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Applying Yield Management in the Mobile Broadband Market

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Abstract

Similar to the airline and hospitality industries before it, the mobile communications industry is concentrating on significant efforts to derive greater value out of existing assets and improve the financial returns from major investments in new technology. This paper builds on the concept of "yield management," discussing its application to mobile communications services, and provides examples demonstrating how yield management techniques can enable communications services providers (CSPs) to increase revenue, reduce CAPEX, and help address the spectrum crunch in the mobile broadband market.

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Introduction

Yield management is the umbrella term for a set of strategies that enable capacity-constrained service industries to realize optimum revenue from operations. Its core concept is to provide the right service to the right customer at the right time for the right price (Enz & Withiam, 2001).

By most estimates, large, modern airlines, such as United/Continental, American, and Lufthansa, gain 4 percent to 5 percent of their revenue, i.e., approximately US$1B each, from the use of yield management techniques. Pioneered by the airlines thirty years ago, yield management has been successfully adopted by other industries, such as hospitality, car rental, retailing, utilities, and transportation.

Recent wireless market trends, such as mobile users' growing appetites for mobile data, combined with technological advances that have led to the definition and interpretation of a mobile broadband policy and charging infrastructure, make the utilization of yield management in mobile networks both increasingly desirable and feasible. In this paper we'll discuss the value proposition of yield management, review the yield management techniques which were successfully applied by the airline industry, consider how the similarities and differences between the airline and telecommunications industries may influence the applicability of yield management to the business of mobile broadband services providers, and present a sample yield management solution for mobile broadband that will help enable communications service providers (CSPs) increase revenue and reduce capital expenditures.

The Yield Management Value Proposition

Yield management, a key strategy in revenue management, encompasses a variety of concepts and analytical tools that aim to enable enterprises to get more (typically revenue and profits) from their existing assets. The term is used to describe techniques to allocate limited resources, such as airplane seats or hotel rooms, among a variety of customers, such as business or leisure travelers (Netessine & Shumsky, 2002). Typically the allocated resources are either goods or services that are perishable — they cannot be stored by the provider and offered to customers at a later time. For example, an empty airline seat can be sold to new prospective passengers only before the plane takes off. From an economic perspective, the airline seat is like a fruit that spoils. The moment the airplane door is closed, the seat has perished. Similarly, if the capacity of a wireless network goes underutilized at any given time, then the opportunity to monetize it is gone forever because the capacity that was unused at the present moment cannot be sold later even at a deep discount.

The value of yield management is most apparent when the marginal cost of offering a particular product or service is close to zero or negligible in comparison to the fixed cost already incurred by the enterprise. For example, if the empty airline seat is filled at the last minute by a paying passenger, the extra cost incurred by the airline will be minimal — often limited to a bag of pretzels. Thus, in cases with negligible cannibalization of sales, the money paid by the extra passenger goes directly to airline's bottom line.

The value of yield management for mobile broadband is that it provides an opportunity for service providers to manage the quality of a user's experience while achieving increased revenues in the context of the exponential CAPEX costs associated with servicing the global demand for mobile broadband services. The use of yield management techniques and the introduction of supporting infrastructure can help CSPs monetize mobile broadband. It also provides CSPs with effective tools to significantly help address a shortage of spectrum — what U.S. Federal Communications Commission Chairman Julius Genachowski has termed the "spectrum crunch."

Lessons Learned by the Airline Industry

Yield management is widely considered to have been invented by the deregulated U.S. airlines in the 1980's and, although the techniques were gradually adopted by other industries, such as the hospitality and retail industries, the airlines are still considered to be the leading practitioners of the art. Many of the lessons learned by the airlines can be applied to the telecommunications market (Humair, 2001).

Since their deregulation in the 1970's, the airlines have had to make the most out of their investments in their fleet of airplanes to remain competitive, and over the past 40 years they've developed many techniques to enable them to increase profits from these large fixed investments.

The Role of Market Segmentation and Pricing in Yield Management

Market segmentation (the process of classifying customers into groups, or segments, based on observed, or inferred characteristics, behaviors and preferences) enables an enterprise to offer products and services targeted at the buyers in each segment. In the early 1970s, airlines began offering different fares for the same flights. One of the first such offerings was BOAC's (presently British Airlines) early-bird bookings, which involved selling discounted seats to passengers who were willing to buy their tickets at least 21 days in advance.

Nowadays, airlines typically segment their market as business, leisure, groups, students, children, youth, and seniors. It is quite normal for an airplane cabin to include a mix of travelers, each of whom paid a different fare for exactly the same flight. Differences in fares for the same flight are driven by the offered quality of service (business vs. coach), as well as many other factors, such as existing take-up of tickets, advance purchase, ticket refundability, weekend stay, etc. Moreover, differences in fares for different flights for the same market segment are not just driven by the disparity between the costs of serving particular routes, but also by competition and value offered to particular market segments, for example, red-eye flights vs. day-time flights, day of the week, season etc.

The Importance of Forecasting

Like many other businesses, airlines attempt to profitably match their customer demands with available supply. The challenge is that both the demand and supply are hard to predict. The shape of random fluctuations of customer demand for airline seats is impacted by many factors, including seasons, weather, the port of origin and destination, the state of the economy, etc. While the supply side is more predictable, it also randomly fluctuates due to airplane malfunctions or unexpected weather-related airport closings.

Accurate forecasting is a key ingredient that can impact the success or failure of other yield management techniques. For example, the effectiveness of overbooking algorithms depends on accurate predictions of passengers' bookings, cancellations, and no-shows. Similarly, effective market segment pricing depends on the availability of an accurate market segment demand forecast. Lastly, forecasting of the future demand is a key ingredient in capacity planning which drives airlines capital investment in airplane fleets.

The Practice of Overbooking

Occasionally, a booked passenger does not show up for their flight. In this case, the airline stands to gain extra revenue if it manages to sell what would otherwise be a potentially unused seat. Based on this realization, for many decades airlines have engaged in the practice of overbooking — booking more passengers than available seats. The level of overbooking is carefully determined based on the historical record of "no show" customers.

The overbooking practice attempts to balance the lost revenues due to empty seats with the negative consequences of instances when the number of customers who arrive at the gate exceeds the number of seats on the plane. The latter scenario leads to both customer dissatisfaction and financial penalties, as the airline needs to compensate the bumped (i.e., not given seats they had booked on the flight they had chosen) passengers.

According to the U.S. Department of Transportation, in 2009, 13 out of every 10,000 passengers were bumped on domestic U.S. flights — or 762,422 out of 582 million. Most of the overbooking cases do not lead to increased customer dissatisfaction, as the overflow is handled by identifying some passengers who voluntarily agree to take a later flight in exchange for financial reward. For example, approximately 60,000 passengers boarded 450 American Airlines flights on a sunny day at the end of March 2010 in Dallas, Texas — 17 flights had a total of 50 oversold seats; 48 people volunteered for a later flight; and two people were bumped involuntarily (Mouawed & Higgins, 2010).

Overbooking is also routinely practiced by hotels and rental car agencies. Facing competitive pressure, many hotels offer their customers the right to cancel reservations without any penalties providing that the cancellation takes place by a certain time on the day of service. As a result, customers, who are not incentivized to perform timely cancellations, frequently cancel at the last minute. Since last minute cancellations do not give hotel management adequate time to find other profitable customers for newly available rooms, hotels protect their revenue streams by practicing overbooking.

Applying Yield Management to Telecom

Similar to the airline industry, the telecommunications industry evolved from a regulated market to a highly competitive, unregulated market. As a result, just like the airlines, CSPs are under constant pressure to derive greater value out of their large sunk cost investments. To analyze which time-proven yield management practices developed by the airlines and hospitality industry can be effectively adopted and improved on by the telecommunications industry, a good starting point is to consider similarities and differences between the two industries in the context of yield management.

Similarities Between the Airline and Telecom Industries

There are several similarities between the telecommunications and airline industries that support the rationale to apply the yield management techniques originally developed for the airlines to telecom (Humair, 2001). Both have:

- **Externally imposed restrictions on capacity expansion** – In the U.S., for example, the Federal Communications Commission allocates spectrum to wireless phone companies. The allocation process for additional spectrum is arduous and lengthy, forcing CSPs to simultaneously pursue other means to satisfy the growing demand for wireless services. Similarly in the U.S., the Federal Aviation Administration limits the number of takeoff and landing slots available for handling traffic at the nation's busy airports. So, just like CSPs, airlines are forced to deal with the externally imposed confines on their capacity to handle peak traffic.
- **Large sunk cost combined with low marginal cost** – Facilities-based mobile CSPs must invest huge amounts of money to build up their network infrastructure and procure wireless spectrum licenses. In addition to this initial expense, CSPs incur large capital costs to keep up with technology evolution. For example, during the first half of 2010, AT&T used $7.9 billion of its cash flow to invest in new capital development, up from $7.0 billion a year earlier, with a focus on increasing its mobile broadband and wired broadband

connection speeds to keep up with demand. In 2010, Standard & Poor's estimated that AT&T continued its spending in the second half of 2010 and finished the year spending its full budget (Standard and Poor's, 2010).

In carriers' networks the marginal cost of providing a connectivity service (e.g., supporting a phone call or a web browsing session) is very low by comparison to the CAPEX expense required to establish the network.

- **Perishable inventory** – Just like an empty airplane seat, unused network capacity represents a lost revenue opportunity. If the available network bandwidth is underutilized at any given time, then the opportunity to monetize that bandwidth is gone forever, just like the opportunity of selling an airplane seat is gone once the airplane takes off.

Additionally, new mobile bandwidth management solutions increase the similarities:

- **Reservations** – The mobile network's bandwidth management functions enable CSPs to reserve bandwidth for specific customers in advance of their actual bandwidth usage. When a customer's reservation is in effect, the network ensures that the customer receives the requested bandwidth even if there are other customers competing for the same bandwidth. In the context of yield management, the reserved bandwidth is largely similar to a booked airplane seat except that, in the case of bandwidth, it is perfectly OK to allocate reserved bandwidth to other users at times when the customer who made the reservation is not fully utilizing their reserved bandwidth. As long as the entire reserved bandwidth is made available to the customer whenever they need it, the customer is not even aware that their underutilized bandwidth reservation enables the service provider to serve other users. In the airline seat analogy, it would be equivalent to an airline placing another passenger in an unoccupied seat whenever the seat's reservation-holding occupant gets up to stretch their legs during a long flight. While it is not a practical solution for the airlines, the scheme is perfectly practical for communications networks.
- **Pricing flexibility** – Real-time charging functionality provides CSPs with pricing flexibility at least on par with, if not better than that used by the airline industry. CSPs can charge based on the attributes of provided services, customer characteristics, context, network state, historical usage, etc.
- **Opportunity for up-selling** – An emerging practice within the budget airline sector is the provision of basic service at low cost with add-ons such as meals and checked baggage, all purchased with minimal overhead to the airline through customer self-service portals. CSPs can replicate this with value-added services and network features. For example, a CSP's basic, usage-based rated, mobile data access offer could be augmented with complementary add-on offers such as the ability to purchase increased bandwidth for short periods of usage (so-called turbo boost) or the purchase of fixed fee (usage insensitive) access for viewing, for example, a sports event video cast.

Differences that Present Challenges

There are also differences between the telecommunications and airline industries that present challenges to attempts to leverage in telecom the airlines' yield management techniques (Humair, 2001):

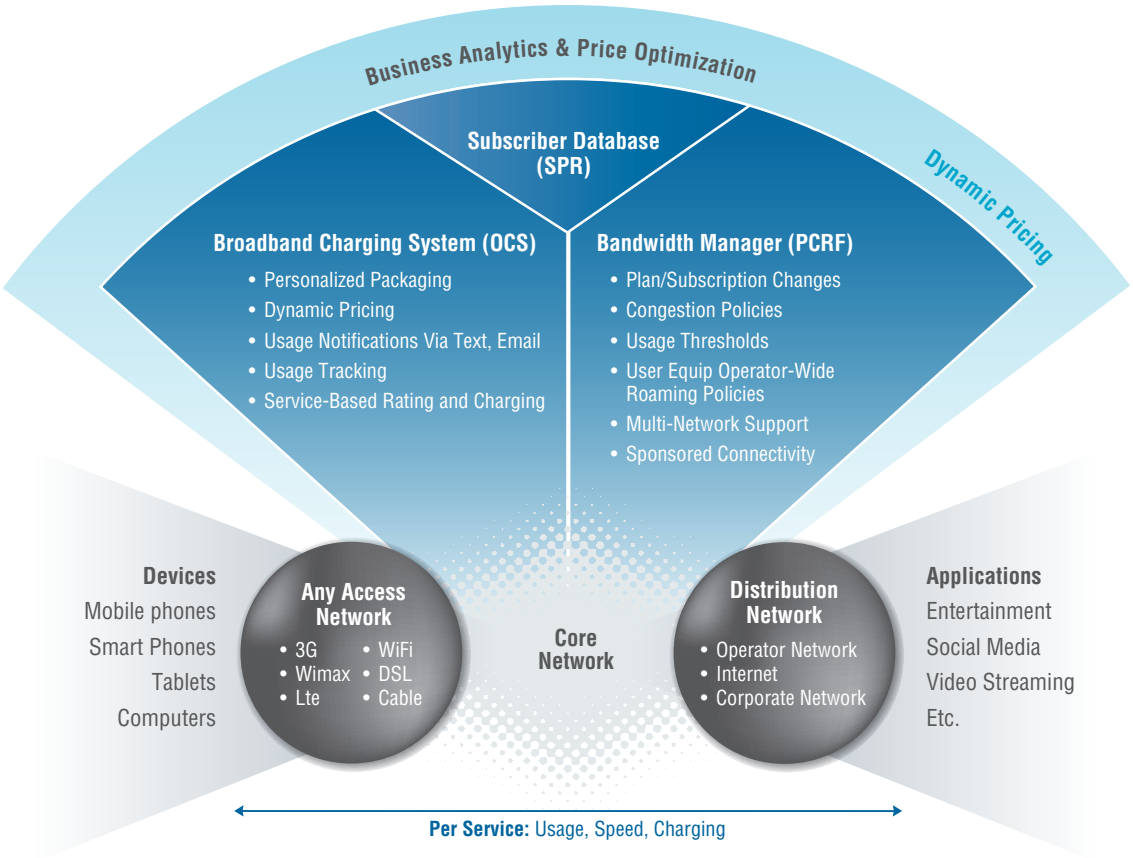
- **Low-value transactions** – The price of individual telecommunications services is often several orders of magnitude lower than the price of the airline tickets. Consequently, the telecom customers are often less price sensitive than airline ticket customers and the demand for telecom services frequently tends to be less price elastic. However, this phenomenon is not universal — price sensitivity (price elasticity of demand) is quite high in underdeveloped and developing countries. In addition, markets in developed countries, such as the U.S., include some segments that are price sensitive (youth, senior citizens, immigrants).

- **Network complexity** – Heterogeneous communications networks offering a large variety of communications services seem to pose a greater challenge to effective applicability of yield management than the airline networks, which essentially offer one service. However, the problem of complexity can be reduced by attempting to apply the yield management techniques to specific services and/or sub-components of the overall network.

A Yield Management Infrastructure for Mobile Broadband

Recent technological advances in mobile broadband bandwidth management and rating enable CSPs to leverage yield management techniques with a focus on revenue management and CAPEX reduction. To do so effectively, they need solutions that can support the charging and delivery of customer centric services, such as the Personalized Policy and Charging solution offered by Telcordia.

The Telcordia Personalized Policy and Charging solution is comprised of a complete ecosystem for the rapid deployment of service offerings and promotions. It enables CSPs to present subscribers with personalized service offerings, allowing the subscriber to choose specifically the services and add-ons they want for wireless data access.



Telcordia Personalized Policy and Charging Solution Enabling Yield Management

With this solution, when a subscriber attaches to the data network in order to start using their customized package, Telcordia® Bandwidth Manager instructs the core network to use the policy and charging rules required for the data session. These rules dictate the required service-level quality of service and appropriate charging characteristics for each service that makes up the subscriber's profile retrieved directly from the service provider's distributed subscriber database.

The core network manages the data connection so that the subscriber receives the desired services at the subscribed quality of service while the network is interacting with the Telcordia broadband charging system for usage monitoring, rating, and charging and discarding data traffic for services that are not part of the subscriber's profile.

Each of the Telcordia components generate detail records that can be retrieved along with core network detail records so that the service provider can assess the effectiveness of service offerings and make adjustments to existing offerings or create new ones. The feedback loop afforded by the technology also allows for new service offerings that can specifically accommodate network congestion or underutilization.

In addition, this data enables service providers to create network usage forecasts based on the analysis of mobile network capacity and traffic patterns. When integrated with a real-time charging component, it enables service providers to offer peak and off-peak pricing on a regional basis. For mobile broadband networks striving to drive increased usage, dynamic pricing concepts will enable innovative offers for users looking to try out mobile broadband services with introductory off-peak offers.

Using Yield Management to Increase Revenue

Improving Market Segmentation and Pricing

Market segmentation enables enterprises to cater products and services, including pricing, targeted at the buyers in each segment. The basic idea, which makes segmentation an effective tool to increase an enterprise's bottom line, is to charge more for products targeted at customer segments with a higher willingness to pay.

Initially, many providers of mobile broadband services initially offered single, "one-size-fits-all" access plans. However, it turned out that they were not capturing all of the revenue possible. They were forfeiting revenues from low-end customers for whom the service was too expensive while missing the opportunity to gain additional revenue from high-end customers, whose willingness to pay for mobile broadband services exceeded the price of the one-size-fits-all services. Some service providers partially addressed the issue by offering several levels of service (e.g., gold, silver, and bronze level tiers of service). However, while the more granular segmentation of tiered services leads to higher revenues than one-size-fits-all service, the tiered services still suffer the same shortcomings of those services and result in unrealized revenue potential.

The new mobile broadband infrastructure enables mobile broadband services providers to address the shortcomings of tiered pricing and increase revenue by leveraging high granularity segmentation (microsegmentation) of the mobile broadband market. Examples of microsegmentation include individual service add-on offerings, such as limited-time access to a specific website (e.g., ESPN) or individual application, such as email or Facebook. The mobile service providers who will be the first-to-market in exploring the potential of this newly available microsegmentation stand to effectively differentiate their offerings from competitors and significantly increase their bottom line (Smyk, 2010).

Monetizing Unused Bandwidth

CSPs stand to increase profits through the creative monetization of their unused network bandwidth. Similar to the empty airline seat, network bandwidth is a perishable resource with a very low marginal cost, so filling the underutilized bandwidth with revenue-producing network traffic will have a direct, positive impact on the CSP's bottom line. However, many CSPs squander this opportunity by allowing their network users to take advantage of the available extra bandwidth without any extra charge. Such practices not only waste revenue opportunities, but

also often lead to increased customer dissatisfaction with the CSP's services. The latter effect is the result of users experiencing inconsistent quality of service — the user who experiences a quality of service boost afforded to them by an underutilized network is frequently dissatisfied when, due to higher network utilization, the available bandwidth is pared back to the level which corresponds to the user's actual contracted level of service.

Instead of giving away underutilized network capacity, CSPs should seek methods of creative monetization. For example, the CSP's strategy could involve the following actions:

1. Introduce bandwidth caps for all service subscribers – for example, providing a "silver" customer with a maximum 2 Mbps regardless of how much bandwidth is actually available in the network.
2. Offer paid add-on services that are designed specifically to utilize the unused bandwidth (e.g., off-peak Facebook access, movie downloads, or email access). The add-on services would be targeted at highly cost-sensitive market segments consisting of customers who are willing to accept limited availability of the service in exchange for price reductions.
3. Consider offering discounted rates for off-peak usage if the basic tiered services include usage sensitive charging. In this case, the discounted off-peak rates may lead to increased off-peak usage (and thus increased revenue), however the CSP would need to assess whether increased off-peak revenues are eroded by the cannibalization of peak services.

In order to implement the above strategies, the CSP must be able to determine when the network resources are underutilized. Frequently, such determination can be performed in non real time. For example, the state of underutilized network capacity, the off-peak state, can be defined by a combination of time periods and/or network location, e.g. it may be determined that typically a particular set of wireless cells is underutilized during specific periods of time.

Monetizing Asymmetric Information

CSPs stand to increase profits by designing their service offerings to cater to a user's ambiguity aversion. To illustrate the concept, consider the dilemma faced by a mobile user, John, who desires to access an ESPN website to watch a football game on his smartphone. Cost-conscious John subscribes to a bronze service, which enables him to access any web site for $1 per 1MB of downloaded data. John's dilemma is that he has practically no ability to predict the total network charges that he will incur if he watches the entire game plus the associated pre- and post-game programming. The total charges will be determined by the length of the game and the associated programming, as well as the quality of encoding (codec) of the content. So while John can evaluate the benefit of watching the game (the upside), he has no ability to estimate the cost (the downside). Such a dilemma often leads customers to entirely give up on using the service.

However, to meet John's needs, the CSP could offer a $2 add-on service that would provide John with unlimited access to ESPN for 6 hours. The service would enable John to perform an unambiguous evaluation of both the upside and the downside of his decision to watch the game. If watching the game is worth more to John than $2, then, in accordance with the ambiguity effect, John is more likely to purchase the add-on service than decide to watch the game without it and incur unpredictable costs.

Things look a little bit different from the CSP perspective. While the specific amount of bandwidth downloaded by a single user, such as John, watching a game on ESPN is random and hard to predict, the CSP is in a position to collect statistical data that will enable it to estimate both the mean and volatility of the bandwidth usage. Armed with this data, the CSP can estimate the expected cost of providing the add-on service and set the price of the service to the level, which provides the CSP with a handsome profit on the aggregate of all the add-on service subscribers.

In the above example, the CSP charges the customer not only for providing the data transmission, but also for reducing the uncertainty associated with unpredictable data usage. The latter aspect of the service is analogous to services provided by insurance companies that provide fire insurance to remove the uncertainty associated with potential fire-related losses. Armed with statistical data, the insurance company prices its services to ensure that it profits on the aggregate of its customers even though occasionally the insurance company has to pay large fire loss compensations to its individual customers.

Dynamic Pricing

Market segmentation and associated segment pricing aims to maximize profits by fixing prices at levels that are optimal for targeted segments. Dynamic pricing encompasses adjusting the prices to changing market conditions and/or the status of the CSP's resources. For example, upon detecting that parts of the network are highly underutilized, the CSP may decide to lower the price for services, which are delivered based on the underutilized resources. However, dynamic pricing does not always entail price discounting. Faced with a large service demand, overloading parts of the network, the CSP may respond with dynamically raising selected prices for services, which use the overloaded part of the network. Note that using dynamic price increases to throttle back the overload traffic is typically superior to alternative overload handling methods which involve either broadly degrading the service below acceptable level (service degradation) or denying the service to selected customers (service rationing). All three methods (dynamic pricing, service degradation, and service rationing) address network overload by ensuring that the CSP continues serving the customers in the presence of demand overwhelming the network resources, however, only the dynamic pricing method leads to revenue increases.

Increasing Profits at Peak Utilization

Although dynamic price adjustments can be used as an effective mechanism to off-load the network during peak usage, periods of peak utilization by definition are synonymous with periods of peak market demand and, as such, should be assessed for opportunities to increase revenues. Just like the airlines, which increase ticket prices during peak travel days/times, and hotels, which increase prices during vacation season or when a large convention is in town, CSPs should assess the opportunity to charge higher prices during peak demand. Similar to airplane seating capacity and hotel lodging capacity, network serving capacity is limited. Thus, when the market demand is high, profit-oriented CSPs may seek ways to ensure that the resources are effectively utilized to handle market segments with the highest willingness to pay.

Auctions

In the previously described scenarios, the prices would have been posted by service providers either statically or dynamically to accommodate the market conditions. Auctions provide an alternative means of dynamically adjusting prices to match market conditions (Talluri & Van Ryzin, 2005). They differ from posted price mechanisms in that typically customers are the ones who offer a price they are willing to pay (their bid) and the CSP decides which bid to accept.

While auctions have been around for centuries, the recent success of online auctions, such as eBay and Priceline, has lead to a wide acceptance of the concept by consumers. There are a large variety of mechanisms that can be used to conduct the auction. The most popular are English auctions (the firm announces a progressively increasing sequence of prices, until there is only one customer left willing to buy at the announced price) and Dutch auctions (the firm announces a progressively decreasing sequence of prices, until there is at least one customer willing to buy at the announced price).

CSPs most likely could utilize online auction methods already popularized by Priceline and eBay. Following the Priceline model, the CSP could allow its customers to declare what they are willing

to pay for services and the CSP would either accept or reject these offers. The mechanism has proven to be quite effective in selling such perishable goods as surplus airline seats, and has been recently gaining popularity in selling discounted phone service. Another auction mechanism alternative is the eBay model of selling the service to the highest bidder.

The advantages of auctions are that they have the potential to uncover near-optimal prices without the need to estimate customers' demand and, generally, they require less information about customers than do alternative price-discrimination mechanism. However, auctions have been most often applied to a sale of items when either a relatively large expenditure or the item's value can justify in customer's mind the extra effort spent on auction participation. Since the services offered by CSPs are relatively inexpensive, CSPs should consider focusing their auctions on selling their priciest offerings. In addition, extreme care should be taken to ensure that customers can participate in CSP services auctions with great ease or pleasure. One technique would be to integrate a "game" into the auction.

Using Yield Management to Reduce CAPEX

CSPs engineer their networks to have sufficient serving capacity to satisfy peak service demand. If peak demand is forecasted to grow beyond the level for which the network is designed, then in order to avoid the deterioration of services provided to their customers, CSPs typically incur capital expenditures to expand their network capacity. However, yield management methods provide CSPs with alternative methods of handling growing customer demand without necessarily incurring these large capital expenditures: demand shifting and overbooking. In considering these alternatives to network expansion, the CSP should consider the tradeoffs, such as weighing CAPEX savings against possible revenue losses.

Demand Shifting

By shifting customer demand in either time or space, the peak network load can potentially be reduced. Shifting customer demand in time typically entails shifting demand from the peak usage time to off-peak. For example, the CSP may accomplish the shift by offering service discounts for off-peak periods or by simply discontinuing low-margin services during the peak-times.

Shifting customer demand in space involves enticing at least some customer segments to reduce their use of services in overloaded network cells. For example, the CSP may accomplish the shift by offering service discounts in underutilized cells and raising prices in overloaded cells.

Overbooking

In general, overbooking methods of yield management are concerned with increasing capacity utilization in a reservation-based system when there are significant cancellations. The goal of overbooking techniques is to increase the overall volume of sales for the particular capacity. It is one of the most mature and most financially successful areas of yield management.

Communications service providers have practiced overbooking since the beginning of the communications network. While telephone service providers sell their customers the convenience of making a phone call at any time, the reality is that telephone networks do not have the capacity to deliver on the promise if all their customers want to make phone calls at the same time. In the case of mobile data networks, overbooking implies that the CSP's aggregate bandwidth commitment to customers exceeds the total network capacity. The bandwidth management functions offered by integrated charging and policy systems enable the CSPs to effectively practice overbooking.

Summary

Every year yield management is credited with driving billions of dollars of revenue for the airlines and hospitality industries. Communications service providers can also benefit from yield management techniques, due to the characteristics of the mobile broadband market and recent technological advances. In particular, the CSPs may increase their revenues and profits through microsegmentation, overbooking, dynamic pricing, auctions, monetizing unused capacity, and/or extracting higher profits from peak demand. In addition, the techniques of demand shifting and overbooking may enable CSPs to reduce their capital expenses. In short, yield management techniques can help CSPs derive more value out of their existing network assets.

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