Business to business online revenue management.

OLIVEIRA, F. and RANA, R.

2008

18 Business to Business Online Revenue Management.

18.1 Introduction

The application of revenue management, known at the time as 'yield management', first began in 1970's in the airline industry. Airlines such as BOAC currently known as British Airways introduced limited discount fare products. Passengers who booked at least twenty one days in advance of the flight received a lower fare price but still shared the same compartment and service as the high fare customers in the aircraft. The airlines' purpose for this action was to try to gain revenue for the seats that otherwise would be left empty. The real challenge arose in determining the number of seat (protection levels) which should be offered to lower fare passengers without losing any revenue that would otherwise be gained from higher fare passenger.

Littlewood (1972) proposed a rule for solving optimal protection levels for two booking classes. He suggested that the protection level for the full fare class should continue to reduce as long as the fare for discounted seats satisfies $f2 \geq f1 \Pr(Y \succ s)$. Where, $f1$ is the average high fare, $f2$ the average discounted fare, Y is the random full fare demand and s is the remaining seats. This rule had many limitations due to the fact that it held five strong assumptions. It assumed 1) low fare customers book before high fare customers, 2) demand for fare classes are independent, 3) passengers do not cancel before the flight and always show up and therefore the airline does not overbook, 4) only single leg flights were considered, 5) the airline does not offer group bookings. Belobaba (1987) carried out research on optimal capacity allocation, he extended Littlewoods' rule to multi-fare classes and proposed an Expected Marginal Seat Revenue (EMSR) model. EMSR model holds the same five assumptions as the Littlewoods' rule. The EMSR is a popular model used by airlines for capacity allocation however it does not produce optimal solutions. Other research and surveys into the airline industry include Rothstein's (1975) model on how to adjust overbooking limits at various decision points that lead up to the target day. (Overbooking is an important feature of revenue management as cancellation and no shows occur commonly. If the airline did not over book then there would be empty seats available hence overbooking increases revenue.)

The success of using revenue management strategies in airlines has encouraged other businesses such as the National Car Rental firm, who encountered the problem of having to increase its profit significantly or otherwise face liquidation (Greenfield, 1996). They employed revenue management systems such as pricing strategy systems as an attempt to save the business. The application resulted in a U-turn for the firm towards profitability. Other services include Cruise lines (Gallego and van Ryzin, 1994), Lodging and hospitality (Bitran and Gilbert, 1996), and Passenger railways (Ciancimino et al, 1999).

We start in section 18.2 by introducing the benefits of using electronic commerce in business to business and analyze the impact of the internet on pricing, section 18.3, and supply chain management, section 18.4. Then in section 18.5 we discuss revenue management and the benefits of using its strategies in business to business electronic commerce within the service industry. We illustrate how it can be used as a tool to improve resource management and a firm's relationship with its customers, showing that

revenue management can be used as a strategic tool to gain competitive advantage. Finally, in section 18.6 we discuss the computational complexity and the algorithms involved in revenue management and section 18.7 concludes the chapter.

18.2 Business to Business Electronic Commerce (B2B-EC)

Electronic commerce is "commercial transactions occurring over open networks" (OECD, 1997). Commercial transactions include buying, selling or exchanging products, services and information. The open network being described is the internet. In our specific case we are analyzing business to business electronic commerce in the service industry. B2B-EC is when products or services are traded from a business to any other business over the internet.

Forrester expects a modest grow of commerce platforms from $1.2 billion in 2003 to $1.4 billion by 2008 (Bartels and Leaver, 2005). Sales made over the internet in the service industries have increased every year, particularly for travel, stock trading, electronic banking and insurance. Hence, for firms to remain successful they need responsive business models to continuously meet ecommerce needs.

The internet has the potential to change B2B-EC tremendously. Businesses with the aid of the internet are now able to reach out to a *Global* market. They are able to link up to many buyers anywhere around the world without having a relationship with the business in person. Small firms especially benefit since their services are promoted to new markets which they previously could not afford to be in contact with. It has increased opportunities for businesses both small and large to gain more customers at *Lower Costs* (Timmer, 2000).

Due to electronic commerce transaction costs are lower as the internet greatly reduces searching costs for buyers and sellers. The internet allows the buyers to explore for the most advantageous supplier and the sellers to gain potential customers without making physical contact. In the past when buyers purchased a service they would physically have to shop around going to many suppliers and most probably only locally, for convenience reasons. This is not only time consuming and costly but the buyer is bounded to use a supplier around his area and must accept the price available. Another cost which has extensively decreased is the cost of updating or altering information (i.e. price), sending and storing information. The pace of the performance of these activities has greatly accelerated i.e. by the click of a button (Lee and Lau, 1999).

Businesses are also able to enhance their *efficiency.* They can find out about products and services on their own accord, online, and buy directly from the supplier. Trading partners are able to communicate more directly with each other avoiding inefficient intermediaries (Turban and King, 2003). The use of the internet also allows immediate and economical access to precise detailed service information to a very large number of people simultaneously (Malaga, 2001). It has also reduced the need of paper and administrative costs (Ramaseshan, 1997). This cost reduction allows the supplier to price more competitively, and, consequently, the customers to purchase at lower prices (Bowersox, Closs and Cooper, 2002).

The internet makes *Information* available to both customers and suppliers in real time. Customers are better informed about the service and information such as service pricing, options, availability and delivery time. The supplier can obtain individual information about customers for customised service; this knowledge can then be used to

increase customer satisfaction, loyalty and as a result, have a competitive advantage over other suppliers. The supplier can capture the wealth of information the internet provides and use it to analyse customers' behaviour and market segmentation**.** It also provides the supplier guidance in developing new services or additional attributes to the services for both existing and new customers. The importance for a firm to have access to information is emphasized by Gates (2000) 'how you gather, manage, and use information will determine whether you win or lose'.

Websites are available 24 hours a day. This prevents customer frustration of waiting in a queue and also lifts the constraint of time for trading. Thus, *Accessibility* of the service has increased and more people are able to purchase the service at any given time. The global time difference of trading is also overcome. Internet technology can improve the quality and speed of *Integration* greatly, it allows easier coordination of activities within the firm and externally. It can be used to make information flow effortlessly from one part of the organization to another. Firms are able to depend on such communication to remain efficient and competitive (Angeles, 2000).

Therefore, the internet offers new prospects and mechanisms to collaborate and compete with millions of people and businesses online. The electronic market has powered firms to achieve these functions with increased effectiveness and reduced transaction costs, resulting in more efficient markets.

18.3 Flexible Pricing and B2B -EC

The characteristics of the electronic commerce have allowed businesses to move away from fixed pricing towards flexible pricing in order to increase effectiveness and efficiency (Bichler et al, 2002). The internet increases the speed of pricing decisions and firms are now faced with more frequent reviewing and changing of price in order remain competitively strong. This differential pricing, a mechanism by which a firm charges different prices across customers (price discrimination) and on the type of service provided (product differentiation).

Price discrimination is the practice of a seller charging different prices to different customers for the same or similar service with additional extras. Pigou (1920) described three different forms of price discriminates, *First-degree price discrimination,* this is when the supplier sells different units of its service for different prices and these prices may differ from customer to customer. *Second-degree price discrimination*, the supplier sells different units of its service for different prices. Customers who buy the same amount of the service pay the same price. Here price is dependent on the amount of service purchased rather than the type of customer. An example of this is volume discounts i.e. the more you buy the more you save. *Third-degree price discrimination*, here, the supplier sells its service to different types of people for different prices. This form of price discrimination usually applies for senior citizens' discounts or student discounts.

Product differentiation is when suppliers personalise their service by adding additional attributes to customize offers to specific customers or market segments. An example can be seen at the Odeon cinemas who offer tea and biscuits as part of their service for the elderly to encourage them to watch films during off peak times. They also offer parents and toddlers the deal of one toddler to go in for free again during off peak

times. The attraction of additional extras will persuade more customers during times where many seat otherwise go unsold and thus they are able to generate more revenue.

The airline industry practices differential pricing in a variety of forms. Airlines offer different types of customers' different fares i.e. senior citizen discounts and frequent flyers. They offer different classes of service i.e. first class, business class and economy. They also offer different sorts of restricted fares i.e. advanced purchasing. Telecommunications industry is another example where differential pricing is applied in many different forms. Telecommunication market offers different rates and service to business and residential customers. They offer volume discounts to business customers. They offer calling plans that offer discounted rates based on individual characteristics and usage patterns.

Businesses use differential pricing on the selling of services purposefully to gain revenue on the portion of the market that is willing to pay more than the average price or by offering price sensitive customers deals to convince them to purchase service which would otherwise go unsold. However differential pricing can have the opposite effect if the firm has failed to recognize market segmentation correctly and if differential pricing causes cannibalizations (i.e. customers from the high purchase segmentation start moving to the lower price segmentation) or arbitrage (the service is brought by a third party and at a lower price and sold on to customers at a higher price, the third party makes the profit of the difference). Since the internet makes information on customer behaviour readily accessible, firms are more able to see the effects of differential pricing and are more knowledgeable on market segmentation. They will also be able to deduce the effects of differential pricing, a negative consequence can be seen in real time and strategies can be altered accordingly.

The internet market has increased opportunities for B2B to improve their network by using another form of flexible pricing known as dynamic pricing. Dynamic pricing is defined as flexible pricing between supplier and buyer in response to supply and demand at any given time. Price changes as the supply and demand in the market changes. Dynamic pricing is usually used when there is uncertainty about the price, demand and supply of the service; it can significantly increase revenue, (Gressens and Brousseau, 2000). Figure 18.1 illustrates the different types of dynamic pricing models that can be used in business to business commences over the internet.

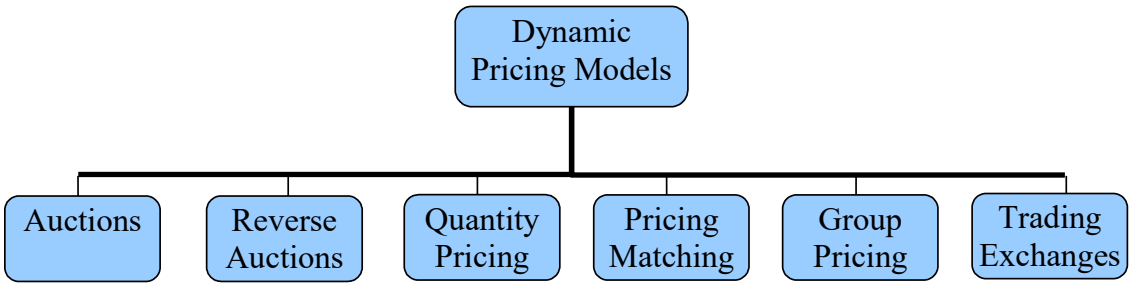

Figure 18.1 Types of Dynamic Pricing Model

Many businesses use online *Auction* to sell excess inventories. An online auction is the process where the supplier and buyer offers a service over the internet for bidding

and sells the service to the highest bidder. An auction allows the supplier to determine the value of its service. Business to business is usually carried out as a private auction. The internet allows the process to be carried out electronically with lower cost, wide array of support services and with many more buyers and sellers. B2B marketers' that use online auctions include consumer products, electronic parts, artworks, holiday packages and airline tickets. In the service industry B2B online auction is increasingly used by electricity transmission capacities, gas and energy options. In the UK, distributors bid for electricity from the suppliers. The distributors have the choice of bidding closer to the time they will need the electricity since they are better informed about the demand or can purchase in advance to ensure they will have enough supply.

The most commonly used mechanism for B2B is *Reverse Auctions.* Here the buyer sets the price that he is willing to pay and then sellers bid for their service. The buyer has more choice and will be able to receive the best price. The buyer places a bid for the service on a request for a quote (RFQ) system. The suppliers give quotes to the buyer and the supplier that gives the lowest price for the service is the one the buyer will purchase from. Reverse auctions used in B2B are usually set with the condition of entry only through invitation (Anon, 2001; Spring, 1999). The wider range of suppliers increases competitiveness and hence results in the reductions of prices. Many of the B2B electronic trading exchanges offer reverse auctions, for example Ariba (Hix, 2001).

A different type of dynamic pricing model is *Quantity Pricing* (Buscher and Lindner, 2004). This is when the supplier offers to sells different units of its service for different prices. Over the internet the firm is able to put across this information effectively by Custom Quantity layouts. The firm is able to show that for different units of service, there is a different price. This makes it easier for customers to buy in quantity and understand savings. The internet makes information readily available and helps to increase average order, customised to the store. The average order may increase since it is made more attractive and easy to do. This may result in a revenue increase for the firm. An Example of this in B2B is Price.Hot.com

To encourage large group booking a firm can offer *Group pricing* (Kauffman and Wang, 2001). The firm offers its service to a group of customers for a rate lower than the standard rate. The technique of group pricing is common in a range of services. An example of this is Economy.travel.com, the lowest international airfares on the web. They offer group airfares on 15 different airlines. The individual consolidator rates to different groups negotiated depending on the circumstances and time. These groups include corporate business groups, musical groups, band groups, athletic groups, food and wine clubs and weddings/family reunions.

The internet makes changing price for services extremely easy, thus making it difficult to continuously know when other competing firms are under priced on homogenous services. *Pricing Matching* is a method used by businesses to ensure their customer the security that they are receiving the best price for the service. It is a trade promise to match or beat all other competitors' prices. The firm promises to refund the difference to the customer if they can buy the same service cheaper. Firms offer promises to their buyers to match their competitors' price in expectation of buyers purchasing with them rather than their competitors. The promise is set with conditions such as time limit of so many days, the exclusion of special circumstances like closing down and loss leaders. Proof of pricing of a service prior to the internet could have been a bother as a

flyer or receipt of the service is required to provide evidence of the other firms' price. Fortunately over the internet a website link showing the other firms' price is sufficient.

The final dynamic pricing model mentioned is *Trading Exchanges*, they are a type of online electronic marketplace, where buyers and sellers are brought together to negotiate for commodities until they reach an equilibrium, so setting a price for the service at a particular point in time or for the future. Using the Internet a number of specialist trading exchanges have become established for such goods as oil, chemicals and electricity (Gylnn, 2001).

Using dynamic pricing models allows the seller to increase revenue at lowered costs with improved efficiency to a larger range of buyers. It brings about mechanism to sell unsold services and to be informed about market demand in real time. The trade partner has opportunities to purchase at lower prices and has access to larger number of diverse of suppliers. The supplier can to participate in multiple auctions at the same time.

The future and success of B2B-EC in the service industry, i.e., such as logistics firms depends largely on the supply chain management and on their revenue management systems.

18.4 Supply Chain Management

In this section, the focus is on how B2B e-commerce has led to the improvement of the traditional supply chain management for service industries. Turban and King (2003) describe a supply chain as the flow of material, information, money, services from raw material suppliers through factories and warehouse to the end customers. A supply chain also includes the organisation and processes that create and deliver these products, information and services to the end customer.

To manage the supply chain effectively and efficiently, the exchange of information from one channel to another must be recognized as an essential part of the process, this is allowed through electronic commerce which allows buyers and supplier to share large amounts of information in real time. The increased collaboration and integration between businesses, for which the supply chain is the main driver (Marbert and Vankataramanan, 1998), as resulted in the improvement of planning and inventory management (Sanders, 2005). Hence managing the supply chain has become a way of improving competitiveness by reducing uncertainty and enhancing customer service (Chandra and Kumar, 2000).

The internet has become the tool used by businesses to exchange information, enabling real-time control of supplies, orders, inventory levels, service updates and shipment information, and offering a standard approach for order entry, order status inquiry and shipment tracking (Ohio State University, 1998). The firm can provide information regarding space availability, service updates, and price changes and allows the market to react by placing bids and orders on real time information. The firm is also able to understand the market demand in real time and take action according to its inventory levels. It facilitates information exchange between firms in the supply chain in real time and at significantly lower transaction cost.

Logistics management is an essential for businesses which trade goods with other businesses. Transportation of goods is a service which can be carried out by air, road, rail or sea. The transportation service can deliver the goods around the country and beyond.

International shipping is accompanied by unavoidable important documentation. Through the internet the import and export firms can send documentation by taking templates and sending them to its custom broker. This eliminates the need for sending faxes and post. The internet has resulted in an incredible increase in the speed of information exchange, improved accuracy and pre-clearing shipments (Angeles, 2000).

Figure 18.2 is an abstract model of B2B e-commerce for the service industry which demonstrates how the improved information exchange can lead to the improvement of relationships between the supplier and buyer and their intermediary partner. The information exchange moves along the supply chain in more detailed accuracy and in real time making physical distribution activities (i.e. time of delivery) and revenue management more efficient.

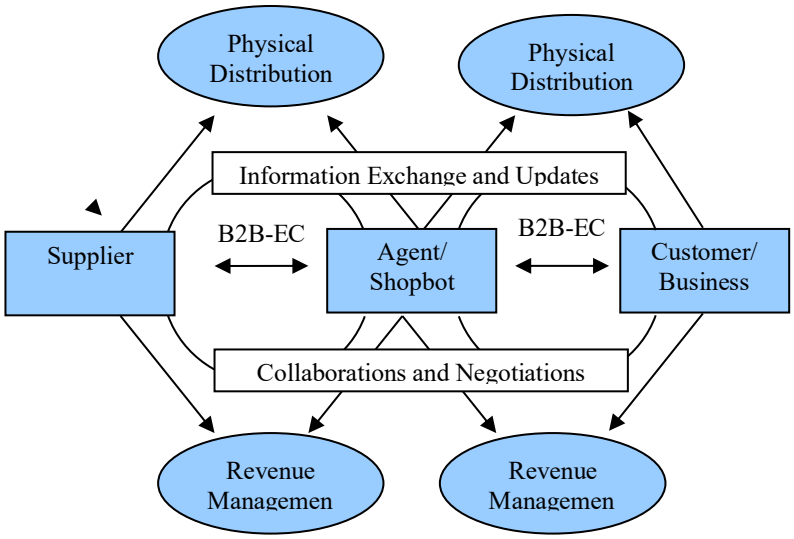

Figure 18.2 Business to Business Ecommerce Supply Chain

An effective B2B ecommerce supply chain will be able to shift from the environment of mass production to mass customisation as all parties of the supply chain would be well informed about customer demand information (Yau, 2000).

An example of when the internet can be used to improve the management of the supply chain for B2B transactions is a business which uses air freight forwarder to import/export goods. An air freight forwarder (AFF) provides pickup and delivery service under its own tariff, consolidates shipments into larger units, prepares shipping documentation, and tenders shipments to airlines. The internet allows the business to communicate its needs more readily to the AFF and the AFF to the airline. Thus the business can be more flexible in its orders. The air freight also has more information on a larger number of airlines (suppliers) on space availability and price at low cost and easy access. The strategy of using the internet to increase efficient, lower cost and increase profits can be taken a step further. Since using the internet makes accessing and updating information almost an automated process, there may be no real need for a business to use an agent, the business can communicate directly with the airline. The cost of the air

freight forwarder would be saved by both the airline and the business. The airline can then price more competitively due the cost reduction. Figure 18.3 illustrates an example of how the internet can lead to the removal of certain intermediaries in the supply chain.

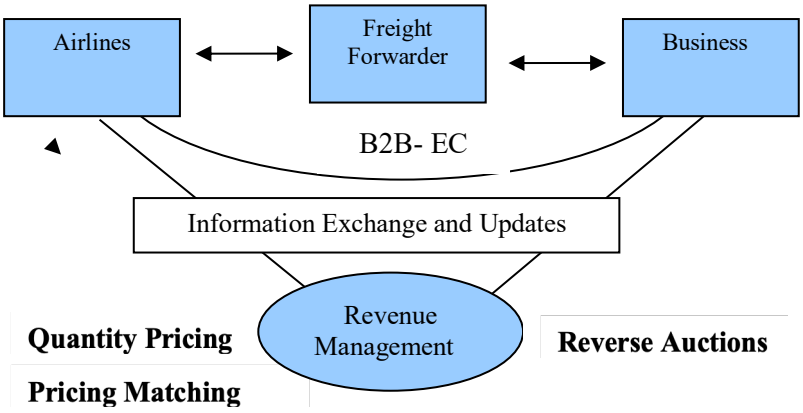

Figure 18.3 Reduction of the Supply Chain

Electronic commerce procedures are altering the marketplace by changing firms' business strategies (Yau, 2002). The internet has boosted competition between businesses as buyers are able to make price comparisons and sellers' costs are transparent to the buyers. Companies need to be able to make decisions in real time and must review their revenue management strategies in order to remain competitive.

18.5 Revenue Management

Revenue management is a process of allocating the right type of capacity to the right kind of customer, at the right price, so as to maximise revenue (Smith et al, 1992). The right price and reservation capability is the key mechanism to revenue management. The objective of using revenue management is to ensure the firm makes the highest profits through demand forecasting and optimising price and inventory accordingly. These techniques involve gaining an in depth insight into customer buying behaviours, predicting and reacting by exploiting the knowledge to maximise revenue. The internet can significantly enhance the revenue management process; revenue optimisation and demand management. Kimes (1989) suggested the definition of revenue management is rather restricted in its field of application. The techniques of revenue management are applicable when the conditions in Figure 18.4 hold true.

Businesses must have a *limited* or *fixed capacity* prior to the demand for a service, for example the number of seats in the transportation business, the time slot for advertisements on the television and the time of service (8.00 to 17.00) of a hairdresser. To gain the most revenue for a service which has a fluctuating demand, observation, experimentation and thoughtful planning is required in allocating the service (Phillips, 2005). If the capacity is not fixed for the service, then there is no need to apply revenue

management as inventory can be controlled to suit demand and no loss would be made i.e. made to order.

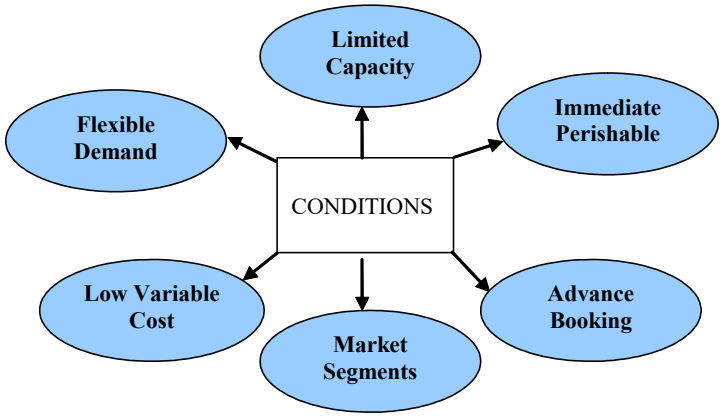

Figure 18.4 Conditions for Revenue Management Applications

The Service is *Immediate Perishable* in other words cannot be stored to accommodate for demand in future. This is true for the transportation business, for examples unused seats on a bus journey cannot be stored for another upcoming journey. Other services include seats in the theatre, cinema and stadium; time slots of hairdressers, engineer and auto repairers; rooms in a hotel and apartments. As the service is immediately perishable, strategic techniques need to be employed to ensure that revenue is not lost by the service being wasted i.e. an empty seat. If products can be stored then Inventory management can be applied instead (Oberwetter, 2001).

Advance Booking is an important feature as it allows the customer to ensure the service will be available to purchase especially since it is limited. It also allows the business to track future demand and hence they can adjust the price so supply can meet demand (Ryzin and Mcgill, 2002). Booking in advance is a feature used to put customers into market segmentation.

Market Segmentation allows the firm to charge different customers different prices. Booking ahead of time allows customer to be put into different segments. Price discrimination is not allowed through customer variation however customer segmentation can be made through characteristics such as the time of purchase (Weatherford and Bodily, 1992) and product differentiation (Kimes, 1989). Price sensitive customers tend to book ahead of time and they are willing to trade flexibly for reduced price. Commonly used is the purchasing of train transport where customers can book over the website in advance for a seat, which allows them to purchase at a cheaper price and they accept the seat which they are given. Perfect market segmentation would mean the average willingness to pay is different for each segmentation. Market segmentation results in the being service sold at varied prices so as to generate the maximum revenue.

Low variable cost to the supplier in the sense that an additional sale does not cost much but allows the service to be sold at a wide range of prices rather than go unsold. For example, an airline operation has high fixed costs and relatively low variable costs. Once the airline break-even for a journey of an aircraft with respect to the fixed costs,

any revenue gained in surplus of the variable costs (additional seat sold) will go towards profits.

If *Demand* for the service is *flexible* then revenue management can be applied to help control the demand. It can be used to help simulate demand when demand for the service is low for example, by promoting special offers. Alternatively when demand is high they can increase price therefore increase revenue. Demand in the airline industry can be flexible due to many factors some of which include, the destination of travel, the time on year and particular day, holidays, conditions and situations of other countries.

There are four key areas of revenue management research: forecasting, overbooking, capacity allocation and network management. Forecasting is a vital part of planning but it is especially important to revenue management because booking limits, overbooking calculations, cancellations, and no-shows are dependent on its forecasted demand. The practice of overbooking capacity beyond the capacity of the service is carried out to allow for the probability of no-shows and cancellations which is calculated using forecasts of past data. Capacity allocation is another component of a revenue management system that controls the availability of capacity for different classes. Network Management is the process of optimising a fixed capacity of services which consists of multi resources. Network management arises in industries such as airline with connecting flights or hotel which promote multi-nights stay. Network management is complex since there is need to consider interaction between the multi-resources and the effect it has on the ability to sell other services.

Next, we look at the models and algorithms used in revenue management.

18.6 Models and algorithms for Revenue Management

Models are used to represent the different problems addressed in revenue management, capacity allocation, network management, overbooking limits, for example. The effectiveness and success of a model is measured by how well it represents the problem at hand and of course more importantly the amount of revenue generated when using it. A twin problem of the modeling issue is the choice of the computational procedure, i.e., algorithm, to solve mathematically a given model of reality. The three most popular algorithms used to solve revenue management problems are described in Table 18.5.

Dynamic programming (DP) is a powerful algorithm which is able to compute optimal solutions. However the algorithm has trouble solving stochastic problems of the real world with increasing interacting variables. Using an approximation to the dynamic programming algorithm is more appropriate for the internet environment. Reinforcement learning is an approximation model of DP, which uses simulation to solve optimisation problems.

Reinforcement Learning (RL) is an approach which can be used to understand a situation or an environment in order to maximise revenue or to allocate resources more efficiently. The way in which reinforcement learning is able to achieve this is by learning what to do and how to map situations to actions, to maximize a numerical reward signal. A reinforcement learning problem is aimed to be a simple framing which captures the most important aspects of the real problem in the presence of a learning agent interacting with its environment to achieve a goal. In RL the firm improves its performance step-by-

step by interacting with an environment and at the same time choosing actions that enable it to to explore an *environment* and to exploit the environment, increasing its profits, e.g., Sutton and Barto (1998).

Algorithm	Solve	Description	Limitations
Expected Marginal Seat Revenue (EMSR)	Widely used for capacity allocation.	Belobaba (1987a) proposed a EMSRa model extension of Littlewoods rule to multi-fare classes to solve optimal protection level for single-leg flights. The Protection level Yj for any fare classes. $j \geq 2$ can be calculated using $Yj = \sum_{i=1}^{j-1} F_i^{-1}(\frac{p_i - p_j}{p_i})$ Where p_i is the price of fare *i.* the price increases as the fare classes gets higher and F_i^{-1} is the inverse cumulative distribution of *i* fare demand.	Model assumes:. 1)Fares classes have independent demands. 2)Lower fare class customer purchase tickets first. 3)No shows and cancellation therefore does not have overbooking limits. (Smith (1992) for American airline estimated that 50% reservation results in no-shows and cancellation. When demand for the product is higher than the capacity and the airline does not overbook then they will be losing out on additional revenue). 4) no grouping or batching booking 5) Single-leg flights Robinson (1995) used the EMSR model when the demand distribution was not follow the same as that of the airline industry, he found the EMSR model produced poor results thus suggest the EMSR model is not robust to other demand distributions. The model has been extended to EMSRb; it takes into account the factor of demand dependence of fare classes. The EMRSb is again a heuristic and is not a true model of consumer choice.
Linear Programming (LP)	Commonly used for airline industry for multi leg flight, hotel which adopts multi-night stays, railway transportation who offers multi leg trips and logistic companies with multi- leg routing.	LP can be used to find optimal allocating of perishable resource for competing service demand. Wollmer (1986) proposes LP network formulation that allows for stochastic demand by incorporating expected marginal seat values as coefficients in the objective function.	LP makes the strong assumption that future demand is known with certainty; in the service industry demand can be very elastic. Hence for real world problems linear programming solutions need modification to account for unknown demand. The size and complexity a system can cause problems when using linear programming to solve the system. Curry (1990) suggested using piecewise linear approximations in a linear program that obtains distinct bucket allocations for different Origin destinations. Real time re-optimizations of the LP model on fares and bookings in the network would improve optimal solutions, updates over the internet can be made every time a booking is accepted or cancelled.
Dynamic Programming (DP)	DP models are able to model Overbooking limits, Cancellations, Multi-leg problems and Batch booking.	DP algorithm finds the optimal solution to a problem which requires N solutions by formulating a series of smaller problems that involve subsets of the N solutions. It is a method of solving multi-stage problems in which the decisions at one stage become the conditions governing the succeeding stages, Rothstein (1975).	DP models are known spiral out of control with increase factors of the real world particularly stochastic ones. Birge and Louveaux (1997) suggest that developing approximation methods of DP and stochastic programming may be useful in revenue management.

Table 18.5 Algorithms for Revenue Management

Martin (2005) modelled a stochastic multi-knapsack booking process of television advertisement with deadlines. Since a TV break is perishable, revenue management technique can be used to ensure that it is sold at the best price. The model was an online multi-knapsack with deadlines, at each period the agent/operator receives is a sequence of arrivals or cancellations. If there is a cancellation then the agent simply updates space availability. At each request for space for the advertisement, the agent must decide whether to accept or reject the client. The algorithm overbooks and calculates the cost of overbooking. A reinforcement learning algorithm is used to find a strategy to maximise the profit in the long run, of the accepted spots at the end of the booking process. The strategy is found by using simulation, learning from previous actions and rewards of these actions. It uses linear regression as a strategy to approximate a dynamic situation. The algorithm will determine whether to accept or reject a client according to the length of advertisement and availability of space using past experience. A limitation to the model is it assumes the clients have no preference to the time their advertisement is shown.

18.7 Summary

The use of online revenue management in business to business electronic commerce allows a firm to learn its customers' willingness to pay and provides the firm with better information on the value of its services. As a result the firm can improve resource management (by allocating the internal resources taking into consideration market preferences) and increases the options available to the customer (by providing a wider range of options regarding quality, speed and price), and consequently, increasing its revenue.

Businesses using the electronic marketplace to trade services with other businesses need to consider the disadvantages it brings to the firm. The firm no longer builds personalised relationships because the internet can accommodate for all the customers' needs. When there is no shortage of supply this may be fine, but if the service become scarce then suppliers are more likely to satisfy their established customers first. Another problem which may arise if clear specifications for the service are not given is the buyer being disappointed when expectations are not met and as a result not trade with the firm again.

18.8 References

Angeles R. (2000), Revisiting the role of Internet-EDI in the current electronic commerce scene, *Logistics Information Management.* 13, Number 1, 45-57.

Anon (2001), Reverse Auctions Are Creating False Savings for Manufacturers, *Manufacturer News*. May 31, 8, Number 10.

Bartels A. and Leaver S. (2005), The Commerce Platforms Market: 2004 To 2008, Commerce Server Interest Grows – Again, January 10.

Belobaba P.P. (1989), Application of a Probabilistic Decision Model to Airline Seat Inventory Control, *Operational Research.* 37, 183–197.

Bichler M. et al. (2002), Applications of flexible pricing in business-to-business electronic commerce, *IBM Systems Journal*. 41, Number 2.

Birgue J. R. and Louveaux, F. (1997), Introduction to Stochastic Programming, Springer-Verlag, Berlin.

Bitran G. R. and Gilbert S. M. (1996), Managing Hotel Reservations with Uncertain Arrivals, *Operational Research.* 44, 35–49.

Bowersox D.J. Closs D.J. and Copper M.J. (2002), Supply Chain Logistic Management. Michigan State University. Mc Graw – Hill Higher Education, 210-213.

Buscher U. and Lindner G. (2004), Ensuring feasibility in 'a generalized quantity discount pricing model to increase supplier's profits', *Journal of the Operational Research Society.* 55, Number 6, 667-670(4)

Chandra C. and Kumar S. (2000), Supply chain management in theory and practice: a passing fad or a fundamental change?, *Industrial Management & Data Systems.*100.

Ciancimino A. Inzerillo S. Lucidi S. and Palagi L. (1999), A Mathematical Programming Approach for the Solution of the Railway Yield Management Problem, *Transport Science.* 33, 168–181.

Curry R. E. (1990), Optimal Airline Seat Allocation with Fare Classes Nested by Origins and Destinations, *Transport Science.* 24, 193–204.

Gallego G. and van Ryzin (1994), Optimal Dynamic Pricing of Inventories with Stochastic Demand over Finite Horizons, *Management Science.* 40, 999–1020.

Gates W. (2000), Business @ the speed of thought: Succeeding in the Digital Economy. New York: Warner Business Books.

Gylnn D. (2001), Clicking once... Clicking twice, *Sunday Business Magazine*. August 12.

Greenfield D. (1996), Facing liquidation, National Car Rental refuels with fresh ideas, pulls a U-turn and heads towards Profitability, *Operational Research & Management science*. 23.

Gressens B. and Brousseau C. (2000), The Value Propositions of Dynamic Pricing in Business-to-Business E-Commerce.
Available: http://www.crmproject.com/documents.asp?d_ID_733#

Hix N. (2001), The business guide to selling through Internet auctions: a proven seven-step plan for selling to consumers and other businesses. Gulf Breeze, FL : Maximum Press.

Kauffman R. J. and Wang B. (2001), New Buyers' Arrival Under Dynamic Pricing Market Microstructure: The Case of Group-Buying Discounts on the Internet. *Journal of Management Information Systems*. 18, Number 2.

Kimes S. E. (1989), The Basics of Yield Management, *Cornell Hotel and Restaurant Administration Quarterly.* 30, Number 3, 15-19.

Lee W. B. and Lau H. C. W (1999), Factory on demand: The Shaping of an agile production network, *International Journal of Agile Management Systems.* 1, Number 2, 83-87.

Littlewood K. (1972), Forecasting and Control of Passenger Bookings, *AGIFORS Symposium Proc.* 12, Nathanya, Israel.

Malaga R. (2001), Consumer Costs in Electronic Commerce: An empirical Examination of Electronic versus traditional markets, *Journal of Organizational Computing and Electronic Commerce*. 11, Number 1, 47-58.

Marbert V.A. and Venkataramanan M.A. (1998), Special Research focus on Supply Chain Linkages: Challenges for Design Management in 21st century, *Decision Sciences*. 537-552.

Martin B. (2005), Combinatorial Aspects of Yield Management, a Reinforcement Learning Approach. Bouygues SA, 1, av. Eugene Freyssinet, France.

Oberwetter R. (2001), Can revenue management land a starring role in the movie theater industry? Revenue Management, *Operational Research & Management science.* June.

OECD (1997), Measuring Electronic Commerce,
Available: <http://www.oecd.org/subject/e_commerce/summary.html>

Ohio State University (1998), Careers Patterns Survey 1998, Council of Logistic Management websites. Available: www.clm.org.

Pigou A.C. (1920), The Economics of welfare. London: Macmillan.

Phillips R.L. (2005), Pricing and Revenue Optimization. Stanford Business Books, California.

Ramaseshan B. (1997), Attitudes towards use of electronic data interchange in industrial buying: some Australian evidence, *Supply Chain Management.* 2, Number 4, 149-157.

Robinson L. W. (1995), Optimal and Approximate Control Policies for Airline Booking with Sequential Non monotonic Fare Classes, *Operational Research.* 43, 252–263.

Rothstein M. (1975), Airline Overbooking: Fresh Approaches are Needed, *Transport Science.* 9, 169–173.

Ryzin G. V. and Mcgill J. (2002), Revenue Management without Forecasting or Optimization: An Adaptive Algorithm for Determining Airline Seat Protection Levels. *Management Science*. June, 760-775.

Sanders N.R. (2005), IT Alignment in Supply Chain Relationships: A Study of Supplier Benefits. *Journey of Supply Chain Management*. 41, Number 2.

Smith B.C. and Leimkuhler J.F. and Darrow R. M. (1992), Yield Management at American Airlines, *Interfaces.* 22, 8–31.

Spring T. (1999), Reverse Auctions: A New Spin on E-Commerce, *PC World*. July 29.

Sutton R.S. and Barto A.G. (1998), Reinforcement Learning: An Introduction. Cambridge: Bradford.

Timmer P. (2002), Electronic commerce, Strategies and Models for Business-to-Business Trading. John Wiley and Sons, LTD.

Turban E. and King D. (2003), Electronic commerce. Prentice-Hall, USA .

Weatherford L. R. and Bodily S. E. (1992), A Taxonomy and Research Overview of Perishable-Asset Revenue Management: Yield Management, Overbooking, and Pricing, *Operations Research.* 40, Number 5, September-October, 831-844.

Wollmer R. D. (1986), A Hub-Spoke Seat Management Model, unpublished company report, Douglas Aircraft Company, McDonnell Douglas Corporation, Long Beach, CA.

Yau B.O. (2001), Business-to-business electronic commerce (B2B e-commerce) and its potential applications in the manufacturing industries (a review of literature), ecommerce Research Forum, Sloan School of Management, Massachusetts Institute of Technology. Available: http://e-commerce.mit.edu/cgi-bin/viewpaper?id=145.

Yau B. O. (2002), An empirical investigation of the impact of Business-to-Business Electronic commerce adoption on the business operations of Hong Kong Manufactures. Available: http://www.firstmonday.org/issues/issue7_9/yau/.