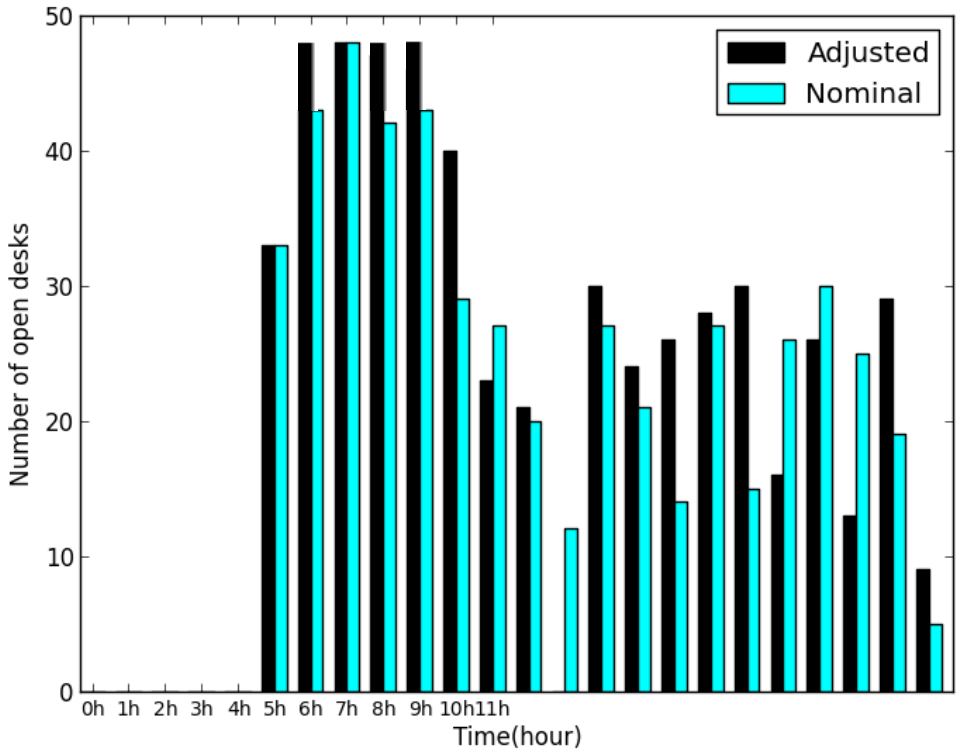
30 October 2012 – Wait Times



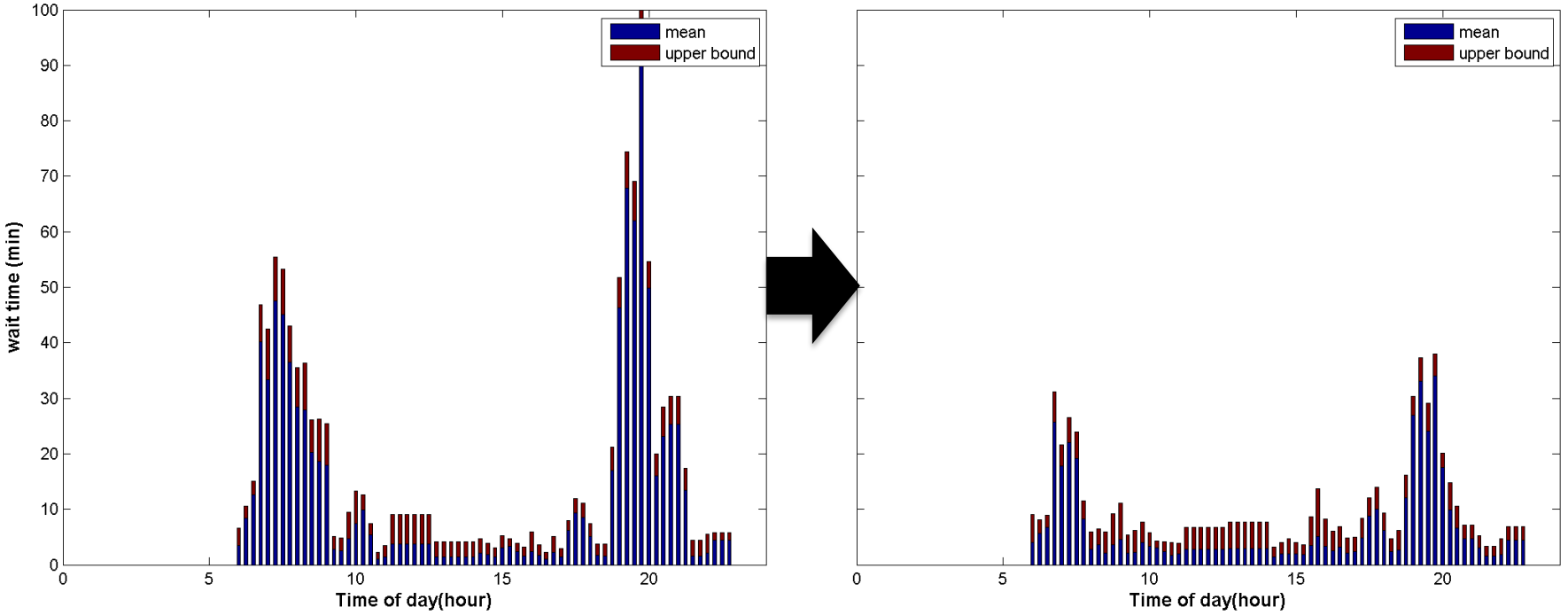
How do we mitigate delays?



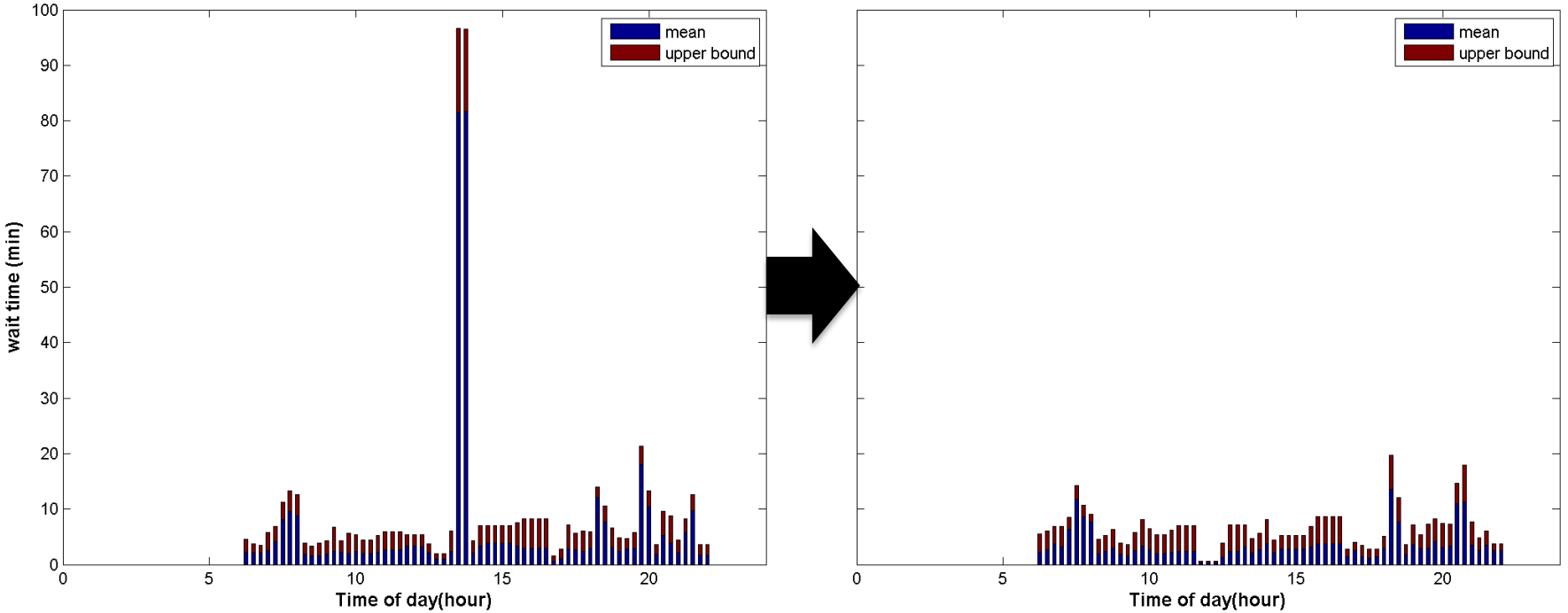
Adjusted Staffing Schedule



27 July 2012 – Adjusted Wait Times



30 October 2012 – Adjusted Wait Times



Predicting and Reducing Delays in Airport Terminals

Summary

Conclusions

- Predictive Analytics has been shown to be an important tool in pro-active decision-making.
- Our studies indicate that predictive analytics can improve airport operations.
  - Common prediction of bottlenecks and capability to explore effectiveness of possible remedies.

Conclusions (cont'd)

- Benefits of predictive analytics in optimizing check-in, security, outbound immigration staffing also investigated.
  - Similar benefits observed.
- Simulation framework can be easily extended.
  - e.g. Used to predict delay 5 weeks, 1 week, 1 day prior.
  - Certainty improves as "look-ahead" time decreases.

Possible Next Steps

- Develop “industrial strength” IT infrastructure and tools to enable use of predictive analytics in airport operations.
- Investigate use of predictive analytics in various other aspects of airport operations:
  - Ground support (under-wing) services;
  - Curbside, parking, etc.