PROS REVENUE MANAGEMENT

PROS O&D

Optimizer

Technical Documentation

Revision History

Product VERSION	DATE	PERSON	REASON FOR CHANGE
1.0	01/16/2005	Florence Carrier	First version
1.1	01/30/2006	Florence Carrier	Update based on science feedback

References

List all documents that are referenced

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Table of Contents

1 Overview

1.1 Purpose

The purpose of this document is to provide additional details on some optimization processes. This document includes information on:

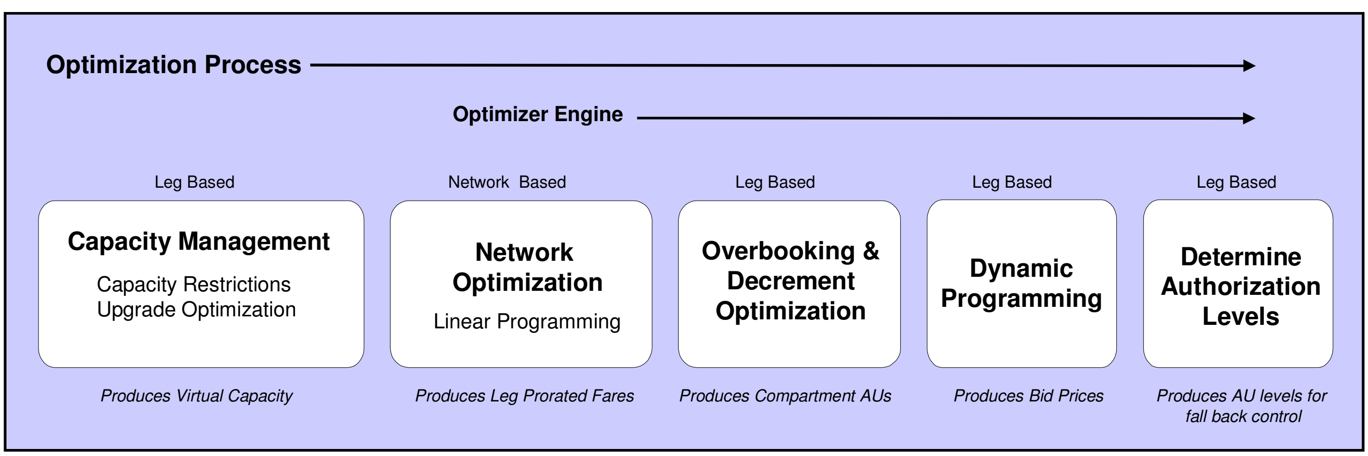
- Decrement Optimization
- Bid price Determination
- AU Determination including the calculation of leg/class pseudo fare

1.2 Optimization Process Overview

The O&D optimization process includes the following steps:

1. Capacity Management (Capacity Restrictions/Upgrade/Convertible Seats)
   The output of this step is the capacity available for the remaining steps of optimization
2. Network Optimization - Linear Programming (LP)
   The outputs of this step are leg/compartment displacement cost and ODIF pseudo fare
3. Overbooking and Decrement Optimization
   The output of this step is leg/compartment AU
4. Dynamic Programming
   The output of this step is availability control mechanisms which is represented by a bid price vector
5. Authorization levels determination
   The output of this is the secondary availability controls mechanisms which is represented by leg/class AUs

This process is depicted in the figure below:



2 Decrement Optimization

2.1 Overview

The decrement optimization is accomplished during step 3 of the optimization process. The goal of the decrement optimization is to anticipate pre-departure cancellations and consequently adjust compartment AU level upwards.

2.2 Decrement Components

There are two decrement components:

1. Step" decrement: constructed for the Group "current bookings" using the Group Summary profile.
2. "Line" decrement: constructed for three components:
   a. Individual "forecasted future bookings" using the O&D Forecaster Individual ODIF/POS cancellation rates
   b. Individual "current bookings" using the same O&D Forecaster Individual ODIF/POS cancellation rates
   c. Group "forecasted future bookings" using the O&D Forecaster Group ODIF/POS cancellation rates

2.3 Inputs

The inputs to the Decrement Optimizer are as follows:

- ODIF/POS Bookings to come by DCP
- ODIF/POS Cancellation Rate by DCP
- ODIF/POS Current Bookings·
- Virtual Capacity

2.4 Methodology

The methodology explained below pertains only to the line decrement.

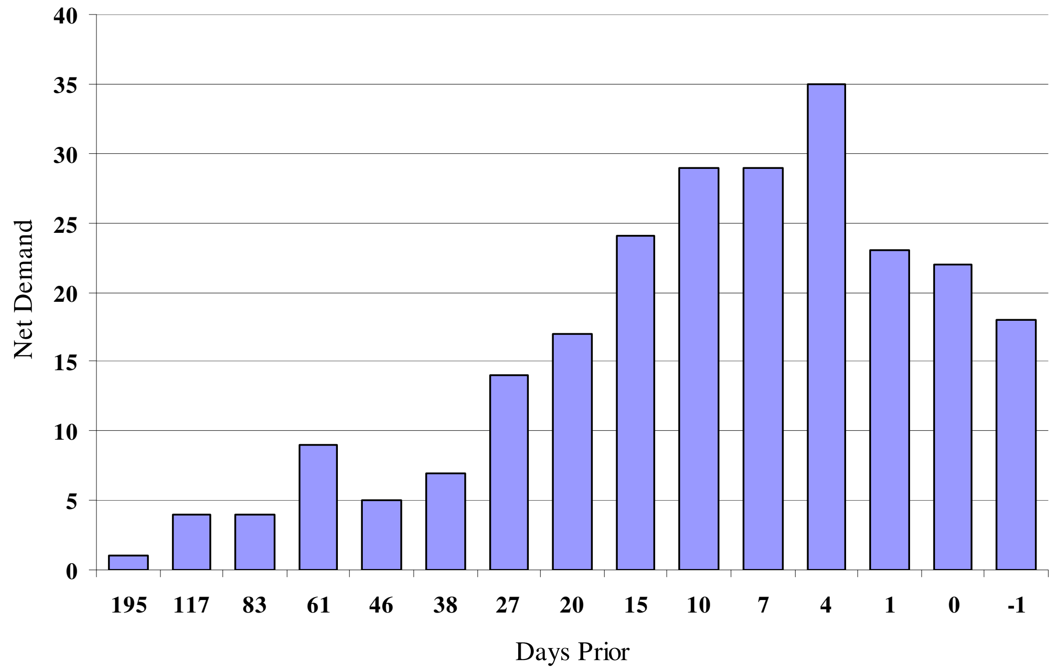
The decrement is based on the leg/class booking curve, which is obtained by aggregating the ODIF/POS net demand curves that traverses a flight/leg. ODIF/POS net demand curves are obtained by taking into account the ODIF/POS Booking to come by DCP and the ODIF/POS Cancellation rate by DCP.

The simplified example below illustrates the methodology to get the ODIF/POS net demand curve.
<u>Example</u>
Assume 3 DCPs. One DCP has already passed and there are 10 booked on hand at the end of this DCP
Assume bookings and cancellation forecasts for DCP 2 & 3 given in the table.

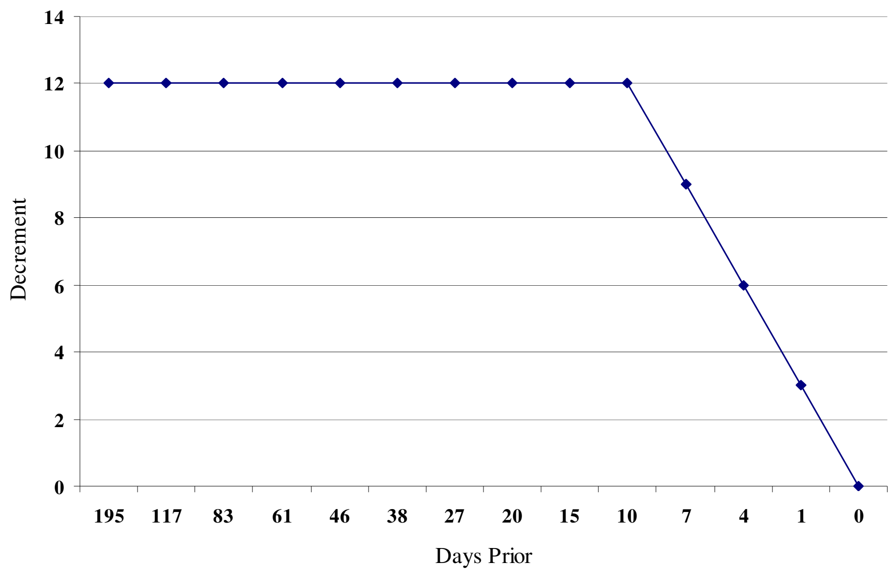
	DCP 1	DCP 2	DCP3
Booking Forecast		5	3
Cancellation Forecast		20%	33%
Net Demand	10	12	10

The net demand at the end of DCP2 is obtained by multiplying the total number of bookings by the survival rate of 20% ((10+5)*(1-0.2)). The same process is used to get the net demand at the end of DCP3.
Note that even though there are cancellations in DCP2, there is no drop in net demand.
Note that one O&D/POS traversing a flight/leg can have a drop in net demand but it might be compensated by another O&D/POS (traversing the same flight/leg) and the aggregated result at the leg/class level might not show a drop in net demand.

The figure below shows a typical leg/class booking curve. In the following case, the peak of the booking curve is at 4 days prior to departure and then there are more cancellations than bookings leading to net cancellation.



The decrement optimizer determines the amount by which to increase a compartment authorization level early in the booking cycle to compensate for later net cancellations. It then determines the point in the booking cycle (APEX) at which it begins to decrease the decrement to reduce to zero on the day of departure. The result is a line decrement. One example is represented below.


14
12
10
8
6
4
2
0
Decrement
195 117 83 61 46 38 27 20 15 10 7 4 1 0
Days Prior

3 Dynamic Programming (DP) – Determination of Bid Price

3.1 Overview

The bid price vector is calculated during the Dynamic Programming step of the optimization sequence.

3.2 Inputs

- Net Demand by DCP
- Leg prorated fares (pseudo fares)·
- Time slot definition**

**The time slot definition is when the total time to departure is sliced into fine intervals, such that at most one event is possible within that time interval. The time slot definition is defined in the O&D system as 500. All DCPs up to departure are sliced in 500 time slots.

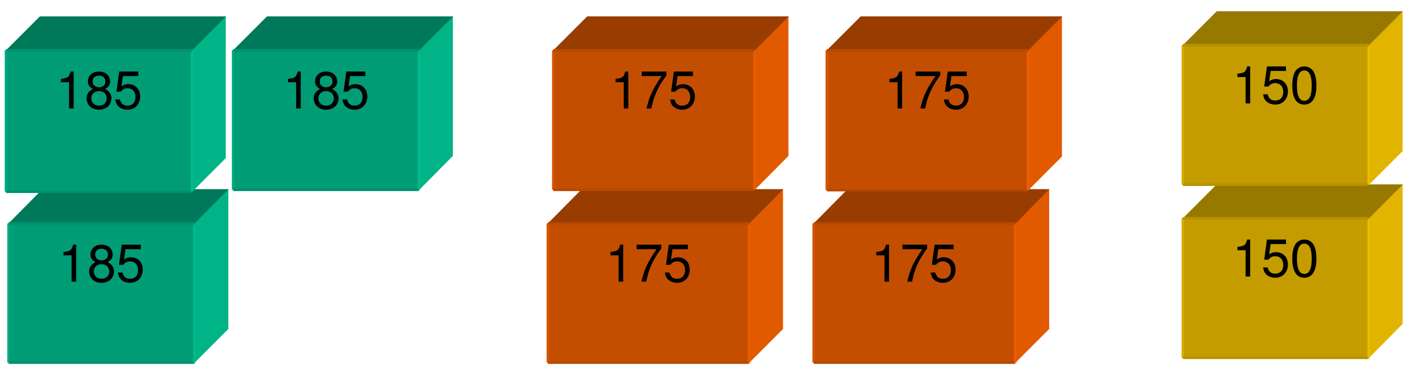
Leg/class current bookings and leg/compartment AU are sometimes mentioned as inputs to the DP. These 2 inputs do not have a direct effect on the DP; the compartment AU just indicates the number of seats for which to run the DP and the leg/class current bookings number is used to set the seat availability index along the bid price vector.

3.3 Methodology

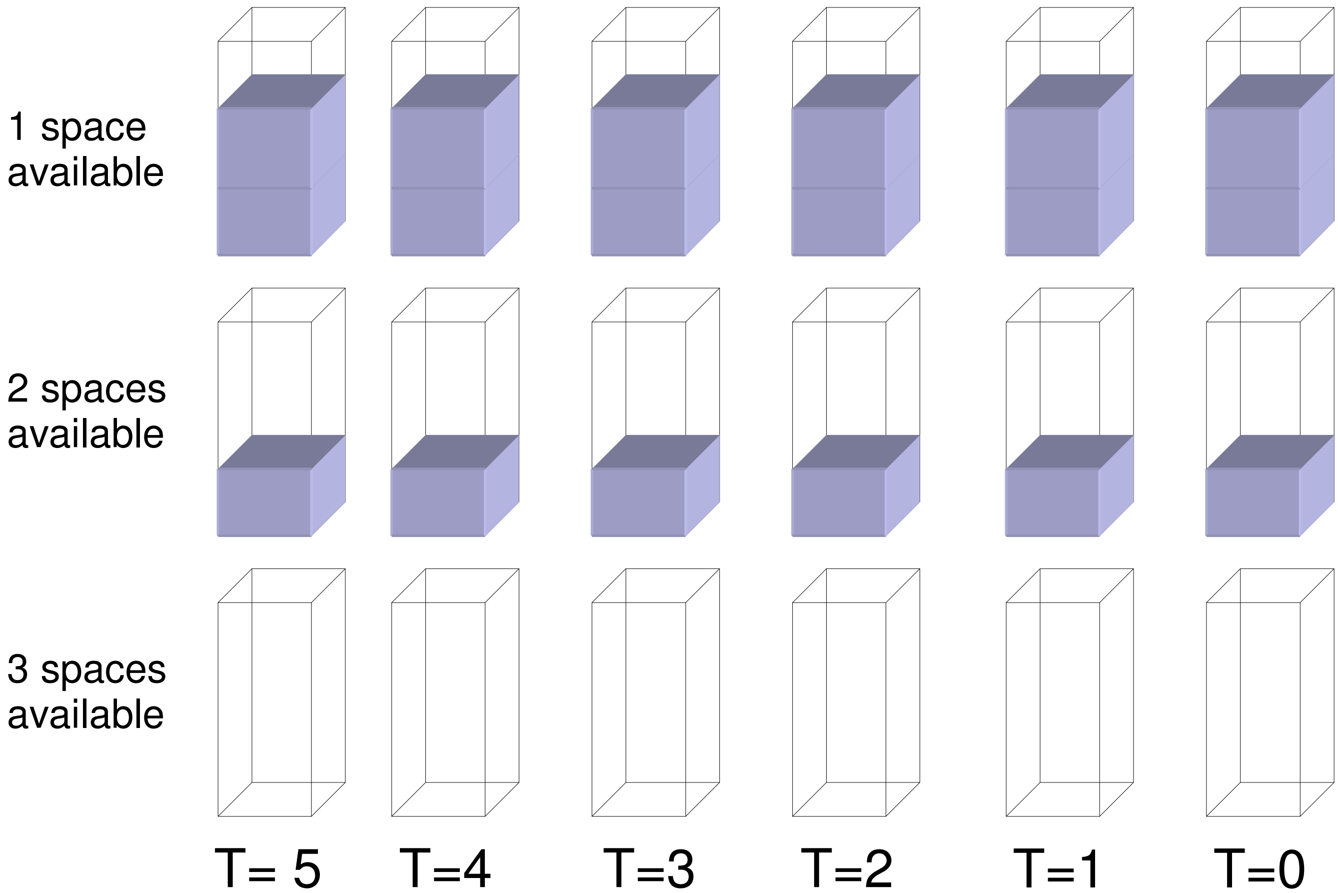
The DP simulates all possible booking events and determines the expected revenue at each point of time (time slot) and for each seat available in the compartment (up to the compartment AU) by starting with the time of departure where the expected revenues are zero for any seat.

<u>Example</u>
The simplified example below illustrates the DP methodology.
Assume a single flight leg
Suppose there are 3 fare classes with fare values = 185, 175 and 150 (these are the ODIF Pseudo Fare value)
Demand for these 3 fare products is 3, 4 and 2 respectively

This is depicted in the graph below. Each cube represents a unit of demand



Below is the state diagram that the DP would construct. For simplification purposes, we just represent 5 time slots to departure, T=0 being the closest to departure

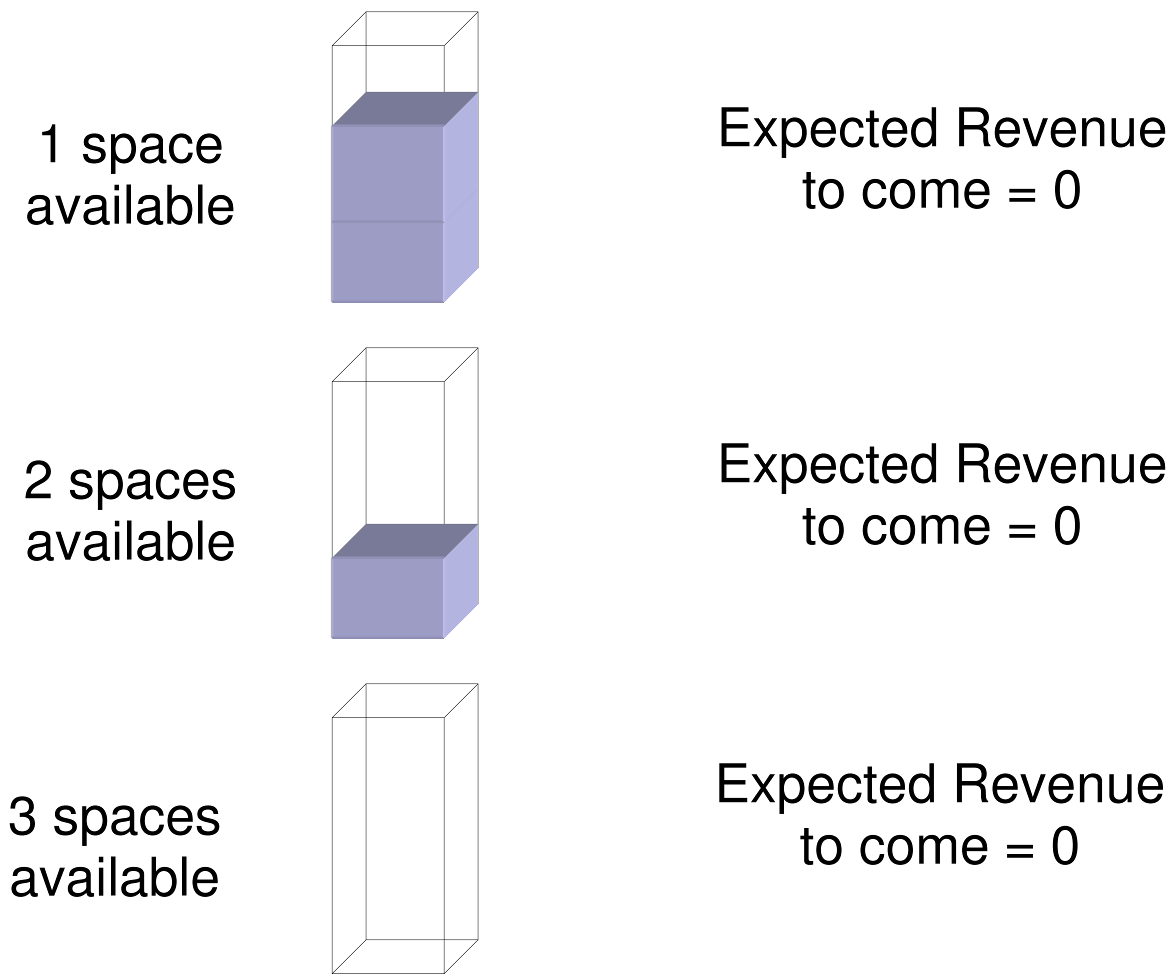


The arrival probability of a passenger for each fare product is equal to the demand/time left. Consequently, the arrival probability of a passenger for the $185 fare product is 3/5 = 60% because the demand for this fare product is 3 while the time left is 5 (time slots).
The arrival probability of a passenger for the $175 fare product is 4/5 = 80%
The arrival probability of a passenger for the $150 fare product is 2/5 = 40%

Since only one event can happen in a time slot, we need to determine the probability that a passenger for the $185 fare product arrives first.
The probability that a passenger for the $185 fare product arrives first is the probability of arrival of this fare product multiplied by the probability that the two other products do not arrive.
Therefore, the probability that the $185 arrives first is equal to 0.6 * (1-0.8)*(1-0.4) = 7.2%
Similarly, the probability that a passenger for the $175 fare product arrives first is 0.8*(1-0.6)*(1-.0.4) = 19.2%
The probability that a passenger for the $150 fare product arrives first is 0.4 *(1-0.6)*(1-0.8) = 3.2%

As a result, the probability that a passenger would arrive for any of these fare products is 7.2+19.2+3.2 = 29.6% and the probability of no arrival is 70.4%.

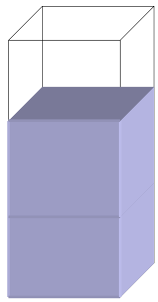
Below is the state of the DP and the expected revenues at **T = 0 (i.e. time of departure)**



As the graph above indicates, expected revenue to come at the time of departure are zero since independently of the seat availability (1, 2 or 3), there is no time to get additional revenue.

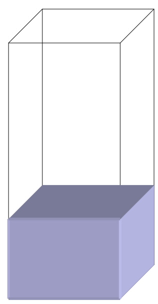
Below is the state of the DP and expected revenues at **T = 1**

1 space available



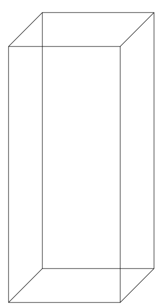
Expected Revenue to come =
0.072*(185 + 0) +
0.032*(150 + 0) +
0.192*(175 +0) +
0.704*0
= 51.20

2 spaces available



Expected Revenue to come =
0.072*(185 + 0) +
0.032*(150 + 0) +
0.192*(175 +0) +
0.704*0
= 51.20

3 spaces available



Expected Revenue to come =
0.072*(185 + 0) +
0.032*(150 + 0) +
0.192*(175 +0) +
0.704*0
= 51.20

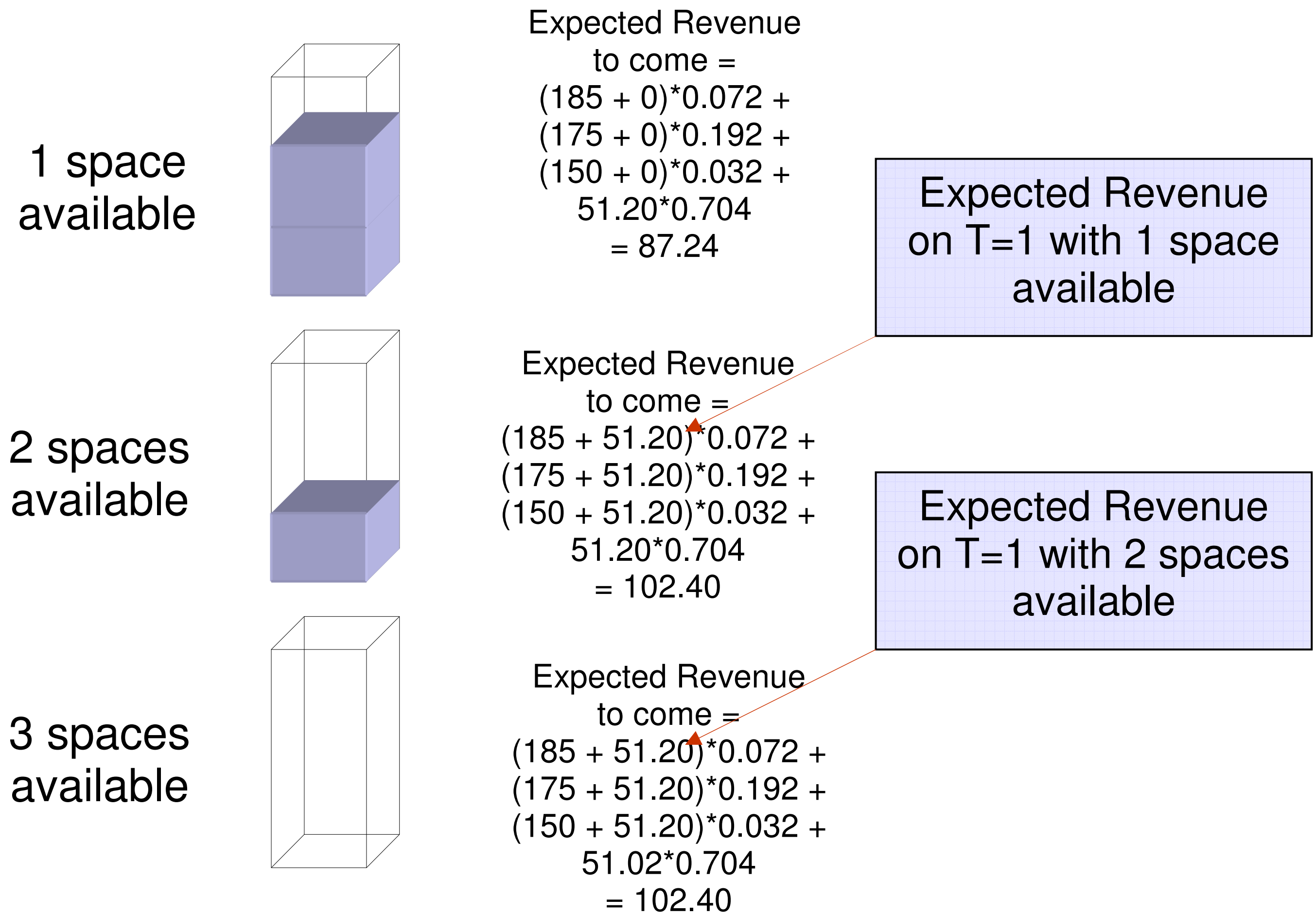
To generalize,

Expected revenue to come =

Probability that a fare product arrives first * (ODIF Pseudo Fare + expected revenue if there is one less seat available at the next time slot)
+ Probability of no arrival * expected revenue if there is the same number of seats available at the next time slot

In the case above, the expected revenue at the next time slot (T = 0) is zero independently of the number of seats available.

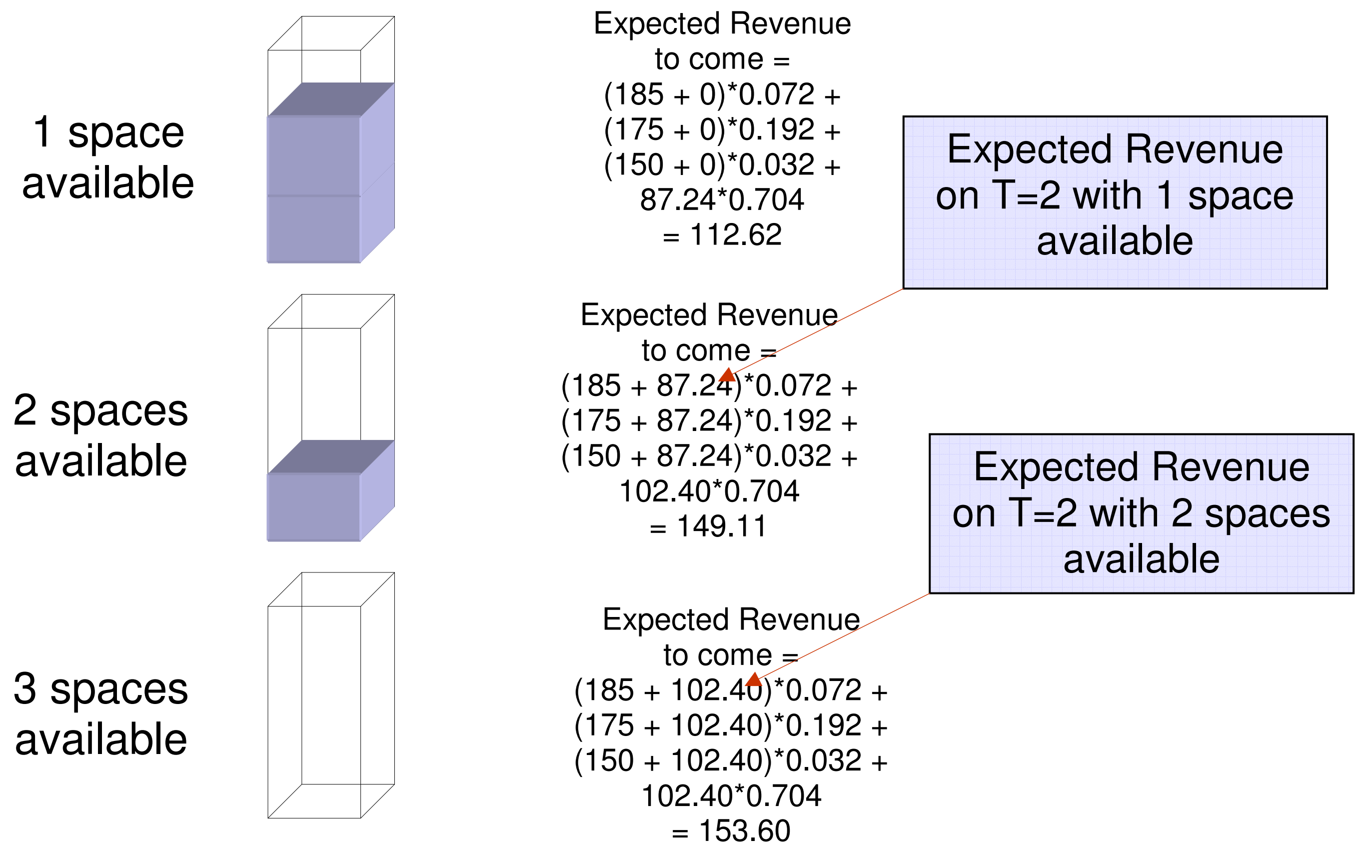
Below is the state of the DP and expected revenues at **T = 2**



At T = 2, the DP is using the expected revenue computed for T = 1.
For example, if there are 2 seats available:

- There is a 7.2% chance of a passenger worth $185 arriving first. If the passenger is accepted, the cumulative expected revenue is $185 in addition to the $51.20 revenue if there is one seat available at the next time slot (T=1)
- There is a 19.2% chance of a passenger worth $175 arriving first. If the passenger is accepted, the cumulative expected revenue is $175 in addition to the $51.20 revenue if there is one seat available at the next time slot (T=1)
- There is a 3.2% chance of a passenger worth $150 arriving first. If the passenger is accepted, the cumulative expected revenue is $150 in addition to the $51.20 revenue if there is one seat available at the next time slot (T=1)
- There is a 70.4% chance of no arrival. In this case, the only expected revenue is the expected revenue if there are still 2 seats available at the next time slot ($51.20)

Below is the state of the DP and expected revenues at **T = 3**



Below is the state of the DP and expected revenues at **T = 4**

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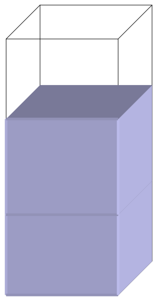
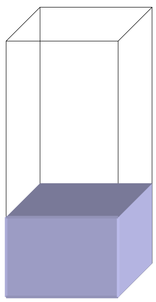


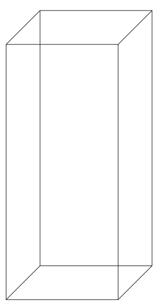
Expected Revenue
to come =
(185 + 0)*0.072 +
(175 + 0)*0.192 +
(150 + 0)*0.032 +
112.62*0.704
= 130.48

2 spaces available



Expected Revenue
to come =
(185 + 112.62)*0.072 +
(175 + 112.62)*0.192 +
(150 + 112.62)*0.032 +
149.11*0.704
= 189.51

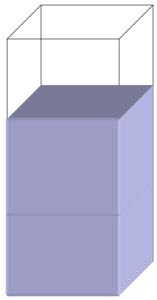
3 spaces available



Expected Revenue
to come =
(185 + 149.11)*0.072 +
(175 + 149.11)*0.192 +
(150 + 149.11)*0.032 +
153.60*0.704
= 203.47

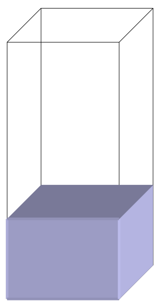
Below is the state of the DP and expected revenues at **T = 5**

1 space available



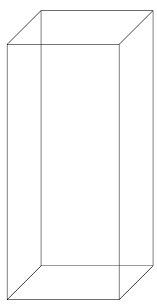
Expected Revenue
to come =
(185 + 0)*0.072 +
(175 + 0)*0.192 +
(150 + 0)*0.032 +
130.48*0.704
= 143.05

2 spaces available



Expected Revenue
to come =
(185 + 130.48)*0.072 +
(175 + 130.48)*0.192 +
(150 + 130.48)*0.032 +
189.51*0.704
= 218.19

3 spaces available



Expected Revenue
to come =
(185 + 189.51)*0.072 +
(175 + 189.51)*0.192 +
(150 + 189.51)*0.032 +
203.47*0.704
= 250.36

Based on the previous 5 states of the DP, we can construct the following expected revenues table. The expected revenues represented below are cumulative from left to right and from top to bottom.

Seats Available	T = 5	T = 4	T = 3	T = 2	T = 1
0	0	0	0	0	0
1	143.05	130.48	112.62	87.24	51.20
2	218.19	189.51	149.11	102.40	51.20
3	250.36	203.47	153.60	102.40	51.20

The bid price for each seat is simply the expected revenue in future if a seat booking request is rejected minus the expected revenue in future if a seat booking request is accepted.

Therefore, for the previous example, we get the following bid price matrix

Space Available	T = 5	T = 4	T = 3	T = 2	T = 1
0	Closed	Closed	Closed	Closed	Closed
1	143.05	130.48	112.62	87.24	51.20
2	75.14	59.03	36.49	15.16	0
3	32.17	13.96	4.49	0	0

4 Determination of Authorization Levels

4.1 Overview

The leg/class AUs are determined in the last step of the optimization sequence as a fallback mechanism. Some conditions when AU levels are used as control mechanism include a flight/ leg not under O&D control or non seamless booking request controlled by AVS messages.

4.2 Inputs

The inputs to this optimizer step are as follows:

- Bid price vector (obtained in step 4)
- Leg/class pseudo fares (detailed in the following section)
- Compartment authorization level (AU)

4.3 Calculation of leg/class pseudo fare

The leg/class pseudo fares are based on ODIF pseudo fares and ODIF/POS demand to come. The ODIF pseudo fares are calculated during network optimization (step 2). To obtain the leg/class pseudo fare, the system weight averages all the ODIF/POS pseudo fare traversing the leg. The weighted average is based on demand to come.

The simplified example below illustrates the methodology.
Assume only these three ODIF/POS are traversing the flight leg on a specific departure date.

Online Origin	Online Destination	Trip Origin	Trip Destination	POS	Fare Class	Demand To Come	Fare Value (ODIF pseudo fare)
HB1	LHR	HB1	LHR	GB	Y	3.2	$730
SYD	LHR	SYD	LHR	AU	Y	2.8	$1040
SIN	LHR	SIN	LHR	GB	Y	1.7	$1190
Leg/Class pseudo fare (HB1 – LHR)/Y							$944.29

4.4 Methodology

The AU level is defined as the maximum number of bookings possible for each class on the specified flight/leg (including lower nested classes). The AUs are calculated by comparing the leg/class pseudo fare to the bid price vector. For a fare class which leg/class pseudo fare is X, the AU level is the number of seats whose bid price is less or equal to X.

<u>Example</u>
Assume a compartment AU of 15 and the following bid price vector.
What is the AU for a leg/class pseudo fare of $180?

AU – pseudo fare = $210

AU – pseudo fare = $205

AU – pseudo fare = $180

Cmp AU	Bid Price
15	$209
14	$206
13	$203
12	$197
11	$192
10	$184
9	$175
8	$167
7	$155
…	…

The AU for a leg/class pseudo fare of $210 is 15 since $215 is above all bid prices
The AU for a leg/class pseudo fare of $205 is 13 since $205 is above all bid prices except the two highest ones.
Similarly, the AU for a leg/class pseudo fare of $180 is 9.