

Anchored Search and Two-Step Shopping in Airline Distribution: Enhancing Fare Integrity and System Performance

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ABSTRACT

Airline distribution has experienced a paradigm shift from static fare filings to dynamic offer optimization, making the integrity of fares and the performance of multi-leg shopping journeys challenging to achieve. Classic round-trip pricing systems assess all potential paths between the return legs in parallel, making calculations excessively computationally intensive, causing failed fares and screen PNR errors. Anchored search and shopping solutions to these systemic problems have implemented one-way dependencies between the fares assessed for each phase, where the outbound leg is priced first to set up the anchor with frozen business attributes such as fare brand, class, and combinability logic. Potential return fares are then assessed on the condition that they are exclusively consistent with the pre-set anchor, making the paths fully compatible. This approach makes the pricing problem complexity switch from the original exponential to the new linear problem, making the solution less costly and more efficient while producing deterministic fares. On the commercial front, the solution helps improve conversion efficiency by removing the problem of price mismatching, helps improve the confidence level of distribution partners by making the fares more predictable, and allows the company to lock its revenue by blocking the use of incompatible fares. Additionally, the solution allows for the provision of customer-focused retailing by retaining the customer's intent signals throughout, hence allowing the construction of relevant offers, including target-related bundling, facilitating revenue optimization.

Keywords: Anchored Search, Two-Step Shopping, Fare Integrity, Sequential Pricing Architecture, Airline Distribution Optimization

1. INTRODUCTION TO DYNAMIC AIRLINE RETAILING ARCHITECTURES

The aviation distribution industry has been going through a paradigm shift, with airlines gradually abandoning traditional fare-filing processes in favor of real-time offer-generation platforms. Today, the future of airline retail architecture must address both the business need for personalized Pricing and the technical need for System Reliability and Performance. This industry shift aligns with the general trend of the e-commerce world, in which consumers have demanded higher levels of transparent Pricing across all retail categories. This shift was further catalyzed by the adoption of new generation distribution standards that allow carriers to transition out of static inventory management processes and into Offer-BASED retail models [1].

Revenue management has become the "nervous system of an airline's operations," significantly impacting the procedures followed by airlines in optimizing inventory and prices. The field of revenue management involves forecasting, optimization, and pricing that significantly influence an airline's profitability. Airline companies are faced with the task of fulfilling the two contradictory aims of reaching high load factors and achieving the highest possible revenue per seat, an exercise that demands advanced analytical functions. The convergence of revenue

management principles with new distribution systems offers fresh avenues in fulfilling customers' expectations, presenting difficulties related to consistency in fares and the ability of the systems to scale [2].

Existing legacy systems utilized pre-filed fare databases, with static fare rulesets to provide predictable but rigid retailing schemes. Modern systems, however, calculate dynamic offers based on real-time inventory, passenger information, and competitive analysis. Such a paradigm change brings about complex calculations for determining prices, primarily due to fare combinatorial conditions that need to be checked for multiple factors at the same time, specifically for multi-segment paths. This scenario is further complicated in high-volume distribution systems, where systems are forced to respond within milliseconds, thus being constrained with limited computational resources to check fare validity. Airlines operating in different distribution schemes, ranging from direct online systems to agencies and business booking solutions, are challenged to ensure fare consistency while being capable of processing millions of shopping transactions per day [1].

The complexity in airline fare management has increased with the growing adoption of additional fare products by airlines, including various levels of airline brands, service bundles, and customer segment-based fare products. Each additional fare product contributes to an increase in the complexity of combining prices, which is more complex when it comes to one-way and return airline tickets. This makes it essential for airlines to have a distribution infrastructure that can support the increased complexity without impacting the customer experience in terms of response times and prices. This has led to the evolution of various architectural patterns aimed at addressing the combinatorial complexities involved in multi-leg pricing scenarios while retaining flexibility in revenue management strategies for competition in the market [3].

2. FARE COMBINABILITY ISSUES RELATED TO ROUND-TRIP SHOPPING

The traditional round-trip shopping model tests both the outbound and return availability and pricing in a single monolithic transaction, causing exponential computational complexity as the number of possible fare options increases. The airline fare management system is a complex process requiring the synchronization of revenue management systems that optimize the allocation of fares and pricing engines that build the customer fare options from the field fare products. The complexity is further escalated when the airline operates a large fare product portfolio to meet the various fare management needs of its customers. This occurs when the outbound fares are subject to directional constraints by the fare rules on the possible fares to combine for return fares derived from various inbound fares [3].

Paths where the fare values are invalid form a very important error category for the traditional shopping model. Filed fare structures often include directionally biased restrictions such as the requirement that the fare values for both directions must have the same booking class, fare basis code, or brand designator. Further restrictions follow from minimum stays, advance purchase rules, and day-of-week fare structures, which, for asymmetric directions, are not the same. If shopping models are checking all possible combinations without pre-filtering for validity, they continually offer the customer invalid fare pairs, leading to repricing errors during checkout that result in a fare increase or a last-minute cancellation. Reasons for the inefficiency include the mismatch between revenue management requirements and the capabilities of the distribution system functionalities [3].

Carrier pricing models further exacerbate the complexity involved in evaluating the combinability of fares. Low-cost carriers' models do prove that highly competitive point-to-point fares can drive demand share, but at a cost of simplified fares with more relaxed combinability rules. Carriers that still operate on a traditional network model with their hubs and spokes experience more complex fares in terms of requiring connected fares that compete well against point-to-point fares while still keeping within network revenue maximization rules. Indeed, competitive forces in a mix of different carrier models exert pressure for more complex fares that can dynamically adapt to changes in market conditions, but afair all, this is only a challenge that results in inefficient handling of this complexity through current shopping systems [4].

The infrastructure cost of the combinatorial price process goes beyond that of computation, implying additional network latencies, memory requirements, and cache performance impacts. Price engine computation requires the retention of fare rule databases, inventory states, and computing contexts for each combination under evaluation.

High-volume shopping hours may involve the execution of millions of price requests per hour, which flood the distributed price infrastructure, thereby leading to performance impacts that ripple through the distribution network. In regard to computation, the centralized evaluation framework does not allow for efficient caching mechanisms since each round-trip combination corresponds to an individual pricing scenario with very minimal reuses within succeeding customer search or session contexts. Customer experience impacts occur most obviously with regard to the failure rate within the checkout process, where surprises within price increments may be identified as the primary factor within the failure rate pertaining to conversion rates. Accordingly, customer distrust is fostered with additional operational expenses pertinent to customer support and distribution disputes associated with performance impacts within customer retention efforts at optimized price points." In other words, "customer experience impacts particularly within the checkout process about failure rates...may be attributed as the primary factor about failure rates for conversion rates" due to "surprises about price increments." This indicates customer distrust, with additional operational expenses pertinent "to customer support and distribution disputes

Challenge Category	Traditional Shopping Impact	System Consequence
Invalid Fare Combinations	Directional restrictions not pre-filtered	Repricing failures at checkout
Booking Class Mismatch	Same class required both directions	Price increases during purchase
Minimum Stay Violations	Asymmetric directional rules	Customer booking abandonment
Advance Purchase Conflicts	Day-of-week pricing asymmetry	Invalid fare pairings presented
Point-to-Point vs Network	Simplified vs complex fare structures	Competitive pressure on complexity
Hub-Spoke Pricing	Connected itineraries with restrictions	Revenue optimization conflicts
Infrastructure Overload	Millions of pricing requests hourly	Response time degradation
Cache Inefficiency	Unique combinations per search	Minimal result reusability

Table 1: Fare Combinability Challenges in Traditional Shopping Systems [3, 4]

3. SEQUENTIAL PRICING ARCHITECTURE: ANCHORED AND TWO-STEP MODELS

"Anchored Search Architecture" significantly remodels the traditional round-trip shopping process, thereby incorporating one-way dependency between the outgoing and incoming pricing cycles. However, the optimization of mixed fares involves complex mathematical formulations that address revenue maximization objectives, in addition to consideration of operational constraints. There arises a challenge in deciding the optimal fare product bundles, considering that these products not only embody revenue-maximization potential but also incur complexity costs in managing and disseminating these products over varied channels. This dilemma becomes more acute when considering personalized extensions, treating customers in a manner that retains efficiency, particularly within the shopping process [5].

In anchored shopping phase one, candidates for only outbound flights are evaluated and priced, and a set of valid offers with full fare rule data, brand, cabin, and combinability information is produced. A candidate outbound flight is chosen by the customer, which serves as an anchor to determine the compatibility constraints for subsequent inbound flights to price against. In this way, there exists a beauty of architectural decoupling, which changes the complexity of pricing from assessing all possible round trips to profile assessment for inbound flights alone, which are compatible with the anchor flights, following some operations research ideas to break a tough optimization problem into a series of stages with decreasing solution spaces, at which a decision needs to be made [5].

The outbound anchoring mechanism captures the Fare State with multiple facets that define subsequent outbound pricing. Most basically, the anchor defines the Fare Basis Code, Booking Class, and Brand Designator that will define subsequent inbound compatibility. Filed Fare structures generally demand directional consistency on these aspects. That is, given a selection in the Premium Economy Cabin with a certain Fare Family, subsequent choices on the inbound leg must be compatible with Premium Economy fares that reside within the same family. The anchor further retains the Fare Pricing context defined by Fare Currency, point-of-sale information, customer type indicators, and any Discounts or Promotions used. Such context retention is essential in that it enables the subsequent inbound prices to be computed in the same commercial environment as the outbound choice, thereby removing a troublesome source of failure for subsequent repricing [5].

Revenue managers are aware that for successful pricing, there is a need to take into consideration the overall journey and not individual segments. The two-step pricing process also creates a temporal gap to achieve advanced pricing, which is compatible with customer behavior. Following the selection of the outbound anchor, there is also consideration for customer intent, which is inferred based on the selection to guide inbound pricing. The carrier has to balance on several fronts, such as maximizing load factor, maximizing revenue per available seat mile, and competitive offering with other carriers and modes. The architectural design admits efficient execution for achieving multi-objective optimization [6].

Architecture Element	Function	Constraint Established
Outbound Anchor Creation	First phase pricing validation	Fare basis code locked
Booking Class Lock	Directional consistency enforcement	Same class for return required
Brand Designator Fix	Family compatibility	Brand alignment across the journey
Pricing Context Preservation	Commercial condition retention	Currency and point-of-sale frozen
Customer Segment Capture	Discount and promotion application	Consistent promotional treatment
Inbound Compatibility Filter	Second phase bounded evaluation	Only anchor-compatible options shown
Temporal Separation	Intent signal capture window	Customer behavior observation enabled
Multi-Objective Balance	Load factor and revenue optimization	Competitive positioning maintained

Table 2: Sequential Architecture Components and Mechanisms [5, 6]

4. INFRASTRUCTURE AND PERFORMANCE OPTIMIZATION

The sequential pricing structure yields verifiable infrastructure improvement in terms of efficiency. The aviation market has undergone radical shifts due to deregulatory initiatives that removed pricing regulations as well as route constraints. The competition being experienced by companies operating in deregulated markets is enhanced to the point of requiring both pricing agility and infrastructure. The underlying technology infrastructure of the aviation retail market has to facilitate adaptive pricing actions that are taken to counter competitive actions without undermining the technological infrastructure performance. The aviation companies have taken proactive measures to implement a distributed computing infrastructure that can rapidly scale during off-peak times and optimize use when traffic is normal [7].

Pricing engines are recognized as the most computationally expensive part of the air shopping applications, requiring large computing resources during periods of high traffic. By minimizing the number of operations involved in the pricing process via anchored evaluation, airlines can also minimize the resource consumption by the CPU, memory, and network utilization. This directly results in cost savings on the underlying infrastructure because the cloud-based air shopping platforms have been reported to charge based on the consumption of computing resources. The cost benefits of the sequential approach become substantial for airlines with large route structures involving intricate fares, where millions of possible combinations would have been evaluated by a traditional air shopping approach for popular origin-destination pairs [7].

Optimizing response time is one of the most important performance advantages of bounded pricing evaluation. Studies that focus on analyzing user behaviors within digital commerce domains have shown that the page loading time is directly related to conversion ratio and customer satisfaction measures. Users tend to view digital interfaces as requiring instant responses, which degrade rapidly once the time crosses one second. Air carriers operating within digital distribution channels need to provide such high-performance aspects while also implementing complex processing algorithms that verify fares, validate the availability of inventory, and provide revenue management constraints. Anchored Architecture allows incremental processing of the results by displaying the validated outgoing options while continuing with asynchronous processing of inbound pricing, thus improving user experience factors [8].

The pricing results are deterministic because of the regulated alignment process that is enforced by the anchored compatibility filtering. In the classical shopping scenario, the causes of repricing failures are related to the selection of a combination chosen by the customer that violates pricing rules that are not accurately validated during search. In general, it happens during the checkout process that implements complete validation of the booking rules because of consistency requirements. Additionally, the anchored architecture implements complete validation during outbound anchor generation. In such a case, it is assured that all displayed inbound options are validated. The anchored architecture removes an entire class of issues that are related to repricing failure at checkout. The effectiveness of caching rises significantly because of better reusability of the calculations in case of sequential pricing models, because their outbound prices are cacheable and shared by multiple customers browsing the same route and date [8].

Performance Dimension	Traditional Shopping	Anchored Shopping	Improvement Area
Pricing Combinatorics	Exponential complexity	Linear complexity	Computational load reduction
CPU Utilization	High resource consumption	Proportionally reduced	Infrastructure cost savings
Memory Footprint	Large context maintenance	Bounded evaluation sets	Resource optimization
Network Bandwidth	Millions of combination requests	Sequential filtered requests	Distributed system efficiency
Response Time Threshold	Multi-second delays possible	Sub-second incremental delivery	User experience improvement
Result Delivery Model	Monolithic completion required	Progressive rendering enabled	Perceived latency reduction
Repricing Failure Rate	Rules validated at checkout	Rules validated at anchor creation	Deterministic pricing achieved
Cache Hit Rate	Minimal reusability	Shared outbound results	Enhanced caching effectiveness

Table 3: Infrastructure Performance Metrics and Optimization Gains [7, 8]

5. INFLUENCE OF COMMERCIAL FACTORS ON THE STABILITY OF THE DISTRIBUTION CHANNEL

Conversion rate optimization is the strongest monetary advantage of enhanced fare integrity with anchored pricing. The travel technology sector has quickly evolved in terms of consumer interface technology, with a higher need for seamless booking processes that do not contain many obstacles from search to completion of acquisition. Advances in distribution technology have zeroed in on higher completion rates by remedying typical pain points in acquisition, such as unanchored pricing, inaccessible checkout processes, and a lack of clarity on limitations. Carriers that utilize efficient pricing systems are capable of providing a stable user experience with an aptitude for increased conversion rates over traditional systems, with a real chance of pricing failure [9].

This affects channel strategy and financial dynamics between the parties. Travel agents and corporations value the interfacing of distribution sources offering stable and reliable prices. This brings about service costs associated with the service offered through the final booking platform, as agents investing their sales effort in the process are directly affected if the transaction does not go through. Today, service level agreements associated with the stability of prices are now a common occurrence in distribution agreements; financial penalties are applied if the airline exceeds the service level on repricing failure. Anchored architecture enables airlines to ensure stability in prices while still staying agile on prices [9].

The airline industry has appreciated the fact that the dimensions of airline service quality not only encompass the operational aspects of the airline's business, such as on-time performance and baggage handling, but also the entire customer experience that takes into consideration the shopping and purchase process. A study on pricing and the airline business model has concluded that perceptions of airline service quality have a profound effect on the customer's willingness to pay and brand loyalty. The distance component has also proved to have major implications for the optimal mix of airline services offered on long and short flights. Service quality is affected by the consistency of the distribution channel, credited with reducing the customer irritation level that derives from pricing inconsistency and check-out errors [10]. Revenue protection mechanisms have benefited from stronger enforcement of fare rules in sequential pricing. This also prevents customers from choosing and trying to purchase fares that would need manual handling, meaning customer service interventions, or revenue-displacing rules. These would typically be considered either unfavourable scenarios, which involve the sum of directional fares falling short of the airline's revenue protection levels, or will be considered as error-prone situations where customers have chosen a set of fares that either exceed airline rules on revenue, causing customer service interventions. Cost savings from operations can thus be achieved with reduced customer service involvement, hence a significant number of customer service calls for resolution on pricing, failures, and abandonment in traditional architectures of shopping. This is based on reference [10].

Commercial Metric	Traditional Challenge	Anchored Solution	Stakeholder Benefit
Conversion Rate	Price increases at checkout	Stable search-to-purchase pricing	Customer booking completion
Checkout Abandonment	Repricing failure friction	Eliminated price mismatches	Revenue capture optimization
Distribution Partner Trust	Unpredictable pricing outcomes	Service level commitment is achievable	Agency confidence strengthened
Transaction Fee Impact	Failed bookings after sales effort	Reduced failure rates	Partner financial protection
Service Quality Perception	Pricing inconsistency frustration	Seamless booking experience	Brand loyalty enhancement
Distance-Based Strategy	Route-specific service differentiation	Context-aware offer construction	Competitive positioning improved

Revenue Protection	Invalid combinations at checkout	Compatibility validated during search	Leakage prevention
Customer Service Volume	Pricing disputes and failure recovery	Reduced intervention requirements	Operational cost reduction

Table 4: Commercial Benefits and Distribution Channel Impact [9, 10]

6. Enabling Personalized Retailing Through Anchored Architecture

Anchored search supplies a supporting role to context-driven pricing with the establishment of customer intention parameters throughout a multi-leg purchasing process. There have been developments in quantitative problemsolving methodologies used in the field of air transport, which include methodologies for dealing with their multidimensional characteristics. Network planning, aircraft allocation, crew management, and revenue management are all interrelated solution spaces whose interaction results in determining profitability and efficiency for airlines as a joint solution space with shared objectives and constraints. Providing a solution to such a solution space requires computational models with a robust ability to perform large-scale optimizations with a variety of objectives [11]. Outbound selection offers behavioral cues such as favorite departure time, is sensitive to prices, as evident from cabin and brand selection, and is indicative of implied purposes. A customer choosing to depart early in the morning in a high cabin category indicates a business travel choice, which allows the algorithm to personalize the inbound offer for an evening return flight, including business-purpose related add-ons. Intent-based personalization offers greater relevance over anonymous pricing, where customers are treated as the same market, irrespective of individual identities. Customer context carried forward is a major step up from the individual legbased analysis, as traditional shopping considers the outbound and inbound as two different, non-related optimization problems, thereby forming an incoherent offer for the journey as a whole [11]. Ancillary revenue sources have emerged as an essential part of air transport firms' business models, and this auxiliary revenue source generates significant income for air transport companies. Various air transport firms have extended these auxiliary product offering services to include seat selection, baggage allowance, in-flight services, ground transport, and activities associated with destinations. The trend of utilizing overall auxiliary retailing has been influenced by current air transport firm merchandising principles, where air transport firms aim to maximize total income per passenger instead of focusing exclusively on base fare maximization principles [4].

It is visible through analysis that auxiliary revenue sources form an increasing percentage of overall air transport firm income, where air transport companies are also focusing on continuous research and development to devise novel revenue sources associated with hotels, car rental firms, and activity booking services [4]. The optimization of ancillary bundle offers can leverage the sequential architecture for informed offer construction. Following the determination of the outbound anchor with its corresponding fare brand and attributes, the architecture can build inbound ancillary offers that are complementary rather than redundant. This complemented bundling strategy can significantly optimize ancillary revenue per booking and increase the value added by reducing redundant offers. The strategy of progressive personalization throughout the booking path can become technologically viable through the separation of pricing phases in sequence, with the system monitoring the buying behaviors of customers during the outbound stage, detailing the preferences considered in viewing the offers and the respective viewing times. As advances continue in personalization technology, the underlying architecture of pricing will facilitate more sophisticated real-time optimization for offers in response to the dynamic preferences and behaviors of customers [12].

Conclusion

Anchored Search and two-step shopping are basic architectural imperatives for a scalable and reliable air distribution system and are the underpinning forces for the Sequential Pricing model. This model combats the problem of the combinatorial explosion found in classic round-trip calculations by overcoming the exponential complexity problem and enabling linear processing, which lowers system costs and transaction time. For the commercial benefits, the air distribution system will have improved benefits such as increased conversion rates through stabilization, reduced system operational expenditures through reduced repricing failures, and partner confidence. Furthermore, the model ensures the absence of revenue leakage by checking for the consistency of fares during the shopping process and preventing the system from considering invalid combinations that need human intervention. Beyond improving the

efficiency of air distribution systems, the anchored architecture lays the technical ground for a personal retail system by providing the intent signals for customers through the construction of contextual offers throughout the customer journey. For the continuing evolution of the air distribution system through the adoption of personalization and real-time systems, the Sequential Pricing Patterns will act as basic system building blocks, fostering a balanced air revenue system while maintaining system consistency on the demands raised by customers and system partners.

References

- [1] GGGI, "NDC Implementation Roadmap Development: Guidelines for Small Island Developing States," 2018. [Online]. Available: <https://gggi.org/wp-content/uploads/2019/01/NDC-Implementation-RoadmapDevelopment-Guidelines-for-Small-Island-Developing-States.pdf>
- [2] IATA, "Revenue Management: The Heartbeat of Aviation,". [Online]. Available: <https://www.iata.org/en/publications/newsletters/iata-knowledge-hub/revenue-management-the-heartbeatof-aviation/>
- [3] Ben Vinod, "The complexities and challenges of the airline fare management process and alignment with revenue management," Springer, 2009. [Online]. Available: <https://link.springer.com/article/10.1057/rpm.2008.43>
- [4] Paolo Malighetti et al., "Pricing strategies of low-cost airlines: The Ryanair case study," Journal of Air Transport Management, Volume 15, Issue 4, 2009. [Online]. Available: <https://www.sciencedirect.com/science/article/abs/pii/S0969699708001221>
- [5] Thomas Fiig, Karl Isler, Craig Hopperstad, and Peter Belobaba, "Optimization of mixed fare structures: Theory and applications," Springer, 2009. [Online]. Available: <https://link.springer.com/article/10.1057/rpm.2009.18>
- [6] Martijn Barten, "Airline Revenue Management: What is It, How Does it Work & Examples," Revfine, 2024. [Online]. Available: <https://www.revfine.com/airline-revenue-management/>
- [7] Severin Borenstein & Nancy L. Rose, "How Airline Markets Work...or Do They? Regulatory Reform in the Airline Industry," National Bureau of Economic Research, 2014. [Online]. Available: <https://www.nber.org/books-and-chapters/economic-regulation-and-its-reform-what-have-we-learned/howairline-markets-workor-do-they-regulatory-reform-airline-industry>
- [8] ThinkwithGoogle, "The need for mobile speed,". [Online]. Available: <https://www.thinkwithgoogle.com/qs/documents/2340/bc22e/TheNeedforMobileSpeedFINAL1.pdf>
- [9] Mike Coletta, "Phocuswright's Travel Innovation and Technology Trends 2025," PhoCusWright Inc. [Online]. Available: <https://www.phocuswright.com/Travel-Research/Research-Updates/2025/Travel-Innovation-andTechnology-Trends-2025>
- [10] Xavier Fageda and Ricardo Flores-Fillol, "Service-quality and pricing strategies in the airline industry: The role of distance," Economics of Transportation, Volume 40, 2024. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2212012224000406>
- [11] Cynthia Barnhart and Barry Smith, "Quantitative Problem Solving Methods in the Airline Industry," Springer, 2012. [Online]. Available: <https://link.springer.com/book/10.1007/978-1-4614-1608-1>
- [12] Abby Crotty, "Airlines set ancillary records, lean into new revenue streams," PhocusWire, 2025. [Online]. Available: <https://www.phocuswire.com/airlines-set-ancillary-records-lead-into-revenue-streams>