

MEANS Overview

Presented June 10, 2002
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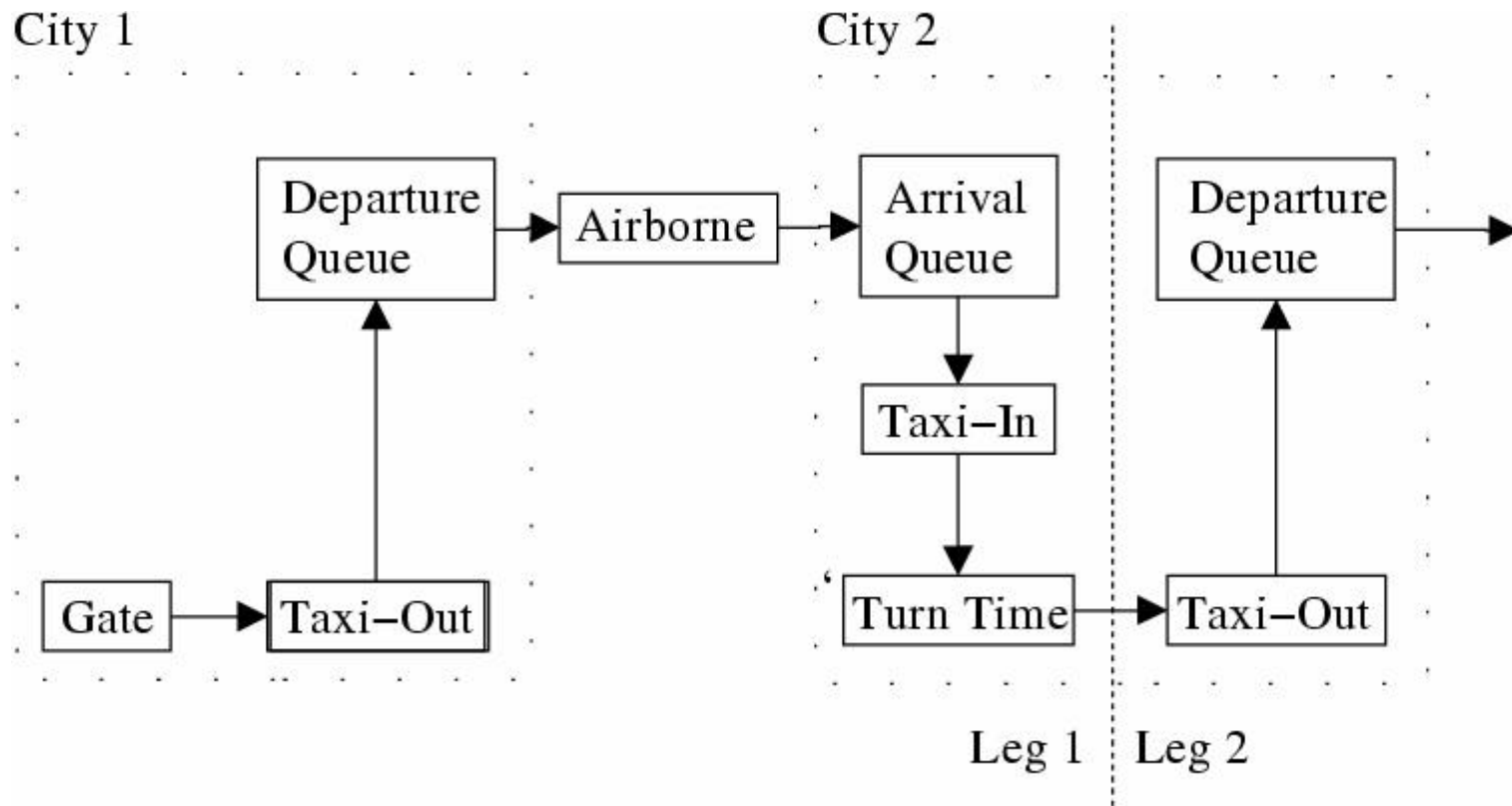
Background

- MIT Extensible Air Network Simulation development started at the beginning of 2001
 - Developed as a tool to evaluate ideas related to CDM, scheduling, disruption recovery, and other related fields
- Recently improvements include better GDP model, improved Pareto Frontier generation, manual AOC module

Overview

- MEANS is an event-based simulation
- Tracks aircraft through several states
 - Emphasis on ground-based effects
- Arrival and departure rates at airports are constrained
 - This produces delays which propagate throughout the system
- Used in past 1-day simulations; can be extended to work with longer runs

Flight States



Data Sources

- Schedule
 - ASQP database
 - CODAS ETMS database
- Airport Capacities
 - FAA Benchmark Report
 - Theoretical Generation
- Airborne, Taxi, Ground Times
 - Historical Data (ASQP)
- Weather
 - CODAS Weather database

Schedule

- ASQP data
 - Useful because it has tail numbers
 - Not complete
- ETMS data
 - Complete, but aggregate only
- ASQP data is used as a base, and "padded" with made-up flights to match the totals in the ETMS data

Capacities

- Capacities can be given in multiple ways
 - Exact arrival and departure rate, from historical information
 - Pareto Frontier, from theoretical calculations or fits to historical data
 - The operating point on the Pareto Frontier is chosen automatically based on anticipated demand
 - One of several Pareto Frontiers for a given airport can be selected based on weather and wind direction
- Pareto Frontier capacities are the principal focus

Implementation

- Modular design allows easy replacement of one component without changes to remainder of simulation
- Written in C++
 - Each component's interface specified in virtual base class
 - Example "trivial" component of each type provided
- Runs on standard Linux or Unix workstation
 - Run times are under two min per day simulated

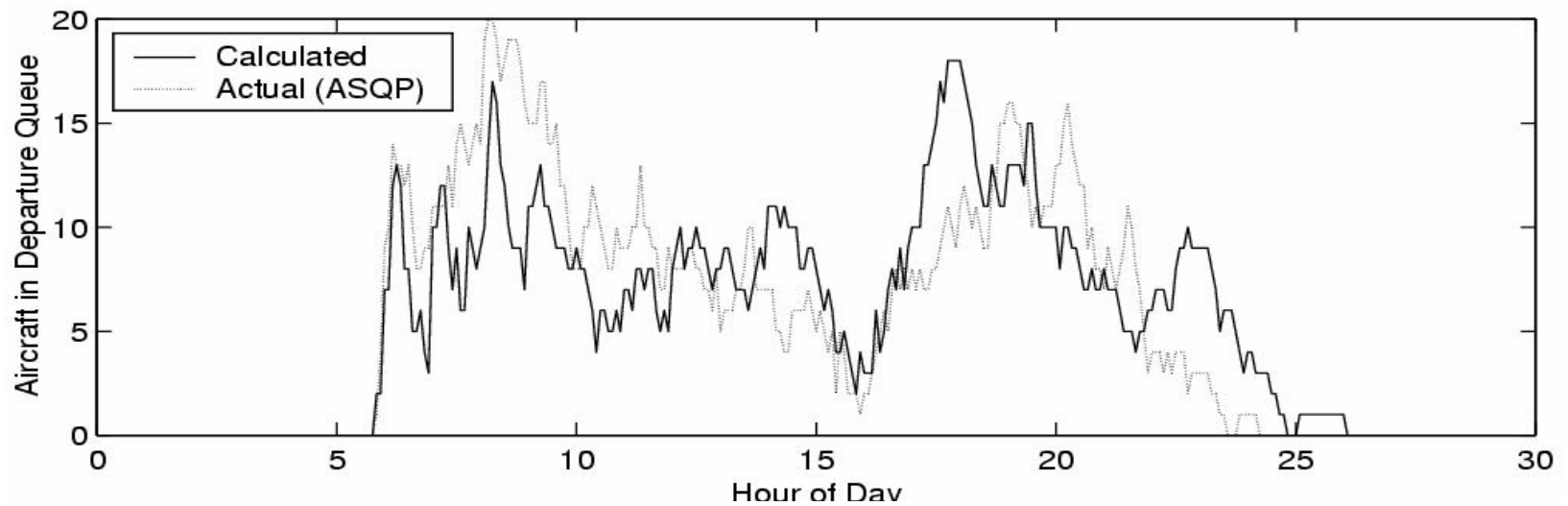
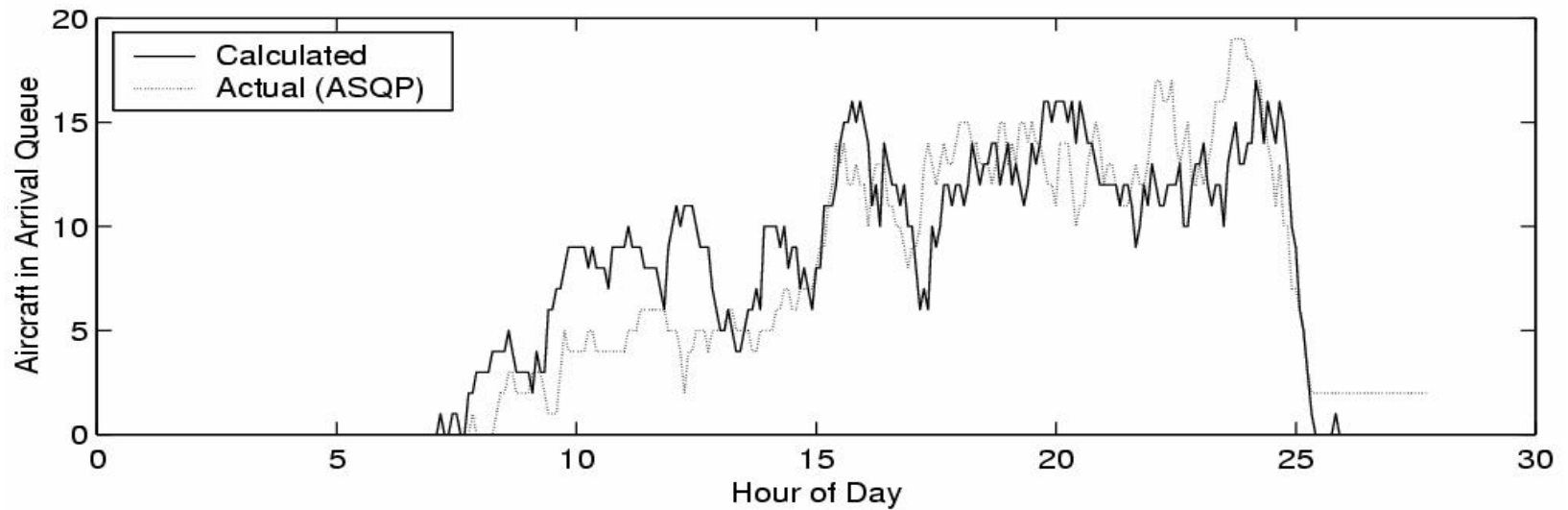
Ground Delay Programs

- GDP central to accurate model
 - Baseline GDP implemented with simplified Ration-by-Schedule algorithm with compression
 - Airline "agents" cancel and reschedule flights
 - GDP initiated automatically when predicted capacity falls short by specified amount
- Results for test days look good compared to historical data from ASQP

Results Available

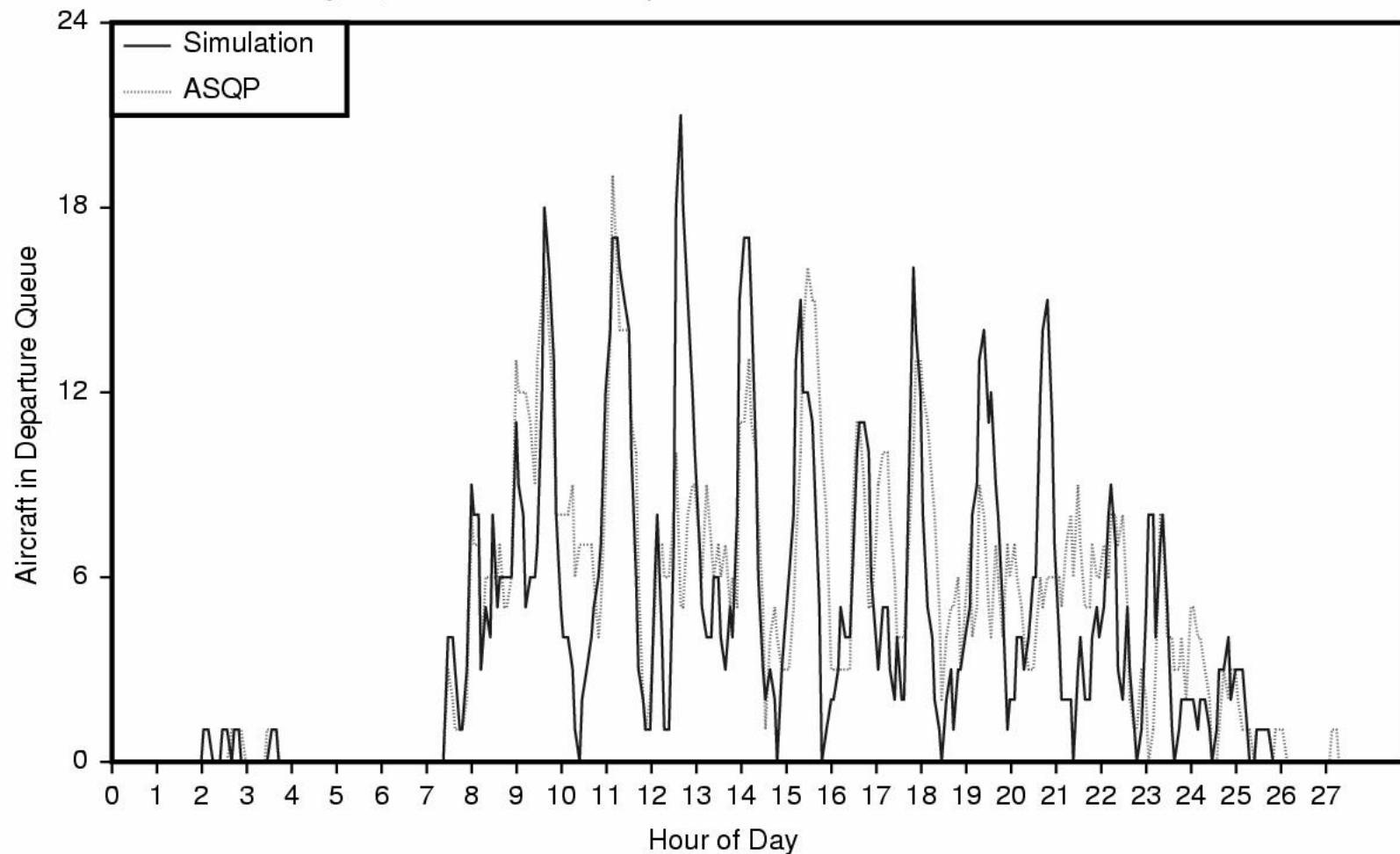
- Detailed results for every flight are produced
- Distilled statistics also available
 - Delay percentages/averages
 - Cancellations, expected missed connections
 - Direct delay cost to airlines in dollars
- Visualization tools allow examination of bank structure and tracking of delayed flights

Sample Results – GDP at Boston



Results – Peak Day at Phoenix

July 30, 1999 at PHX – Comparison of Simulation and Historical Data



Results – What If

- What if we cancelled 20% of the flights?

September 17, 1999

Total Systemwide Delay: 412223
Total Cancelled Flights: 0

carrier delay(min)

AA 29485
UA 28215
DL 25251
NW 21957
...

city delay(min)

LAX 54944
DFW 45049
MIA 32586
MSP 26974
DTW 21407
CVG 19833
ORD 18700
SEA 17125
STL 16851

September 17, 1999 minus 20%

Total Systemwide Delay: 181008
Total Cancelled Flights: 0

carrier delay(min)

DL 14528
NW 13889
UA 12190
AA 11121
...

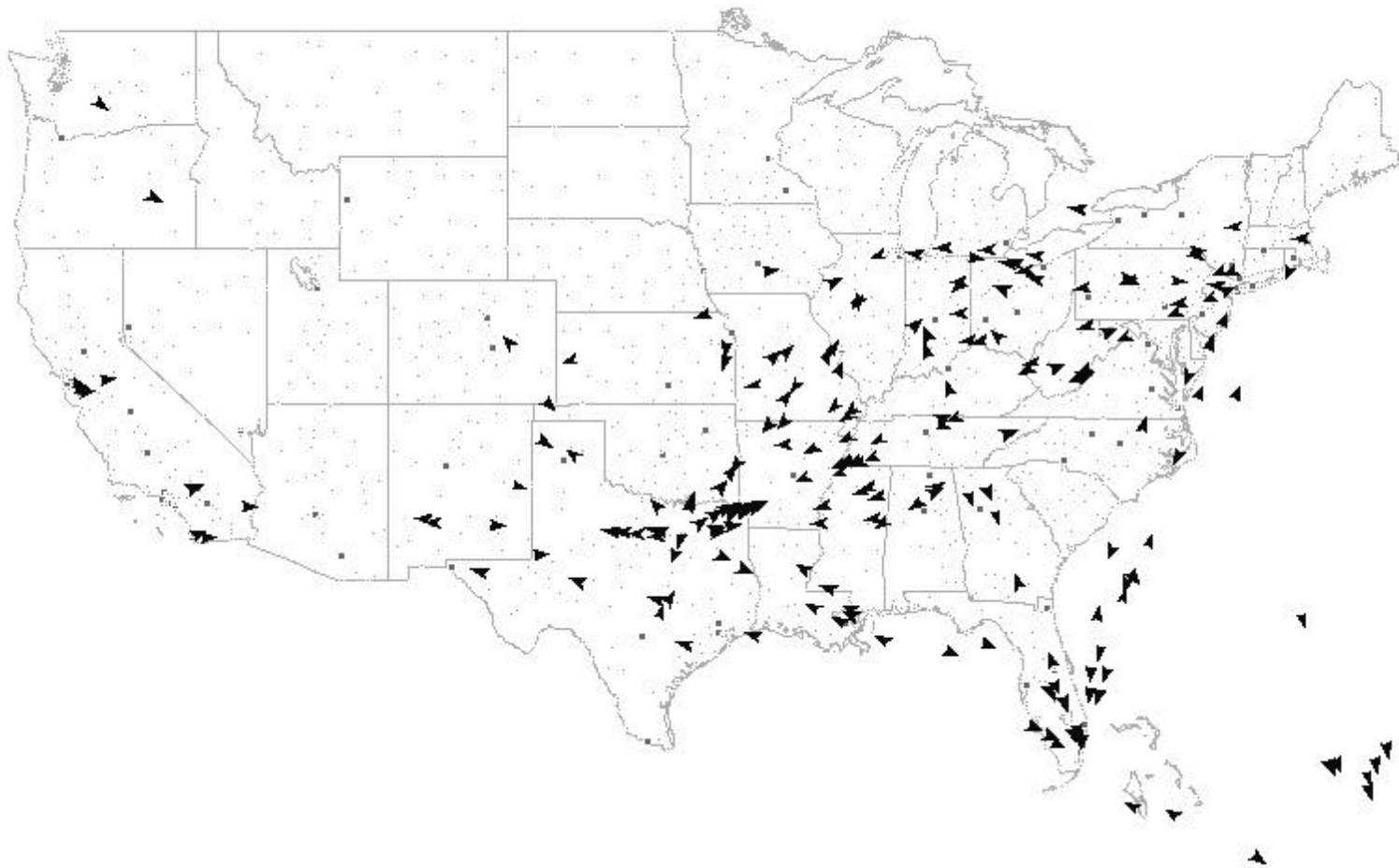
city delay(min)

MIA 15803
MSP 14323
DFW 12617
DTW 10762
CVG 10414
SEA 9157
STL 7757
ORD 7274
SFO 7184

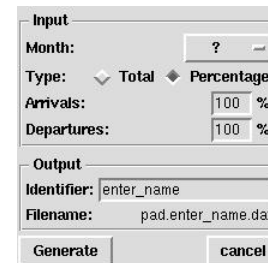
Visualization Example

Time of Day: 08:35 EST

Showing only AA.



Graphical Interface



- Previous command-line interface still available when desired

Present Work

- Continuing development of remote–module interface
 - Allows other sites to provide a module for MEANS without needing to release source code
 - Can also be used to let a human operate certain components as the simulation runs
 - Planned support for multiple protocols to maximize support

Present Work Cont'd

- Generation of Pareto Frontiers
 - Data in Benchmark Report is incomplete; doesn't allow for consideration of hypothetical futures
 - Development in progress of new program to theoretically calculate Pareto frontiers from known arrival/departure interaction
 - Looking at effect of maximum time that arrivals can be held on shape of frontier

Future Work

- Stochastic Modelling Framework
 - Develop framework to run MEANS repeatedly as a Monte Carlo simulation and collect results from each run
 - Develop tools to extract probability distributions of interesting parameters from these data
- Passenger model
- Improved AOC model