Network Revenue Management: O&D Control

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Background: Fare Class Control

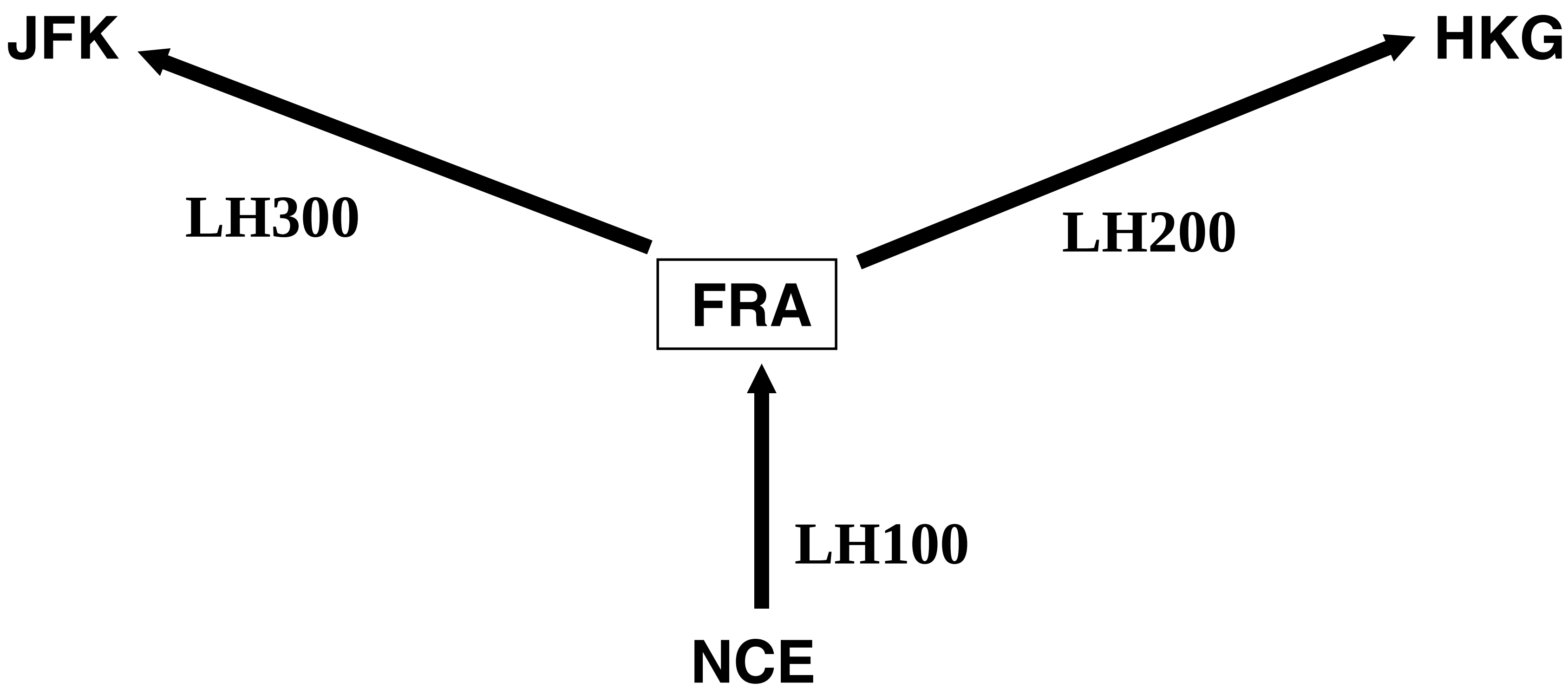
- **Majority of world airlines still practice "fare class control":**
  - High-yield ("full") fare types in top booking classes
  - Lower yield ("discount") fares in lower classes
  - Designed to maximize yields, not total revenues

- **Seats for connecting itineraries must be available in same class across all flight legs:**
  - Airline cannot distinguish among itineraries
  - "Bottleneck" legs can block long haul passengers

Yield-Based Fare Class Structure (Example)

BOOKING CLASS	FARE PRODUCT TYPE
Y	Unrestricted "full" fares
B	Discounted one-way fares
M	7-day advance purchase round-trip excursion fares
Q	14-day advance purchase round-trip excursion fares
V	21-day advance purchase or special promotional fares

O-D Control Example: Hub Network



Leg-Based Class Availability

FLIGHT LEG INVENTORIES

LH 100	NCE-FRA
CLASS	AVAILABLE
Y	32
B	18
M	0
Q	0
V	0

LH 200	FRA-HKG
CLASS	AVAILABLE
Y	142
B	118
M	97
Q	66
V	32

LH 300	FRA-JFK
CLASS	AVAILABLE
Y	51
B	39
M	28
Q	17
V	0

ITINERARY/FARE AVAILABILITY

NCE/FRA	LH 100	Y	B			
NCE/HKG	LH 100	Y	B			
	LH 200	Y	B	M	Q	V
NCE/JFK	LH 100	Y	B			
	LH 300	Y	B	M	Q	

Leg Class Control Does Not Maximize Total Network Revenues

(A) SEAT AVAILABILITY: **SHORT HAUL BLOCKS LONG HAUL**

NCE/FRA	
CLASS	FARE (OW)
Y	$450
B	$380
M	$225
Q	$165
V	$135

NCE/HKG	(via FRA)
CLASS	FARE (OW)
Y	$1415
B	$975
M	$770
Q	$590
V	$499

NCE/JFK	(via FRA)
CLASS	FARE (OW)
Y	$950
B	$710
M	$550
Q	$425
V	$325

(B) SEAT AVAILABILITY: **LOCAL VS. CONNECTING PASSENGERS**

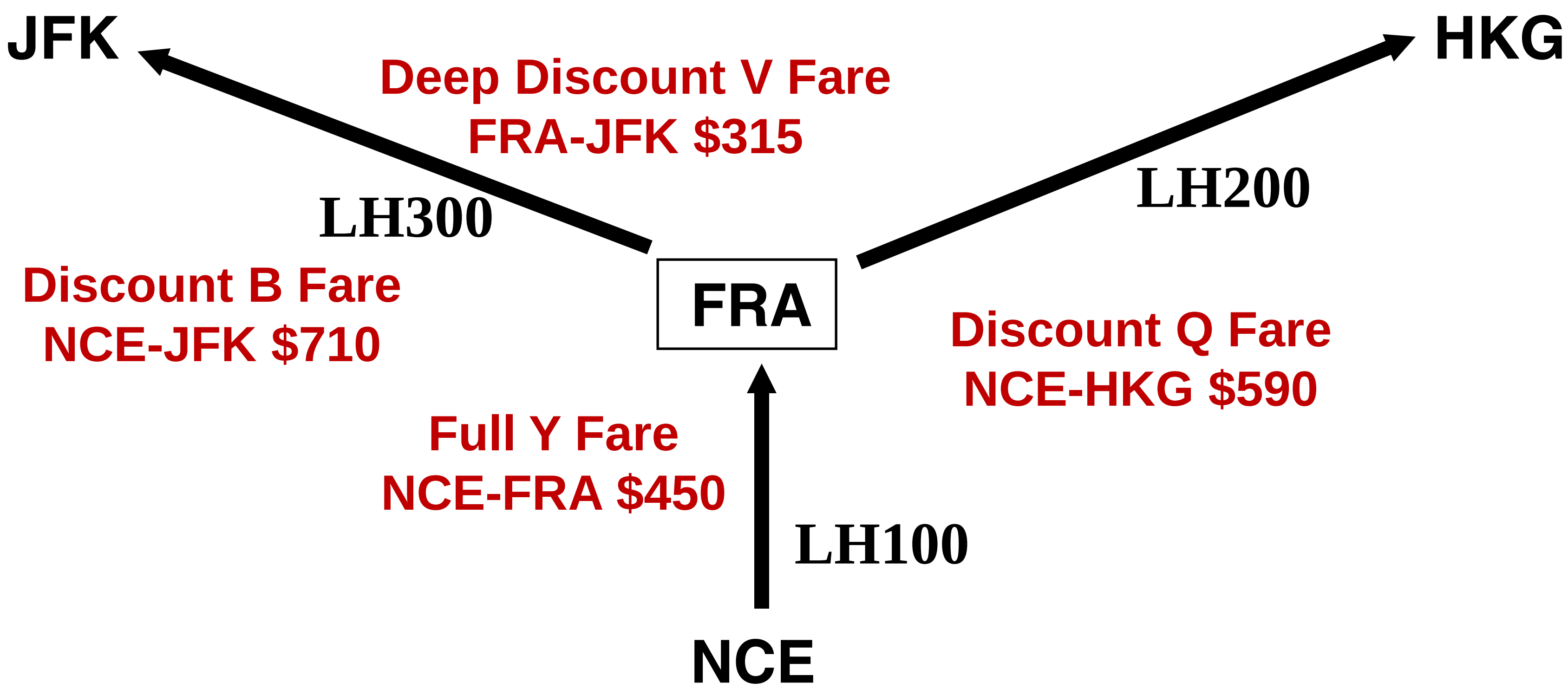
NCE/FRA	
CLASS	FARE (OW)
Y	$450
B	$380
M	$225
Q	$165
V	$135

FRA/JFK	
CLASS	FARE (OW)
Y	$920
B	$670
M	$515
Q	$385
V	$315

NCE/JFK	(via FRA)
CLASS	FARE (OW)
Y	$950
B	$710
M	$550
Q	$425
V	$325

O-D Control Optimization Quiz

QUESTION: With 1 seat available on each flight leg, which of these 4 O-D requests should we accept to maximize network revenue?



What is O-D Control?

- **The capability to respond to different O-D requests with different seat availability.**

- **Can be implemented in a variety of ways:**
  - Revenue value buckets ("greedy approach")
  - EMSR heuristic bid price (HBP)
  - Displacement adjusted virtual nesting (DAVN)
  - Network probabilistic bid price control (ProBP)

- **All of the above can increase revenues, but each one has implementation trade-offs.**

Revenue Value Bucket Concept

- **Fixed relationship between fare type and booking class is abandoned:**
  - Booking classes ("buckets") defined according to revenue value, regardless of fare restrictions
  - Each itinerary/fare type (i.e.., "ODIF") assigned to a revenue value bucket on each flight leg
  - ODIF seat availability depends on booking limits of value buckets

- **Development of Virtual Inventory Classes:**
  - Substantial cost of new inventory structure and mapping functions to virtual classes
  - CRS seamless availability links are essential

Virtual Class Mapping by ODF Revenue Value

FARE VALUES BY ITINERARY

NCE/FRA	
CLASS	FARE (OW)
Y	$450
B	$380
M	$225
Q	$165
V	$135

NCE/HKG	(via FRA)
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MAPPING OF ODFs ON NCE/FRA LEG TO VIRTUAL VALUE CLASSES

VIRTUAL CLASS	REVENUE RANGE	MAPPING OF O-D MARKETS/CLASSES	
1	1200 +	Y NCEHKG	
2	900-1199	B NCEHKG	Y NCEJFK
3	750-899	M NCEHKG	
4	600-749	B NCEJFK	
5	500-599	Q NCEHKG	M NCEJFK
6	430-499	V NCEHKG	Y NCEFRA
7	340-429	B NCEFRA	Q NCEJFK
8	200-339	V NCEJFK	M NCEFRA
9	150-199	Q NCEFRA	
10	0 - 149	V NCEFRA	

Value Buckets with Displacement

- **Contribution of an ODF to network revenue on a leg is less than or equal to its total fare:**
  - Connecting passengers can displace revenue on down-line (or up-line) legs
- **Given estimated down-line displacement, ODFs are mapped based on <u>network</u> value:**
  - Network value on Leg 1 = Total fare minus sum of down-line leg displacement costs
  - Under high demand, availability for connecting passengers is reduced, locals get more seats
- **Revision of displacement costs is an issue:**
  - Frequent revisions capture demand changes, but ODF re-mapping can disrupt bucket forecasts

Virtual Class Mapping with Displacement

FARE VALUES BY ITINERARY

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Displacement Adjustment

Alternative Mechanism: Bid Price

- **Under value bucket control, accept ODF if its network value falls into an available bucket:**

  Network Value > Value of Last Seat on Leg; or
  Fare - Displacement > Value of Last Seat

- **Same decision rule can be expressed as:**

  Fare > Value of Last Seat + Displacement, or
  Fare > Minimum Acceptable "Bid Price" for ODF

- **Much simpler inventory control mechanism than virtual buckets:**
  - Simply need to store bid price value for each leg
  - Evaluate ODF fare vs. itinerary bid price at time of request
  - Must revise bid prices frequently to prevent too many bookings of ODFs at current bid price

Example: Bid Price Control

A-------B-------C-------D

- **Given leg bid prices**

A-B:	$35	B-C:	$240	C-D:	$160

- **Availability for O-D requests B-C:**

	Bid Price = $240	Available?
Y	$440	Yes
M	$315	Yes
B	$223	No
Q	$177	No

Example: Bid Price Control

A-B: $35 B-C: $240 C-D: $160

A-C	Bid Price = $275	Available?
Y	$519	Yes
M	$374	Yes
B	$292	Yes
Q	$201	No

A-D	Bid Price = $435	Available?
Y	$582	Yes
M	$399	No
B	$322	No
Q	$249	No

Network vs. Heuristic Models

- **How to determine network value of each ODF for O-D control purposes?**
  - Leg-based EMSR estimates of displacement
  - Network optimization techniques to calculate displacement cost on each flight leg

- **Estimates of displacement costs and bid prices can be derived using either approach:**
  - Most O-D RM software vendors claim “network optimal” solutions possible with their product
  - Most airlines lack detailed data and face practical constraints in using network optimization models
  - Revenue gain and robustness, not optimality, are most critical questions in practice

Network Optimization Methods

- **Network optimization mathematics needed for both bid price and value bucket controls.**
- **Several optimization methods to consider:**
  - Deterministic Linear Programming
  - Dynamic Programming
  - Nested Probabilistic Convergence Algorithm (Bratu, MIT)
- **Simulated revenue gains are quite similar:**
  - ODF database, forecast accuracy and robustness under realistic conditions make a bigger difference

Leg-Based Heuristic Approaches

- **Several large airlines have implemented approximation models of network effects:**
  - Estimates of displacement costs and/or bid prices based on leg/bucket EMSR calculations
  - Use existing inventory structure, databases, and RM system capabilities
  - Compatible with RM analyst work routines

- **Low-risk approach to O-D revenue gains, as an intermediate step to network optimization**

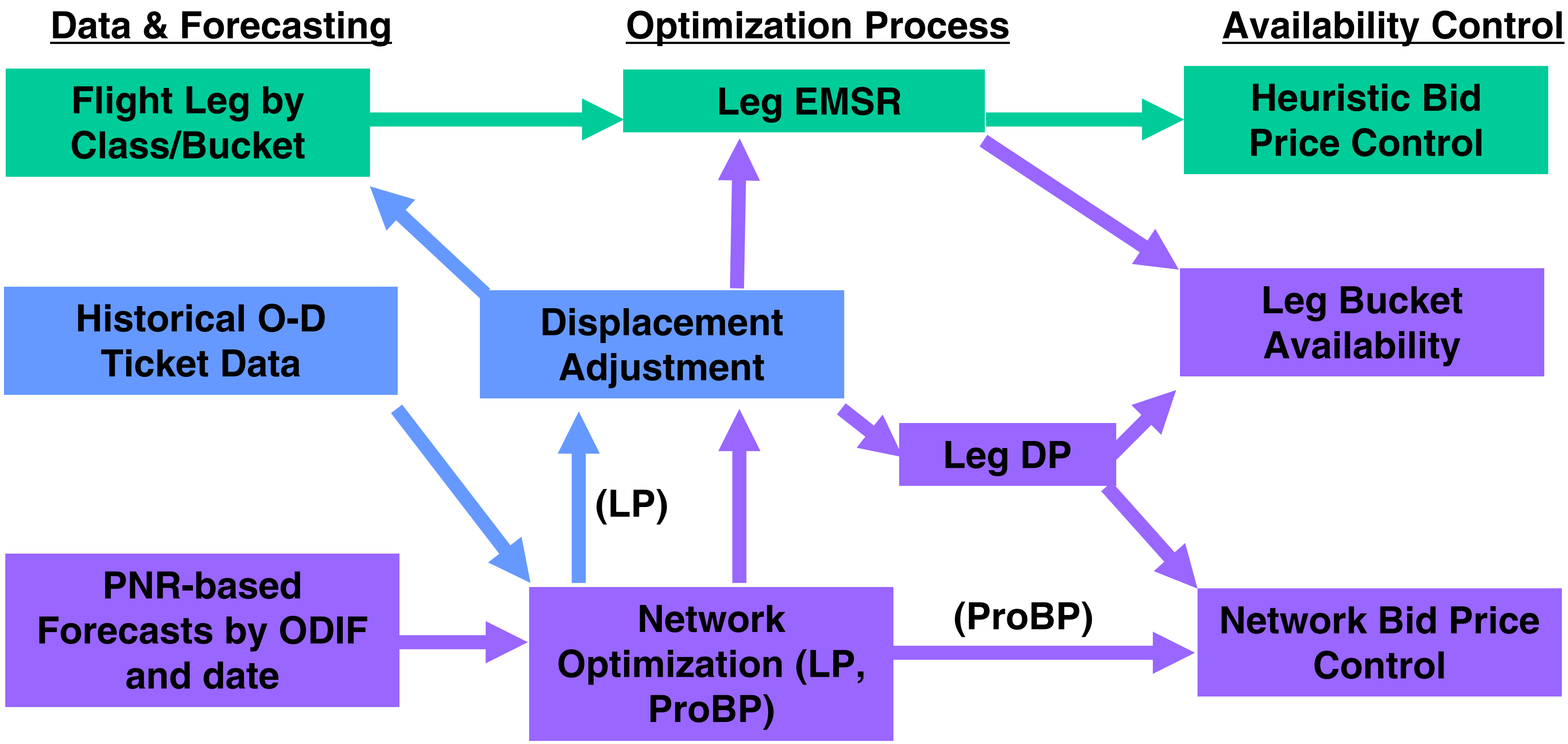
O-D Control System Components

- **Much more than an optimization model:**
  - Database Requirements: Leg/bucket vs. ODF.
  - Forecasting Models: Level of detail to match data; detruncation and estimation methods.
  - Optimization Model: Leg-based or network tools; deterministic vs. probabilistic; dynamic programs
  - Control Mechanism: Booking classes vs. value buckets vs. bid price control.
- **Many effective combinations are possible:**
  - Revenue gain, not optimality, is the critical issue.

O-D Control System Alternatives

O-D Control System	Data and Forecasts	Optimization Model	Control Mechanism
Rev. Value Buckets	Leg/bucket	Leg EMSR	Leg/bucket Limits
Heuristic Bid Price	Leg/bucket	Leg EMSR	Bid Price for Connex only
Disp. Adjusted Virtual Nesting	ODF	Network + Leg EMSR	Leg/bucket Limits
Probabilistic Network Bid Price	ODF	Network	O-D Bid Prices

Overview of O-D System Alternatives



Potential for O-D Control

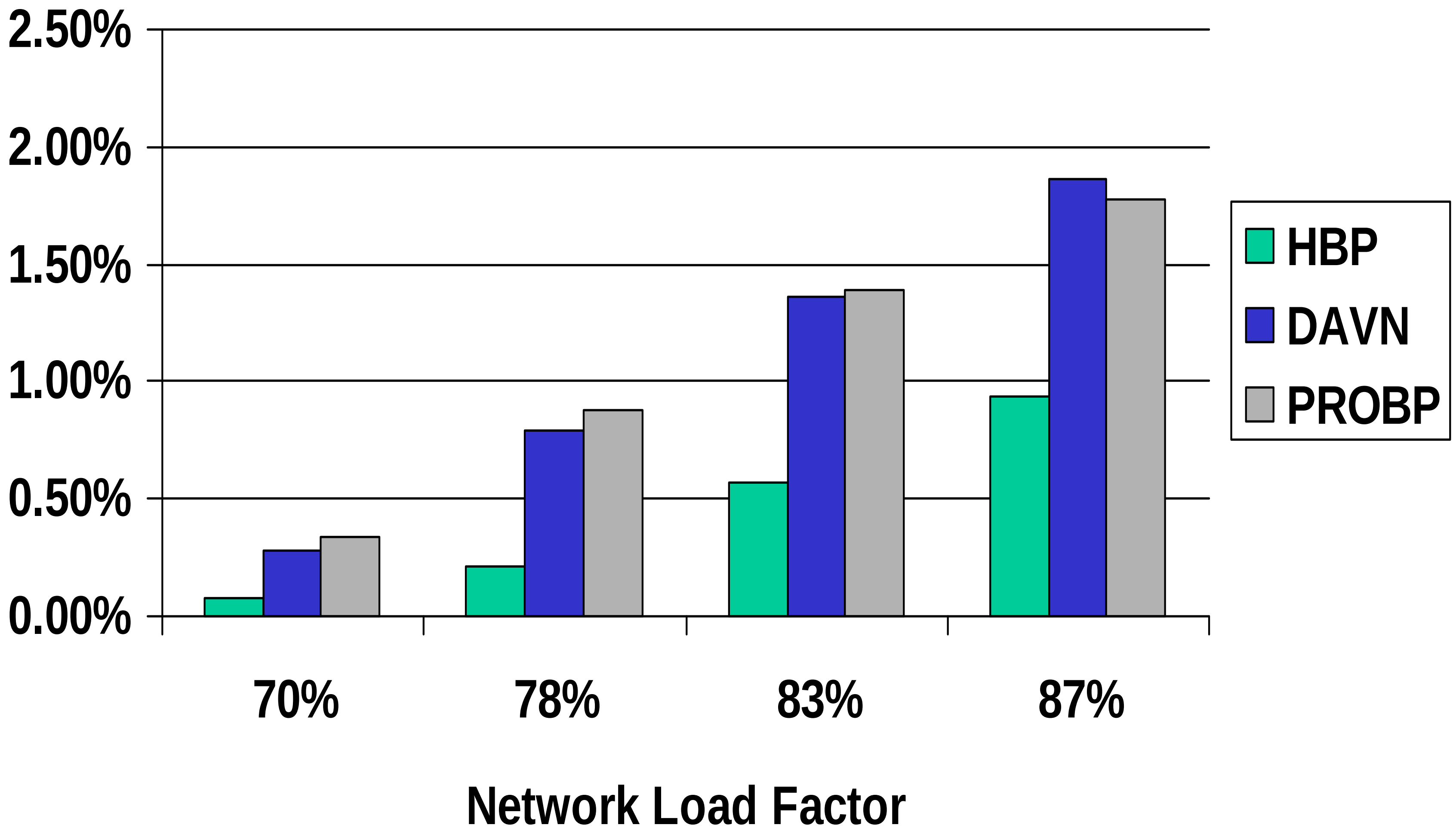
- **Simulations show potential O-D revenue gain:**
  - As much as 1-2% additional gain over leg/class control under ideal simulation conditions

- **Network characteristics affect O-D benefits:**
  - Substantial connecting traffic required
  - High demand factors on at least some feeder legs
  - Greater benefits with greater demand variability

- **CRS seamless availability links essential:**
  - Different responses to different ODF requests

O-D Revenue Gain Comparison

Airline A, O-D Control vs. Leg/Class RM



Additional Benefits of O-D Control

- **Simulation research and actual airline experience clearly demonstrate revenue gains of O-D control**
  - Return on investment huge; payback period short
  - Even 1% in additional revenue goes directly to bottom line

- **O-D control provides strategic and competitive benefits beyond network revenue gains**
  - Real possibility of revenue loss without O-D control
  - Improved protection against low-fare competitors
  - Enhanced capabilities for e-commerce and distribution
  - Ability to better coordinate RM with alliance partners

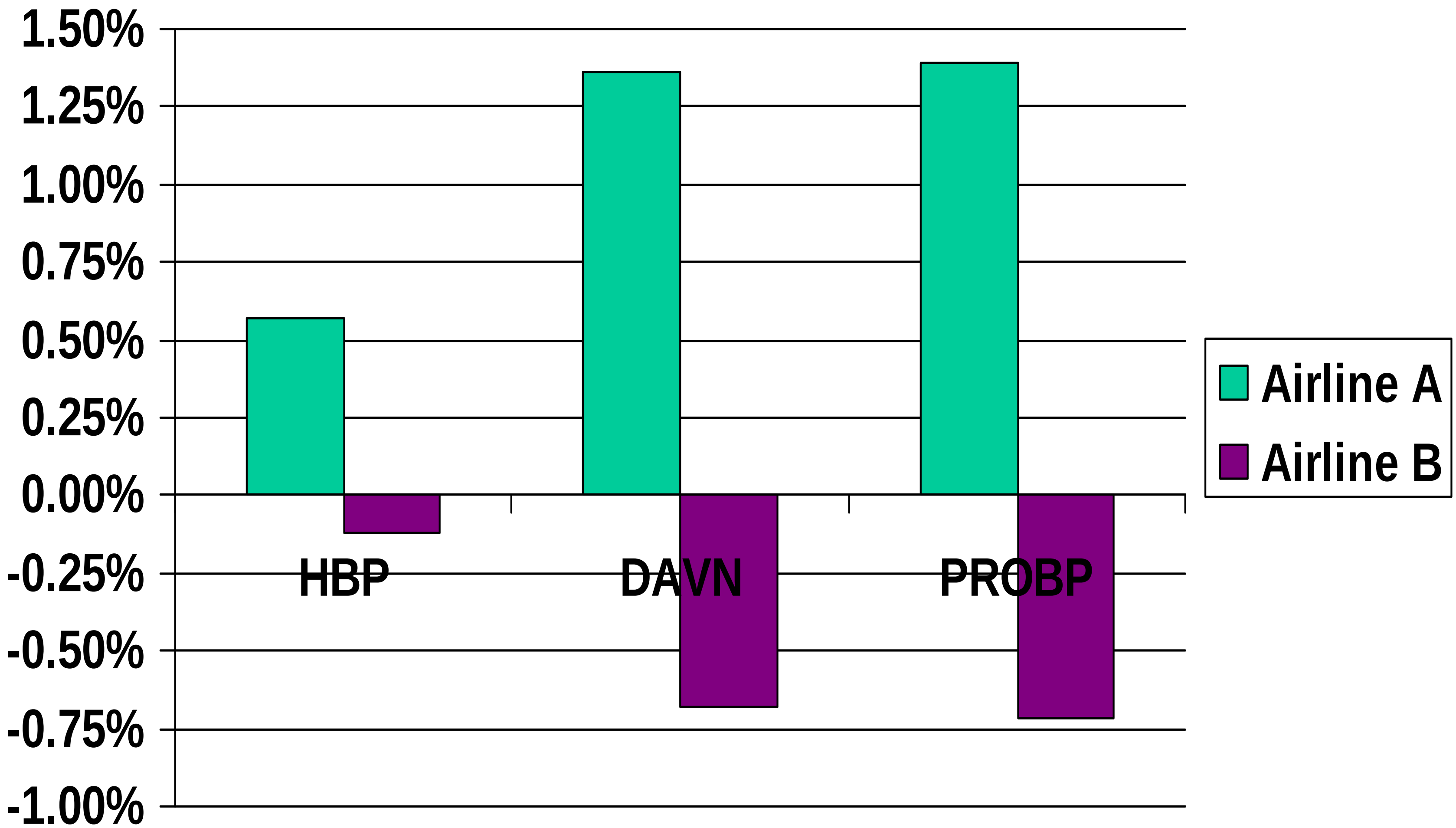
Competitive Impacts of O-D Methods

- **Implementation of O-D control can have negative revenue impacts on competitor:**
  - Continued use of basic FCYM by Airline B against O-D methods used by Airline A results in <u>revenue losses</u> for B
  - Not strictly a zero-sum game, as revenue gains of Airline A exceed revenue losses of Airline B
  - Other PODS simulation results show both airlines can benefit from using more sophisticated O-D control

- **Failure to implement network RM (O-D control) can actually lead to revenue losses against competitor!**

Competitive Impacts of O-D Control

Network ALF=83%, Airline B with Basic YM



Response to Low-Fare Competition

- **Under basic leg/fare class RM, no control over different O-D markets booking in each class**
  - With low-fare competitor, matching fares requires assignment to specific fare class
  - Fare class shared by all O-D itineraries using same flight leg and supply of seats

- **With O-D control, bookings are limited by network revenue value, not fare type or restrictions**
  - Low matching fares will still be available on empty flights
  - But will not displace higher revenue network passengers

Changing Distribution Channels

- **O-D control also allows for improved control of bookings by distribution channel**
  - Differential valuation of origin-destination-fare requests from a growing variety of alternative distribution options
  - Each new distribution channel represents an opportunity to increase revenues, but also a major risk of revenue dilution
  - Different costs and net revenue values to the airline

- **In e-commerce, RM fundamentals are unchanged**
  - Forecast and protect seats for high revenue ODF requests
  - Use O-D control to accept bookings only from channels and points of sale that will increase total network revenues

Summary: Airline O-D RM Systems

- **O-D control is the 4th generation of RM:**
  - Data collection, forecasting, optimization and control by origin-destination-fare type as well as distribution channel

- **Not just a revenue enhancement tool, a strategic and competitive necessity for airlines:**
  - Incremental network revenue gains of 1-2% over basic RM
  - Essential to protect against revenue loss to competitors
  - Increased control of valuable inventory in the face of pricing pressures, new distribution channels, and strategic alliances