Practice Article

History of revenue management – From leg to O&D

Stefan Poelt

Lufthansa German Airlines, Frankfurt, Germany

Stefan Poelt is a senior manager at Lufthansa German Airlines where he is responsible for the revenue management tools. He holds a PhD in computer science from the University of Dortmund, Germany, and joined Lufthansa in 1995. He has published several articles in the *Journal of Revenue and Pricing Management* and is a member of its editorial board. He is recognized as an expert in forecasting and optimization methods with emphasis on bridging the gap between research and practical application.

Correspondence: Stefan Poelt, Lufthansa German Airlines, FRA IM/DR, 60546 Frankfurt, Germany
E-mail: stefan.poelt@dlh.de

ABSTRACT   One of the biggest milestones in the development of airline revenue management (RM) has been the step from leg to O&D (origin and destination) control. The first computer reservation systems that automated the former manual accept/reject decisions of booking requests controlled the number of bookings by booking limits per leg and booking class. The main disadvantage of this leg-type control was the inability to distinguish between local and connecting passengers.The advances in computer power and distribution capabilities (seamless polling) in the 90s enabled forecasting, optimization and availability control at O&D level. This enhancement allowed better evaluation of booking requests and closer integration of RM and pricing. Looking back, one of the biggest challenges in the evolution from leg to O&D control was the change management process.

LEG CONTROL

Revenue management (RM) started in the late 70s with manual accept/reject decisions of queued booking requests. Later on, this process has been automated in the computer reservation systems (CRSs). They controlled the number of bookings in a compartment for a flight with help of booking-class limits that were calculated by RM tools.

Demand was assumed to be independent between different legs and independent between booking classes. That simplified the task of forecasting and optimization. The demand forecasts for a leg and booking class were based on snapshots of historical booking and availability data within the booking window.

One of the first optimization methods to calculate booking limits was the expected marginal seat revenue heuristic of Belobaba (1987), an extension of Littlewood's (2005) rule. Beside demand forecasts the optimization also required fare inputs at leg and booking-class level.

Drawbacks of leg control

For a point-to-point carrier with few connecting passengers leg control is sufficient, but for a network carrier with a hub and spoke network

and an O&D fare structure leg control is sub-optimal.

The fare structure of a network carrier usually differentiates by market (point of sale) and is non-additive in the sense that a ticket for the connecting itinerary A–B–C is cheaper than the sum of the tickets for A–B and B–C in that same booking class.

For leg optimization network carriers had to condense their O&D fare structure in order to calculate leg/class fares, for example, by an average of the O&D fares (for all itineraries that contain the leg) or by using the local fare valid for the one-leg O&D.

The main disadvantage of leg control is that it cannot distinguish between local and connecting traffic in availability control. A booking request for a connecting itinerary A–B–C is accepted in class X if it is available at both legs, A–B and B–C. A booking request for the non-stop itinerary A–B gets the same availability as a booking request for the connection A–B–C (assuming A–B is the bottleneck leg and B–C has better availability than A–B).

For a feeder leg the fares in a booking class range from local fare to long-haul connections. All of them are controlled by the same booking limit that is calculated based on the same (average) optimization fare.

Figure 1 shows a simple example of a connecting itinerary with two legs A–B and B–C and three different demand scenarios. If demand is low at both legs, all demand should be accepted and O&D control does not have advantage over leg control. If demand is low at one leg but high at the other, then it is revenue beneficial to prefer (within a booking class) connecting passengers with higher total fare over local passengers at the bottleneck leg, but leg control cannot distinguish
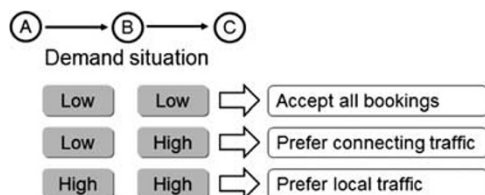
Figure 1: Three different demand situations.

between both. If demand is high at both legs, then it is revenue beneficial to prefer two local passengers that pay more than one connecting passenger, but again leg control cannot distinguish between them.

O&D CONTROL

O&D control, also called network RM, reduces the above mentioned drawbacks of leg control, mainly the inability to distinguish between local and connecting passengers and the huge and overlapping fare ranges of booking classes.

The advances in computer power and distribution capabilities (seamless polling) in the 1990s made forecasting, optimization and availability control at O&D level possible. This enabled better evaluation of booking requests and closer integration of RM and pricing that always had the market (O&D) focus.

Seamless polling means that the global distribution system (GDS) does not answer an availability or booking request by the pre-stored leg/class availabilities, but sends it via a seamless link to the operating airline that can calculate and send back O&D-based availabilities.

Two types of O&D control have been established in the past: bid pricing and displacement adjusted virtual nesting (DAVN, also called value buckets). Details are described, for example, in Talluri and van Ryzin (2004). The following description is based on the bid price control method.

Distribution

Since the GDS can store leg/class availabilities only, some enhancements have to be done in order to allow O&D control. Figure 2 shows the data flow for an O&D booking request under seamless availability.

First, all availability and booking requests have to be routed to the airline's inventory system. This connection is called 'seamless link'. The inventory evaluates an incoming booking request by the corresponding O&D fares. Availability is given in a booking class if the O&D
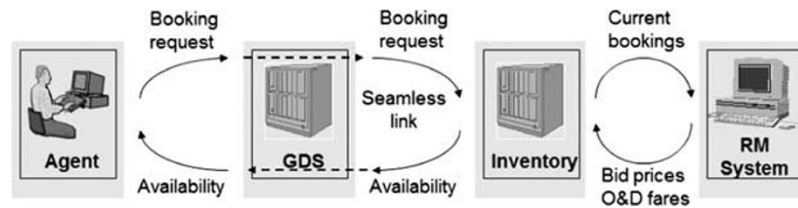
Figure 2: Seamless link for O&D control.

fare of this class is greater than the sum of the bid prices of the concerned legs. The bid prices and the O&D fares are provided by the airline's RM and pricing tools.

It is worth noting that the data flow for bid price control consists of two separate loops. The response to a booking request has to be provided within a few seconds. That is the data loop from the agent via the GDS to the inventory system and back. The data loop between the RM and the inventory systems is decoupled and has different triggers for re-optimization, such as fixed days before departure, schedule changes or user activities.

BENEFITS

The main benefits of O&D RM are more differentiated availabilities for bottleneck legs. The level of O&D control usually is by itinerary, fare class and point of sale. It is much more detailed than the leg/class level of leg control and allows better evaluation of a booking request.

Furthermore, O&D forecasting allows capturing basic demand characteristics, like seasonality, at the right (product) level of customer behavior. Also the quality of the estimation of unconstrained bookings based on constrained bookings and availability information is increased at the O&D level, as leg-level availability information is inaccurate. If a booking class is available at one leg, not all of the demand in this class can book if the same class is closed at a connecting leg.

Revenue benefits

RM simulation studies like PODS (passenger O&D simulation) have consistently reported

revenue gains of 1–2 per cent for O&D over leg control (Belobaba, 2008). The specific numbers depend on several factors:

- Overall demand level, especially the fraction of high-demand flights.
- Portion of connecting traffic within the network.
- Fare structure and spread in fares (between highest and lowest class).
- Competitive situation and so on.

PODS is a static and simplified simulation environment without trends, seasonality, events, group bookings, data errors and other practical challenges. Hence the results should not be translated 1:1 in real revenue gains.

A measurement of O&D gains on real data during the implementation of network optimization at Lufthansa has indicated even bigger revenue gains than the ones that have been simulated in PODS (Alder and Rockmann, 2009).

Structural benefits

O&D forecasting allows a better reaction on schedule changes. If the departure time of a flight is moved some travel flows get invalid because of connectivity while other traffic flows get more attractive because of decreased connecting time.

These structural changes of demand can only be capture at the O&D (itinerary) level. But it has to be mentioned that capturing those demand shifts at the itinerary level is a complex task that can even reduce forecast quality if it is not done right.

Another advantage of O&D forecasts and availabilities is better communication between RM and other departments such as pricing and

sales, which think in terms of markets, O&Ds and points of sale rather than in legs and flights. Common thinking and common reports at the same (O&D and point of sale) level help to increase the understanding and cooperation between those departments.

RM forecasts at the O&D level for future demand as well as future (constrained) bookings, for example, can be used to set the right sales targets and incentives. They help to analyze which traffic flows have to be stimulated if load factors are below expectation.

CHALLENGES

All the benefits above are arguments for moving from leg to O&D, but there are also some obstacles and challenges.

Complexity and costs

Enhancing the RM tools and availability calculation from leg to O&D and setting up the seamless links with all relevant GDSs is a heavy invest and also increases operating costs.

Furthermore, O&D control has to be secured in the GDS by additional functions like 'married segments control' and 'journey data' in order to prevent cheating. If O&D control for a connecting itinerary A–B–C gives availability in a class that is not available at the local O&D A–B then passengers are tempted to book the connecting O&D A–B–C and then cancels the leg B–C afterwards. This has to be prevented. Married segment control recognizes such cancellations of parts of the itinerary and allows it only if the remaining part B–C still has availability in the class that was booked.

O&D forecasting also requires booking data at the O&D and point of sale level. As inventory systems usually store booking counters only at the leg/class level a new data feed based on PNR has to be set up from the airline's reservation system to the RM system. Trip building and PNR interpretation is a task that should not be underestimated.

Also the organizational complexity increases. With leg control it is easy to geographically divide the airline network into parts for which a revenue manager is responsible. With network control there is a dependency between tasks at the O&D level (forecasting, availability) and tasks at the leg level (overbooking, bid price). This requires intense communication between demand analysts and route controllers in order to take coordinated actions on the revenue performance of a flight.

Handling of small O&Ds

Many connecting O&Ds have little demand because of long connecting times or big deviations in the routing. Only a few passengers that want to fly from London to Oslo, for example, accept a deviation via the hub Frankfurt.

In Figure 3 all O&Ds of a larger European network carrier have been sorted by decreasing traffic volume. The graph shows that the biggest 20 per cent of all O&Ds already cover 90 per cent of all passengers.

One should not forecast the remaining 80 per cent of small O&Ds at the lowest level for two reasons. First, it requires substantial investment in hardware and IT infrastructure to forecast many thousands of O&Ds at the lowest level of detail. And second, forecasting
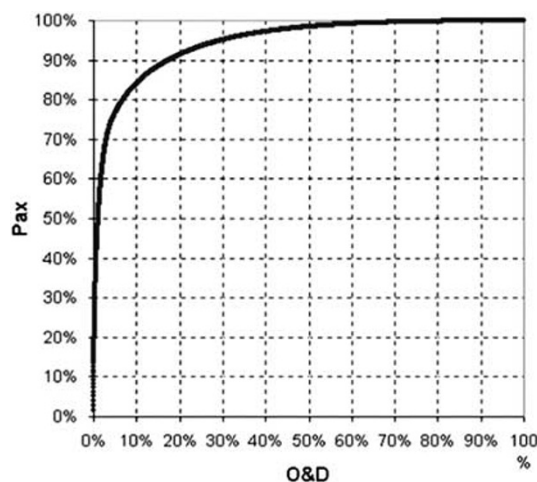

Figure 3: Distribution of O&D sizes.

low-demand O&Ds runs into sparse data and small numbers problems. If most departures have zero demand, it is impossible to forecast exactly for which future departure we can expect a booking request and an average forecast close to zero is wrong for all the departures. Hence it is a good idea to aggregate low-demand O&Ds. This can be done by aggregating over booking classes and points of sale or by breaking up the connecting O&Ds into their legs and aggregating them in pseudo-leg buckets.

Change management

The step from leg to O&D control is much more than replacing some IT tools. It requires a change of mind-set and business processes. If the involved people do not understand and accept the network RM principles they can screw up the whole benefits by taking wrong actions.

Looking back, one of the biggest challenges at Lufthansa in the evolution from leg to O&D control was the change management process. Some months after I joined Lufthansa back in 1995, the cutover to bid price O&D control took place. I still remember all the baskets of telex messages from sales people that were sent to the RM department in the weeks after cutover. Most of them blamed the project team that they got wrong (not enough) availability.

Some messages uncovered real bugs, but in the vast majority of all cases the sales people did not understand why their markets now got less availability on a flight than another markets – the basics of O&D control.

This happened although the project team had performed intense roadshows through all parts of the organization explaining the new O&D logic. You can never communicate enough.

Especially in such situations, but also in general, it helps if RM is anchored at top management level within the airline's organization and gets the right backing in the permanent fight between RM and sales that is mainly caused by different targets. For the acceptance of O&D control it helps if the sales targets and incentives are in line with availability control strategies.

MIGRATION

Network RM affects all three components of RM (forecasting, optimization and availability control) and different migration orders are possible. It can be a big bang or a gradual migration.

From a risk management point of view it is a good idea to break it up into several steps. As shown in Figure 4, all three components of RM
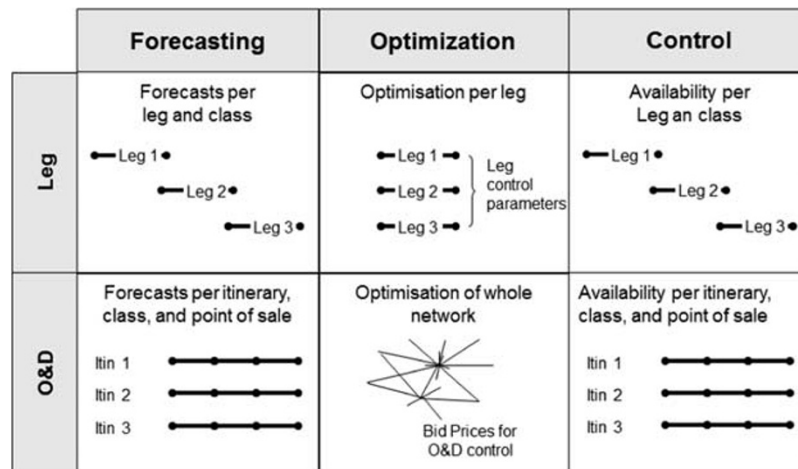

Figure 4: Leg and O&D options for the three RM steps.

can be either at the leg or the O&D level, but not all combinations make sense.

O&D network optimization, for example, needs O&D forecasts. It is necessary to enhance the forecaster before the optimizer, or in parallel. And if O&D optimization is already implemented it should be used for O&D control. An interesting option is to start the migration at availability control, that is, to use leg forecasting and leg optimization for O&D control. This is possible if the leg optimization algorithm calculates so-called 'bid prices'. This is especially interesting as O&D control alone already achieves about half of the revenue gains of a full network RM implementation.

Lufthansa, for example, first introduced O&D control in 1995, then O&D forecasting in 1998 and as a last step network optimization in 2003.

CONCLUSIONS

Going from leg to O&D control is an interesting journey for an airline. Those who have already experienced it know what I mean. Despite all challenges it is a must for all network carriers with substantial connecting traffic in order to improve their bottom line.

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