Welcome friends. In our earlier videos, we were discussing about revenue maximization. And for that purpose we discussed that how we are using the concept of booking control and in the booking control we are using the concept of nesting. We discussed the booking limits and protection levels that concept in our last class. Now, we understood that how are we calculating the protection levels.

So that you know that at least these seats are exclusively reserved for this upper class and we have seen with the help of one example in our last class that there are five booking classes and for each booking class there is a given booking limit. And we understood that how those booking limits can also be seen in the form of a particular protection levels. So, you saw that this example that for any particular label from left to right we are talking of booking limits. And from right to left these are booking limits and from right to left we are talking of protection levels. Just to revise what we discussed in our previous video, let us consider a simple example where we have 4 classes 1, 2, 3, 4 classes and for these 4 classes the booking limits are given to us.

For example, these are 73, 12, 4 and 0. These are the booking limits available for these particular classes. We know that booking limit when I am saying 73, it means the total seats available for b1, if it is b1 which is 73. What does this mean? that total number of seats in your system are equal to 73. And if you remember we already discussed that class 1 is the highest fare class, class 2 is the next highest level, class 3 is the further lower and class 4 is the cheapest fare class.

Right now, in this example, we are not taking any bookings for the cheapest fare, which is class 4. Now, using this data, the total seats available for class 1 are 73. Because, as we discussed, it is not possible or justifiable that at any particular time, you may still take bookings in a lower fare class while not taking bookings in the upper class. So, this concept of nested booking came about: we are always keeping all the inventory for the higher class, and therefore, if the system has a total of 73 seats, all these seats are always available for the higher class. Then, the total seats available for class 2 are 12, and the total seats available for class 3 are 4, with no bookings open for class 4.

So, that is the meaning of these booking limits. Now, using this concept of booking limits, we also calculated the protection levels. And you may remember that these protection levels are represented by Y's, and booking limits are represented by b's. So, this is b1, b2, b3, b4, and correspondingly, the protection levels Y1 equals b1 minus b2, and the protection level that 73 minus 12 makes it 61. That means 61 seats are exclusively available only for category 1.

Y2 is b1 minus b3, which is 73 minus 4, that is 69, and Y3 is b1 minus b4, which is 73 minus 0, that is 73. The total capacity available in this server, in this facility. Y1 means that the total seats available for class 1 are 61. Total seats available, protected for class 1 and class 2, are 69. And the total seats available for class 1, class 2, and class 3 are 73.

Managing cancellation

$$Y_1 = b_1 - b_2 = 73 - 12 = 61$$

$$Y_2 = b_1 - b_3 = 73 - 4 = 69$$

$$Y_3 = b_1 - b_4 = 73 - 0 = 73$$

	1	2	3	4	Classes
Booking limits	73	12	4	0	
	b_1	b_2	b_3	b_4	

Total seats avail for Class 1 = 73

Total seats av. for class 2 = 12

" " Class 3 = 4

No booking for class 4

booking limits $b_1 = 73$

Protection levels

In fact, that is the total capacity of your system. So, that is how we have understood the concept of protection level and booking limits. Now, whenever you are accepting bookings based on these booking limits, there are rough estimations that around 30% of the bookings get canceled also. You are receiving requests for new bookings, and in the meantime, you may get some requests for the cancellation of your bookings also. And whenever you get a request for cancellation of booking without any kind of restriction, we are assuming that you allow cancellations.

Now, there are two possibilities: possibility number 1 and possibility number 2. Let us discuss here, case 1: you are booking some requests, you are continuously accepting the requests, and as a result of that, for example, one lower category class is already over and you have closed booking. Now, when a cancellation request comes, it will come from a particular class. Now, there are two issues in front of you. If you have closed the particular class, should you reopen that class?

So, if you are not opening a class, case 1 is not opening a closed class, which is known as irreversible. That class which is already over now, when you have reached the zero level of capacity for a particular class, that means the class is closed. Now, some cancellations have happened, but whenever a cancellation is happening, there is additional capacity coming to your server. Now, where to add this capacity? That is the question I am discussing. So, it is possible that you add all this capacity to the classes which are already active, otherwise you can say add this canceled capacity to a closed class also.

So, a closed class can be opened again if cancellation occurs, and this is known as a reversible case. So, there are two types of cases: reversible and irreversible cases. Since cancellation is a very common phenomenon in any kind of service, examples show that people book in advance, often far in advance, and keep canceling due to changes in their plans. So, whether it is airline tickets, hotel bookings, or any other services, cancellations occur. In the airline industry, there are around 30 percent cancellations per flight, which is the average rate reported in research papers. So, irreversible and reversible are the two possible ways through which we can manage cancellations. So, let us see how cancellations happen.

	Event	Irreversible BOOKING LIMITS					Reversible BOOKING LIMITS				
		1	2	3	4	Action	1	2	3	4	Action
1	Request 2 seats in Class 3	73	12	4	0	Accept	73	12	4	0	Accept
2	Request 2 seats in Class 3	71	10	2	0	Accept	71	10	2	−2	Accept
3	2 bookings cancel	69	8	0	0		69	8	0	−4	
4	Request 5 seats in Class 3	71	10	0	0	Reject	71	10	2	−2	Reject
5	Request 3 seats in Class 2	71	10	0	0	Accept	71	10	2	−2	Accept
6	Request 2 seats in Class 3	68	7	0	0	Reject	68	7	−1	−5	Reject
7	3 bookings cancel	68	7	0	0		68	7	−1	−5	
8	Request 2 seats in Class 3	71	10	0	0	Reject	71	10	2	−2	Accept
9	Request 2 seats in Class 3	71	10	0	0	Reject	69	8	0	−4	Reject
10	2 bookings cancel	71	10	0	0		69	8	0	−4	
11	Request 1 seat in Class 2	73	12	0	0	Accept	71	10	2	−2	Accept
12	Request 1 seat in Class 3	72	11	0	0	Reject	70	9	1	−3	Accept
	Final state	72	11	0	0		69	8	0	−4	

In fact, let me tell you that we have taken the same data I used to give you the example of protection levels: 73, 12, 4, 0. These are the initial booking limits, the initial booking limits. So, these are the same on both sides of this table. You can say this is side A and this is side B. On both sides, you have the same initial booking limits. But one side of the table works on the principle of irreversibility, and the other side works on the principle of reversibility. Now, you see, we will go up to, let us say, 4, 5, 6, 7, and the remaining table I request you to complete on your own.

Let us see how we have developed the booking levels in this particular case. Now, whenever a request comes for a particular class, the booking control will check whether there is enough capacity in that class or not. If there is enough capacity in that class, you will accept the booking. So, whatever event is happening, as mentioned in column 2, side A and side B take actions based on their logic and their available booking limits. So, now, if a request for two seats comes in class 3, you will check class 3.

I am doing this exercise on both sides, side A and side B. Okay, for a minute, let us do only side A, and then we will do side B, so that there will be no confusion. So, for some time, please do not pay any attention to side B of this table; focus only on side A of the table. So, 73, 12, 4, 0—you got a request for two seats in class 3, and since you have 4 seats available, you are going to accept the request. Please remember, you will reduce your capacity by 2 seats. Now, please remember this: you have to reduce this capacity from all the classes, not just from class 3, but from class 1, class 2, and class 3—all 3 classes. You have to reduce your seats by 2 numbers. So, therefore, 73 minus 2 is 71, 12 minus 2 is 10, and 4 minus 2 is 2. That is the new booking limit available to you.

So, please see that whatever request comes in a particular row, the impact of that is shown in the next row subsequent to that particular thing. The decision based on that request is shown in front of that row only, but the impact in terms of booking limits is reflected in the subsequent row. So, the impact of this is coming here. This is the impact. Similarly, now the second event is: 2 seats are requested again in class 3.

Now, again, you have 2 seats available in class 3. So, you are going to accept the request, and again, you will subtract 2 from all the classes. So, 2 becomes 0, 10 becomes 8, and 71 becomes 69. So, all that is the result of event number 2. Now, there comes a cancellation.

Now, since by default you are going to accept the cancellation, so we are not writing anything here. In fact, cancellations are always accepted, cancellations are always accepted. So, therefore, there is no need to write it separately, just to give you this idea that wherever there is a blank space in this table with respect to actions, it means there is a cancellation request which we are accepting without putting any judgment. So, now when two booking cancels are there, since we are doing under the irreversible system. Now, under the irreversible system, when a particular class is closed, it will not be reopened.

So, like here you see, this class is closed. Class 4 is permanently closed. Class 4 is closed from the beginning of this system, but now we have closed the class 3 also. So, class 3

and class 4 are closed, class 3 and 4 are closed. And under this irreversible system, you cannot reopen these closed classes.

So, therefore, the capacity which you are generating because of 2 booking cancels you will add it to class 2 and class 1. So, 8 becomes 10 and 69 becomes 71, 0 remains 0 and this 0 also remains 0. So, that's how in side A now the rule becomes. Now the rule becomes, you are adding, you are adding, you are adding capacity due to cancellation in existing live classes. So, only two live classes were available when the booking cancellation request came.

These are class 1 and class 2. So, this additional capacity of 2 is added in class 1 and class 2. Going further, now there is a request of 5 seats in class 3. You are already at 0 level in class 3. Nothing going to happen, you are rejecting this request and therefore, after this it remains 71, 10, 0, 0, because you have cancelled the request.

Now, another request is coming 3 seats in class 2. So, 3 seats means 10 becomes 7, you are ready to accept this and you are reducing your all active classes by a capacity of 3. So, 10 becomes 7 and 71 becomes 68, 0 remains 0 and 0 remains 0. Now, you are getting request of 2 seats in class 3, class 3 is already 0. So, nothing is going to happen it remains like this only.

So, again you got a cancellation request of 3 bookings and you get again you are going to accept this. So, you are getting 3 additional seats in your system and you will add these 3 at active classes, class 1 and class 2 are the active classes. So, 68 becomes 71 and 7 becomes 10, 0 remains 0 and 0 remains 0 and this is where I will like to stop my calculations. This slide is available to you and I will request all of you to do the calculations with respect to row number 8 to row number 12 and please check your calculation with the calculation available on this slide and see whether you are also getting the same final state of the capacity. Please see whether you are getting the same final state or not.

So, this is irreversible system where once a class is closed, it is closed, it will not be reopened. There is some logic in this also, we will discuss that logic that how it is going to benefit us. Then comes this reversible system side B of this particular table. And here you see, the opening class, opening limit is 73, 12, 4, 0 as it is. Request of two seats is coming in class 3.

You are accepting two seats. So, 4 becomes 2, 12 becomes 10, 73 becomes 71. But here, one more thing will happen. And what will that be? The initial capacity of your class 4 was given as 0.

Now, in this system of reversible cancellations, 0 will become minus 2, you will subtract 2 units, 2 units in class 3 which you are assigning, you will subtract it across the board. So, 0 will also go to the negative side practically, the meaning of minus 2 capacity has no significance. You cannot physically tell anybody that I do not have any capacity but I have a capacity of minus 4. So, practically it has no meaning just for our calculation purpose you will see the meaning of this particular thing in few moments. The second request which are coming that is 2 seats again in class 3.

So, this minus 2 becomes minus 4. 2 seats in class 3 that means this 2 will become 0. This 2 becomes 0. 10 becomes 8 and 71 becomes 69. These are the new booking limits for different classes.

Now comes the cancellation. 2 bookings are cancelled and when 2 bookings are cancelled, you see that you will add 2 the cancelled amount, the additional capacity coming because of cancellation in all the classes, even if a class is cancelled you will add that. So, therefore, you are adding plus 2, plus 2, plus 2, plus 2 everywhere. It becomes 71, it is 10. Now, you compare side A and side B. In side A, it was up to this only, 71, 10.

But, when I see side B, you have opened a closed class. The closed class was class 3, where it became 0 earlier. But now, because of this cancellation, you have a capacity of 2 seats in class 3 also. And class 4, which went up to minus 4. Now, you are adding plus 2 into that though, it is still in minus 4 but now it is minus 2.

Similarly, you will see that now you are getting a request of 5 seats in class 3 and you have only 2 seats in class 3, you are going to reject it further, you are getting 3 seats requirement in class 2. So, here you see that you are supplying 3 in class 2 and you will subtract 3 from everywhere minus 3, minus 3, minus 3, minus 3. So, 71 becomes 68, 10 becomes 7, 2 becomes minus 1 because, you are subtracting 3 seats from 2. So, it becomes minus 1 and you are subtracting 3 seats from minus 2 therefore, it becomes minus 5. So, that is another change which you can see from side A to side B. So, therefore, you can now come to stage event 8 directly.

Now, infact, here if you see the side A, you do not have any capacity because you are not opening a closed closed class. While, here you have already opened a closed class, now

you have two seats available in class 3 and fortunately the event number 8 says that there is a request of two seats in class 3. And if you see side A you have rejected that request while you are accepting that request in side B, because, you have opened a closed class. So, this is I think a major difference in our so far discussions that if I am going with the idea of irreversibility, I am rejecting the request for class 3, while I am accepting the request for class 3 in the same level of sequential events in this way And I will ask you to do this later part on your own as homework but, just to give you a comparison again in event number 12, when we are asking for one seat in class 3, since again this is having no quota available you are rejecting this request.

But, in side B which is representing the reversibility you have one seat available therefore you are accepting this request. So, you get chances of accepting some requests of booking in case of reversible management of cancellation. In case of irreversible management of cancellation since, you are not opening a class and it is always possible that at any time, you may get a request for that particular class for which you do not have any capacity. If you follow the idea of reversibility, there may be chances that at a later time you may open that particular class. Otherwise, that booking is permanently lost.

So, this is how you will manage cancellations, where we see how, over a period of time, we are able to generate more revenue if we follow the system of reversible cancellation management. I hope by doing the practical work using this concept of reversibility and irreversibility, I request that for this much data, for this much data. Let us say these classes have fares: class 1 has a fare of 150, class 2 has a fare of 100, class 3 has a fare of 80, and class 4 has a fare of 50. These are the four fare classes. I request that all learners create a table and calculate the revenue your company will get when they follow an irreversible or reversible system.

So, how much is the total revenue they get in irreversible, and how much is the total revenue they get in reversible? So, that is there, and let us say whenever there is a cancellation, whenever there is a cancellation happening. So, cancellations are paid at a flat rate of 25 rupees or 25 dollars whenever there is a booking cancellation. So, with this, tell me how much is the total revenue collection for side A and side B, and then we will probably get an idea of the benefit of reversible cancellation management and irreversible

cancellation management. Now, moving further after handling this cancellation part, when we see that instead of having so many classes, organizations may go with only two classes in their entire system.

Nowadays, in our country, let us say Indigo is a very popular airline, and Indigo may have only two classes: economy class and business class. When you travel in international flights, there may be more than two classes—three or four classes—but in many examples, not only this, you have only two classes: class A and class B. Class A may be a premium class, and class B is a normal class, so this simplifies our entire discussion of the multi-class optimization model. So, we have to decide how much capacity we allocate to a particular class, and based on that, it will become very important how much revenue you earn because of this capacity allocation. So, the case is like, say, a flight, and you have a fixed capacity. Now, there are two types of customers.

One is the discount customers who are ready to book much in advance, maybe one month in advance, two months in advance. And the second type of customers are full fare customers who are booking, let us say, one week or even less than one week prior to the actual flight. So, discount customers and full fare customers, these are the two categories of customers. Discount customers pay a fare pd, which is more than 0; obviously, it is some kind of fare, and full fare customers pay pf, where pf is higher than pd. So, pd is one fare, pd is the discounted fare, and pf is the full fare.

And it is easy to understand that pf is generally always more than pd, which is the discounted fare. Now, we are going to develop a mathematical model using this two-class model. We will continue this two-class model in our next class and then see how we are going to apply it to decide the capacity allocation for a particular scenario. With this, we come to the end of this particular video. Thank you very much.