

Revenue Management

Outline

- ◆ **History**
- ◆ **Levels of Decisions**
 - **Strategy**
 - **Tactics**
- ◆ **Net Contribution**

Based on Phillips (2005) Chapter 6

Some U.S. airline industry observations

- ◆ Since deregulation in 78, **137 carriers** have filed for **bankruptcy** until 2006.
- ◆ From 95-99 (the industry's best 5 years ever) airlines earned **3.5 cents on each dollar** of sales:
 - The US average for all industries is around 6 cents.
 - From 90-99 the industry earned **1 cent per \$** of sales.
- ◆ Carriers typically **fill 72.4% of seats** while the **break-even load is 70.4%**.
 - Utilization is about 3% higher in 2007-08 perhaps due to flight cancellations.
- ◆ **Gas prices are high and will remain so.**
 - Downsize airlines
 - Merge. Domestic/international
 - » UnitedContinentalHoldings.com
 - Alternate transportation means
 - » High speed train



Matching supply to demand when supply is fixed

◆ Examples of **fixed supply**:

- Travel industries (fixed number of seats, rooms, rental cars, etc).
- Advertising time (limited number of time slots).
- Telecommunications bandwidth.
- Size of the MBA program.
- Doctor's availability for appointments.

◆ **Revenue management** is a solution:

- If adjusting supply is impossible – adjust the demand!
- Segment customers into
 - » High willingness to pay
 - » Low willingness to pay.
- Limit the number of tickets sold at a low price,
 - » i.e., control the average price by changing the mix of customers.

Environments suitable for revenue management

- ◆ The **same unit of capacity** (e.g., airline seat) can be used to deliver services to different customer segments (e.g., business and leisure customers) at different prices.
- ◆ **High gross margins** (so the variable cost of additional sales is low).
- ◆ **Perishable capacity** (it cannot be stored) and **limited capacity** (all possible customers cannot always be served).
- ◆ Capacity is sold in advance of demand: **Costly adjustment of sold capacity**.
- ◆ There is an opportunity to **segment customers** (so that different prices can be charged) and different segments are willing to pay different prices.
- ◆ It is not illegal or morally irresponsible to discriminate the customers.
 - ◆ Is revenue management for incoming MBA class possible?

History: Airline Reservation Before Computers

Sabre (reservation system) Became Operational in 1964




Published Fares – Controlled by Civil Aeronautics Board

Deregulation in 1978 removed the restrictions on schedules and fares

JULY 1, 1941

AMERICAN AIRLINES INC.



ROUTE OF THE FLAGSHIPS

EXAMPLES OF PASSENGER FARES

For fares not shown call any American Airlines office or your transportation agent.

Origin	Albany, N.Y.	Boston, Mass.	Buffalo, N.Y.	Chicago, Ill.	Cincinnati, Ohio	Cleveland, Ohio	Columbus, Ohio	Detroit, Mich.	St. Louis, Mo.	Indianapolis, Ind.	Little Rock, Ark.	Los Angeles, Calif.	Los Angeles, Calif.	Memphis, Tenn.	Newark, N.J.	New York, N.Y.	Omaha, Neb.	Philadelphia, Pa.	Portland, Me.	San Francisco, Calif.	Tucson, Ariz.	Tulsa, Okla.	Washington, D.C.
Boston, Mass.	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00	18 00
Buffalo, N.Y.	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00	22 00
Chicago, Ill.	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00	26 00
Cincinnati, Ohio	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00	30 00
Cleveland, Ohio	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00	34 00
Columbus, Ohio	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00	38 00
Detroit, Mich.	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00	42 00
St. Louis, Mo.	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00	46 00
Indianapolis, Ind.	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00	50 00
Little Rock, Ark.	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00	54 00
Los Angeles, Calif.	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00	58 00
Los Angeles, Calif.	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00	62 00
Memphis, Tenn.	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00	66 00
Newark, N.J.	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00	70 00
New York, N.Y.	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00	74 00
Omaha, Neb.	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00	78 00
Philadelphia, Pa.	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00	82 00
Portland, Me.	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00	86 00
San Francisco, Calif.	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00	90 00
Tucson, Ariz.	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00	94 00
Tulsa, Okla.	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00	98 00
Washington, D.C.	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00	102 00

NO REDUCTION ON EXCESS BAGGAGE OR SLEEPER CHARGES.
CHILDREN TWO YEARS OF AGE AND UNDER TWELVE WILL BE CHARGED ONE-HALF THE ONE-WAY AND ROUND-TRIP FARES SHOWN ABOVE.
 1—Slightly higher fare via New York.

EXPLANATION OF REFERENCE MARKS

- an—Times in Light Face.
- an—Times in Dark Face.
- AA—American Airlines.
- BAF—Branch Airways.
- CHI—Chicago & Southern Air Lines.
- DAL—Delta Air Lines.
- EAL—Eastern Airlines.
- NWA—Northwest Airlines.
- PAA—Pan American Airways.
- PCA—Perry/Canada Central Airlines.
- TVA—Trans-Canada Air Lines.
- UAL—United Air Lines.
- a—Daily.
- b—Daily except Sundays.
- c—Daily except Saturdays.
- d—Sunday Only.

- F—Flag Stop.
- 1—Limozone Service only between Airlines Terminal, Manhattan and Newark Airport.
- 2—Daily except Sundays and Holidays.
- 3—On Sunday leave Boston 2:05 pm, arriving New York 3:30 pm.
- 4—Limozone Service to and from Newark Airport and Airlines Terminal, Manhattan.
- 5—In U.S. connecting at Seattle.
- 7—Arrival.
- 8—Departure.
- 9—Except Saturdays, Sundays and Holidays.
- 10—On Sundays use Flight 7 departing Detroit 4:17 am.
- 11—On Sundays leave New York 12:00 pm, Buffalo 2:20 pm, Detroit 5:30 pm.
- 12—On Saturday leave Boston 5:20 pm, arriving New York 6:40 pm.

- *—Complimentary meal afloat after leaving this station.
- c—Via connecting flight.
- f—Via connecting airline.
- X—Service temporarily suspended pending airport improvements.
- Sleepers charge between some points.
- Advance reservations will be accepted only for transportation from New York to Ft. Worth, Tucson or Los Angeles, or from Ft. Worth to Los Angeles.
- Advance reservations will be accepted only for transportation from Los Angeles to Ft. Worth and New York, Tucson to New York or from Ft. Worth to New York.
- Dallas stop serves both Dallas and Ft. Worth. AA limozone service available to and from Dorchester, Ft. Worth or Merchants Field, Ft. Worth. Consult AA agent for details.

American vs. PeopleExpress

- ◆ After deregulation, low-cost carrier PeopleExpress was established circa 1980
 - PeopleExpress charged 70% less than major airlines
 - Fast growth over 1980-1984 by serving underserved markets: Leisure passengers
 - In 1984, attacked AA's bread-and-butter routes: Newark-Chicago and New Orleans-LA

- ◆ January 1985, American's counterattack: Ultimate Super Saver
 - Discount fare if reserving 2 weeks before departure and staying over a Saturday night.
 - Restrictions on the number of seats available under Ultimate Super Saver program

- ◆ Leisure passengers used Ultimate Super Saver while Business travelers pay the full fare.

- ◆ September 1985, PeopleExpress on the verge of bankruptcy
 - We had great people, tremendous value, terrific growth. We did a lot of things right. But we didn't get our hands around the yield management and automation issues.
 - Donald Burr, CEO of PeopleExpress

American's Experience with RM in 1980's

- ◆ **MOMS**: Multiclass Optimization Modeling System, 1979
- ◆ **DADS**: Discount Allocation Decision System, 1980
- ◆ **CARS**: City Allocation Report, 1981
- ◆ **SCARS**: Super City Analysis System, 1982
- ◆ **DINAMO**: Dynamic Inventory Allocation Modeling Optimizer, 1986

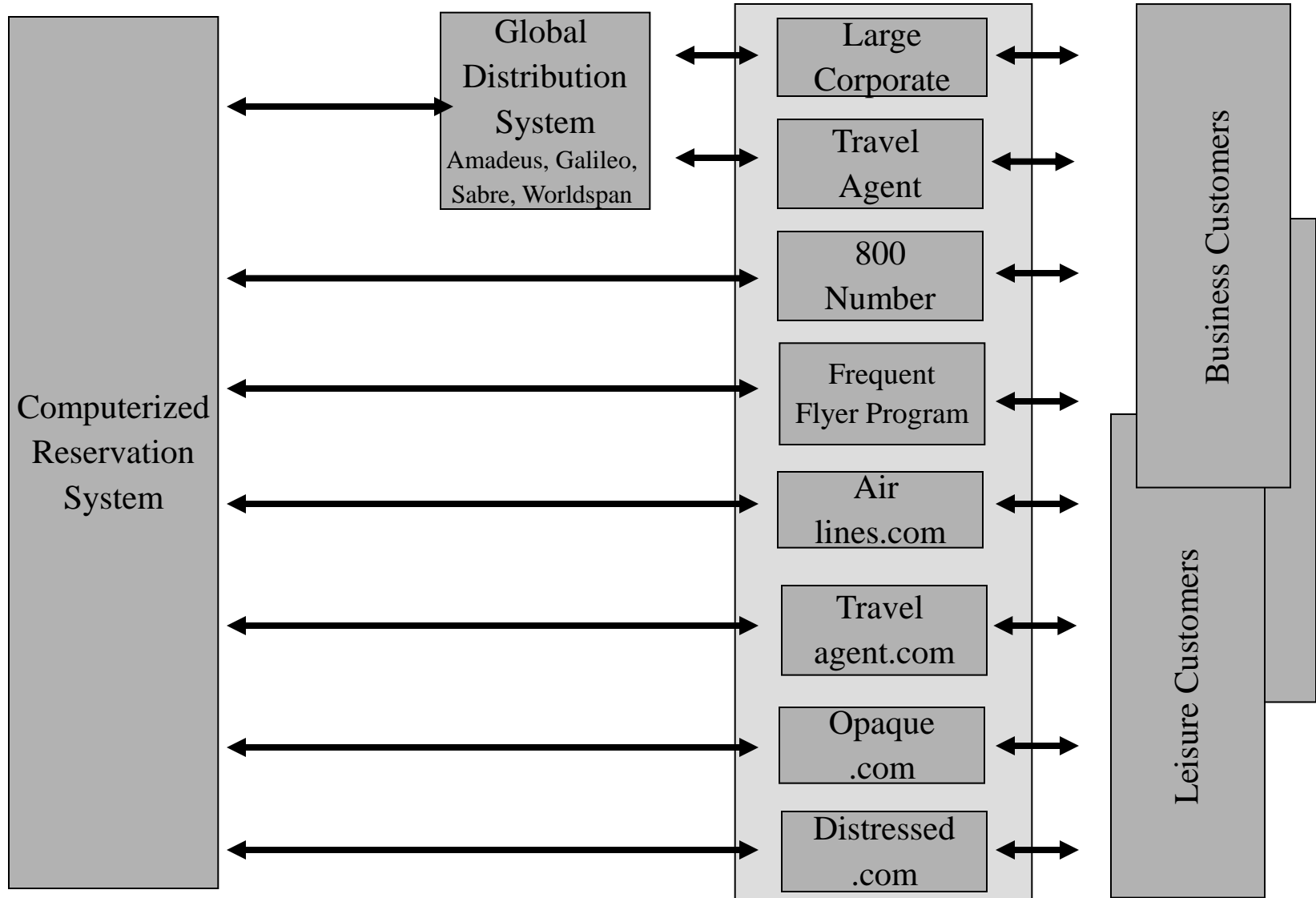
Airlines have been in the RM game for a long while. Hotels and Car Rental companies came afterwards.

Revenue Management Strategy

Customer Segmentation

- ◆ Leisure Passengers vs. Business Passengers
 - Leisure passengers are **highly price sensitive**
 - They **book earlier**
 - They have **more flexibility in departure and arrival times**
 - They accept or prefer **Saturday night stayover**
- ◆ Finer segmentation is also possible among Leisure and Business Passengers depending on price sensitivity, schedule flexibility, etc.
- ◆ Other airline customer segments include
 - Government employees, senior citizens, children, frequent flyers, etc.
 - International pricing: Same ticket at different prices in different countries.
 - » Any logic here? This may be a relic of the past as it does not make much sense in the age of Internet.
 - Distribution channel based segmentation: Travel agent in person vs. Travel agent software vs. Airline's website.
- ◆ In addition to these, hotels, theme parks and cruise lines can have **city-of-origin based pricing**
 - Hotels: Kamaaina rates for Hawaii residents
 - Theme Parks: Disney's resident rates for Orlando residents
 - Cruise Lines: City-of-origin needed to fly the passengers from out of town

Reservation and Distribution System



Booking Control

Booking Limits and Protection Levels

- ◆ Booking control is about restricting the number of products (seats, rooms, rental cars) sold to each customer class
- ◆ Booking control ensures that the number of products sold to low-paying customers is limited.
- ◆ **Booking limit (b)** for a fare class is the maximum number of products that can be sold in **that class or in lower classes**.
- ◆ **Protection level (y)** for a fare class is the number of products reserved for **that class or higher classes**.
- ◆ Protection levels ensure that enough products are sold to high-paying customers.

Booking Limit vs. Protection Level

2 Fare Classes at a Hotel

Two classes: low paying and high-paying customers.

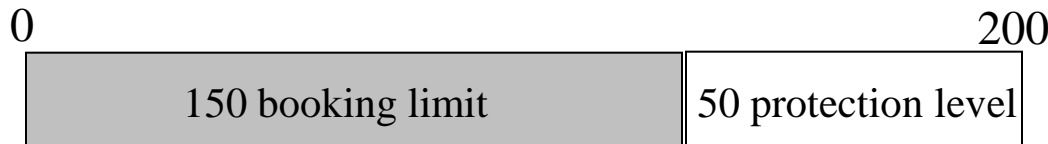
The *booking limit*,

- for the **low-paying customers**, is the maximum number of rooms to sell to **low-paying customers**.
- for the **high-paying customers**, is the maximum number of rooms to sell to **low-paying and high-paying customers**. Effectively, the booking limit for high-paying customers is the capacity of the hotel.

The *protection level*

- for the **low-paying customers**, is the number of rooms reserved for **low-paying and high-paying customers**. This is the hotel capacity.
- for the **high-paying customers**, is the number of rooms reserved for **high-paying customers**.

Two numbers differ from zero above: booking limit for the low-paying customers and the protection level for high-paying customers:



The rooms are not physically allocated to classes. Allocation is virtual. Room number 206 can serve both class 1 and class 2.

Multiple Fare Classes Nested Booking Limits

Booking limits are nested

Nested limits: A booking limit is set for a class and all lower classes. Suppose classes are 1,2,3, and 1 is the highest class.

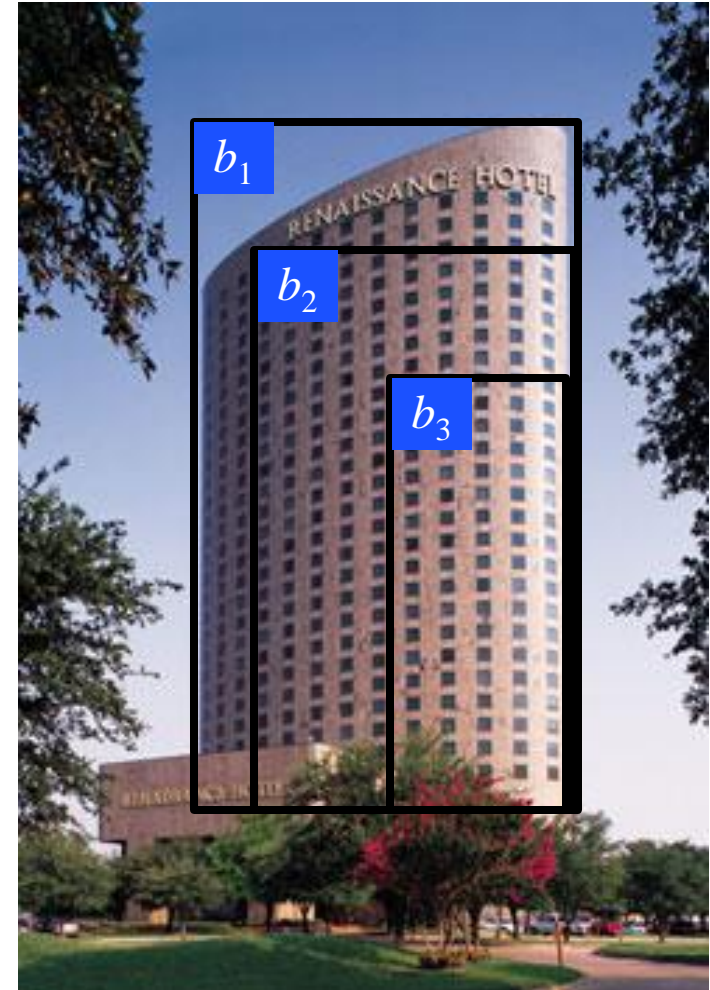
- » **Booking limit for class {3} is 10 and the booking limit for classes {2,3} is 20.** After selling 10 to class 2 customers, booking limits become 10 for class {3} and 10 for class {2,3}. Afterwards a
 - ◆ Request for 10 more class 2 or 3 is accepted.

Allotments: What if a limit is set for a single class only?

- » **Booking limit for class {3} is 10 and the booking limit for classes {2} is 10.** After selling to 10 class 2 customers, booking limits become 10 for class {3} and 0 for class {2}. Afterwards a
 - ◆ Request for 10 more class 2 is rejected.
 - ◆ Request for 10 more class 3 is accepted.

This is accepting low-paying customers while high-paying customers are rejected.

- » Allotment is a blasphemy of Revenue Management's first principle that high-paying customers must have priority over the low-paying customers.



What are Fare Classes at a Hotel?

Consider a standard room, not a deluxe or suit.

Class 1: Free Internet; Free Fruits at arrival; Free daily newspaper; Free two bottles of water everyday; Free choice of bed (two queens or a king). Note that these services are just add-ons that are not specific to the room size.

Class 2: Internet at \$5/day. The rest is the same as Class 1.

Class 3: No fruits; The rest is the same as Class 2.

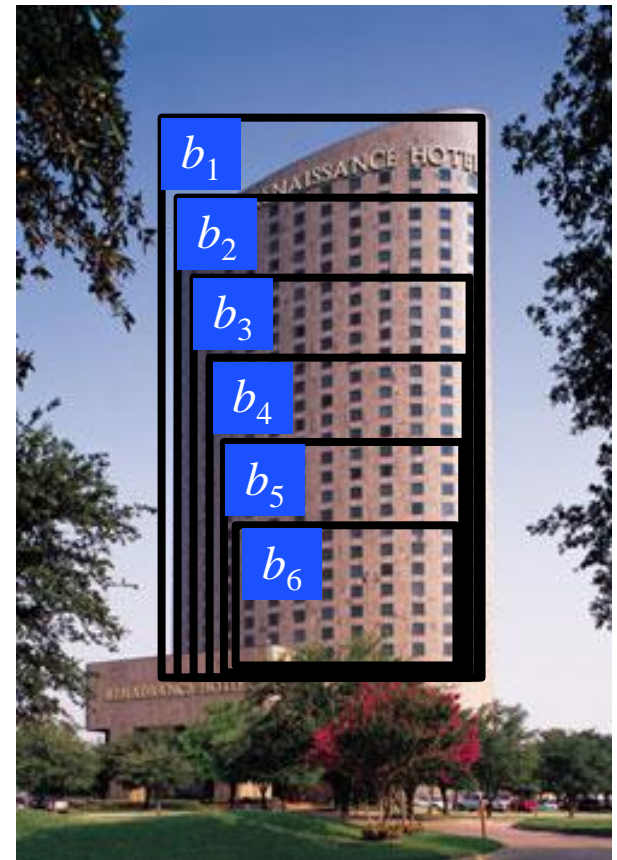
Class 4: No newspaper; The rest is the same as Class 3.

Class 5: Water at \$3/bottle; The rest is the same as Class 4.

Class 6: No choice of bed type; The rest is the same as Class 5.

Prices: \$250; \$220; \$190; \$160; \$130; 100. Cost of extra services cannot justify the price differential of \$30.

Prices are not cost based but are used to segment the customers.

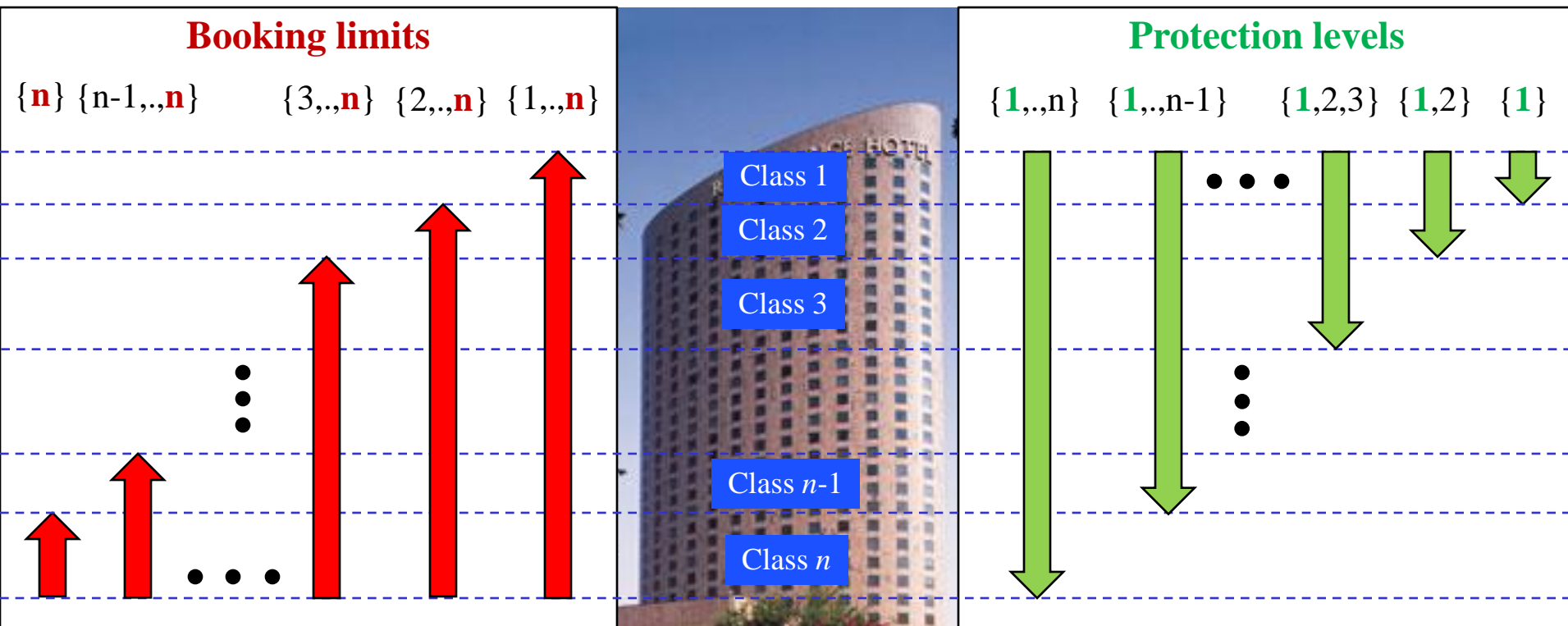


Rooms are not physically allocated to classes. Allocation is virtual. For example, room number 206 can serve class 1, 2, 3, 4, 5 or 6.

Multiple Fare Classes

Nested Booking Limits and Protection Levels

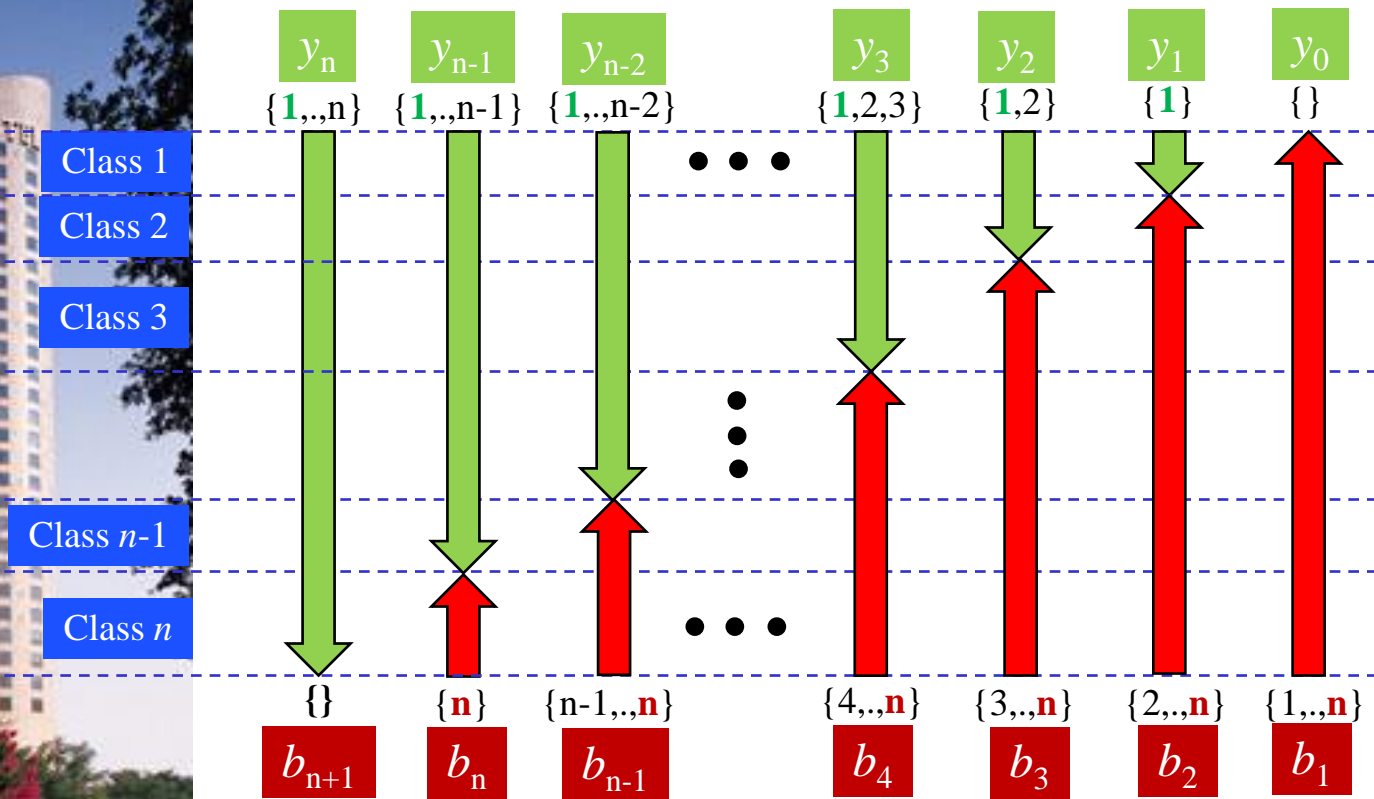
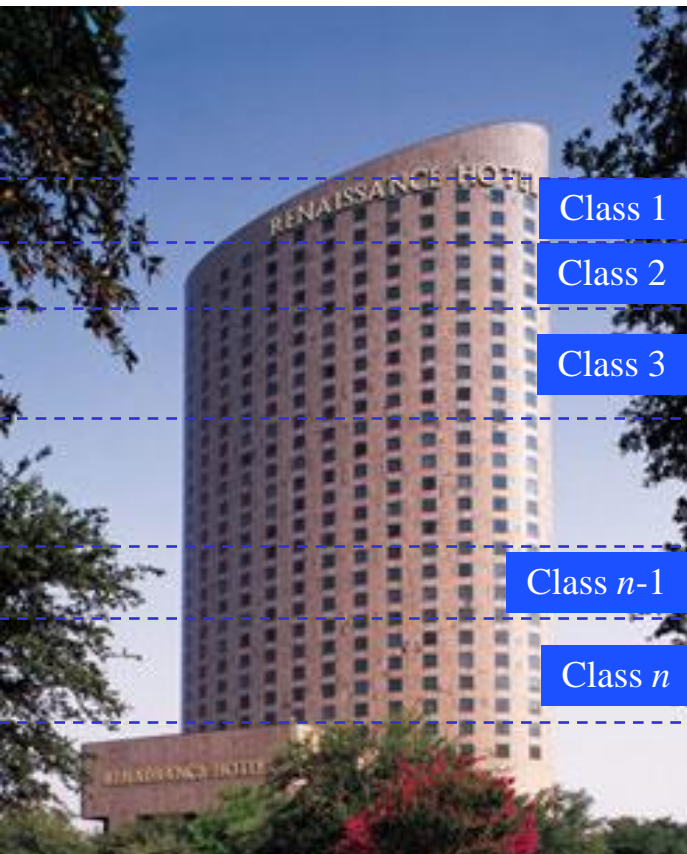
- ◆ Fare classes indexed by $j=1,2, \dots, n$. $j=1$ is the highest class, while $j=n$ is the lowest class.
- ◆ Booking limit b_i for class i limits bookings for classes $j=\{i, \dots, n\}$.
- ◆ Protection level y_i for class i protects future reservations or classes $j=\{1,2, \dots, i\}$.



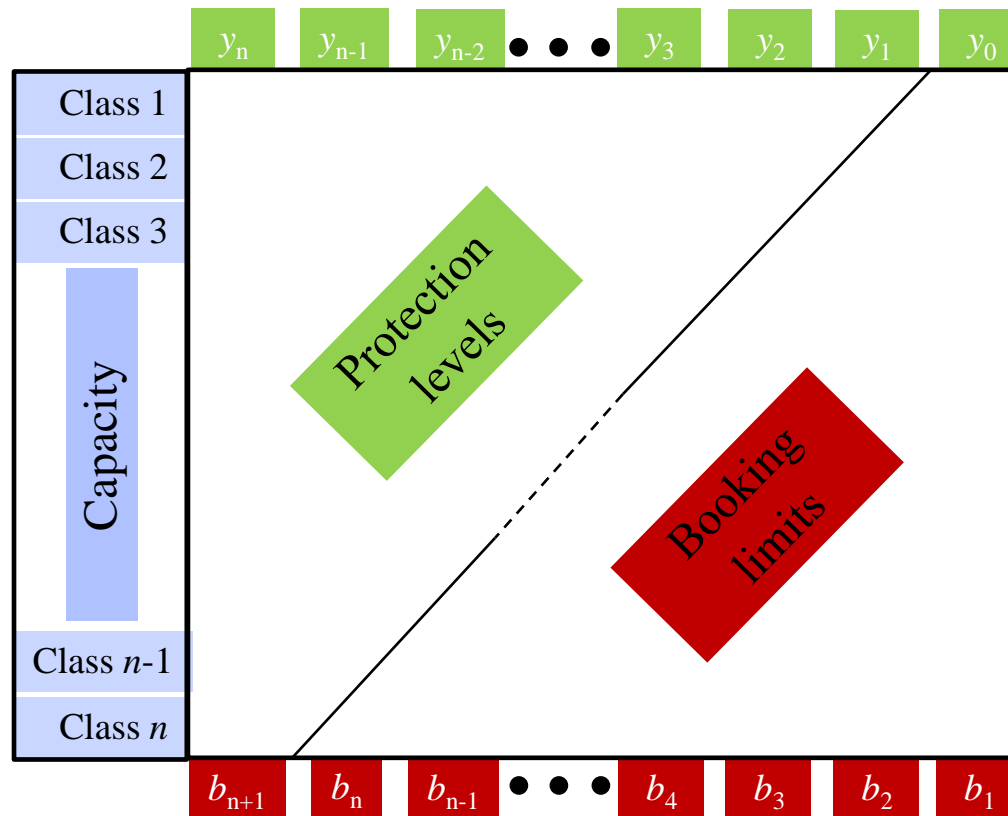
Because of nestedness, $0 < b_n < b_{n-1} < \dots < b_1$ and $0 < y_1 < y_2 < \dots < y_n$

Capacity=Booking Limits + Protection Levels

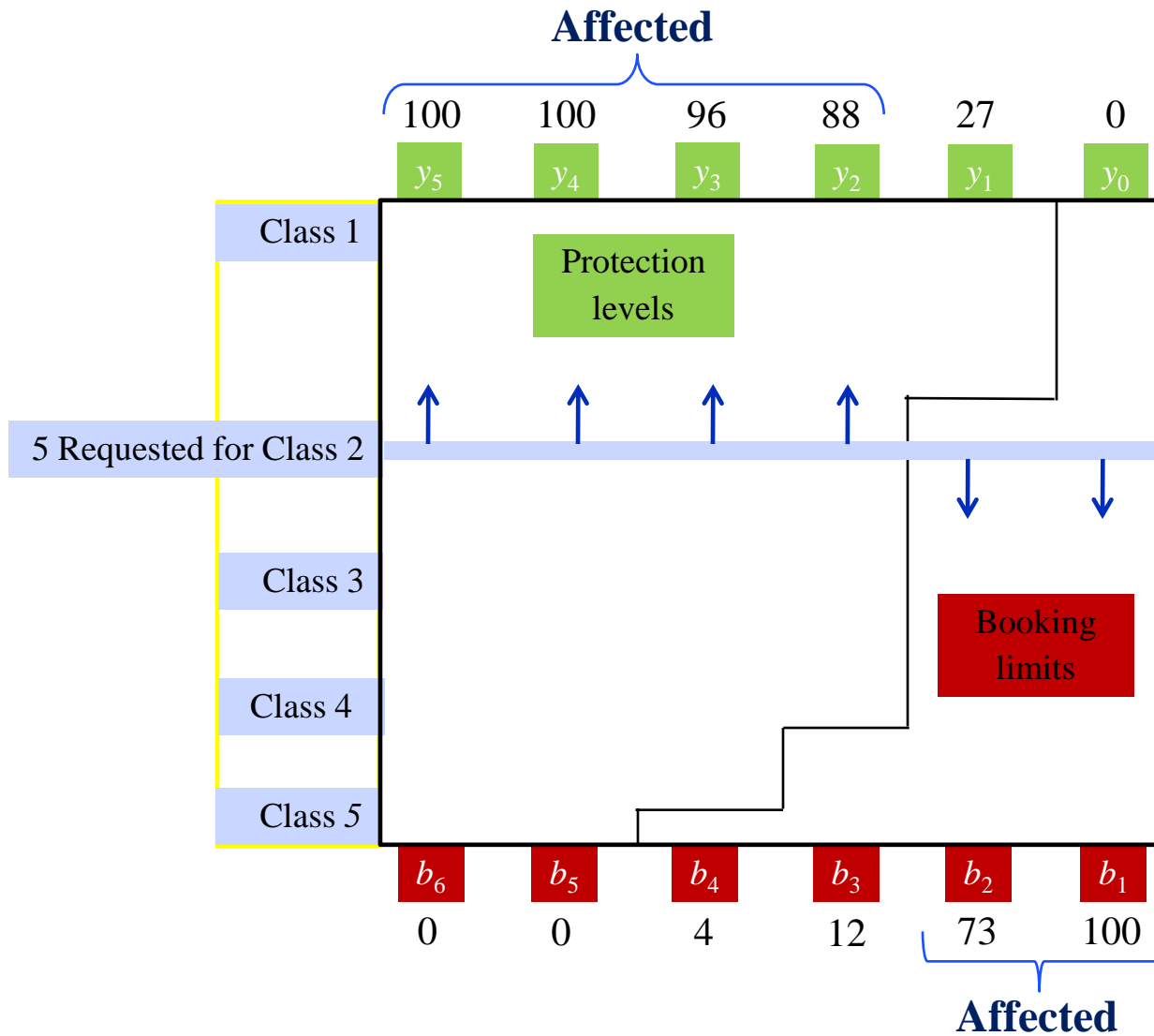
- ◆ Booking limit b_i for class i limits bookings for classes $j=i, \dots, n$. Protection level y_{i-1} for class $i-1$ protects future reservations or classes $j=1, 2, \dots, i-1$.
- ◆ Booking limit b_i protects classes $j=1, \dots, i-1$ as what is not sold to classes i, \dots, n is sold to classes $1, \dots, i-1$. The protection level for class $i-1$ is related to the booking limit for class i : $y_{i-1} = \text{capacity} - b_i = b_1 - b_i$ or $b_i + y_{i-1} = \text{capacity}$



Summary: Booking Limits and Protection Levels



Example: Increasing Bookings while Keeping Booking Limits Constant



Example: Increasing Bookings while Keeping Booking Limits Constant

- ◆ Suppose Booking limits $=b=(b_1, b_2, b_3, b_4, b_5)=(100, 73, 12, 4, 0)$.
- ◆ Current bookings $=B=(B_1, B_2, B_3, B_4, B_5)=(0, 0, 0, 0, 0)$
- ◆ 5 requested for class 2; Let $x=(x_1, x_2, x_3, x_4, x_5)=(5, 5, 0, 0, 0)$ for the request.
 - ◆ Class 2 bookings are restricted by $b_2=73$ (applies to classes 2..5) and $b_1=100$ (applies to classes 1..5) . Both have enough room as $b_2-x_2=68 \geq 0$ and $b_1-x_1=95 \geq 0$, so accept the request.
 - ◆ Set the current bookings to $B=(5, 5, 0, 0, 0)$.
- ◆ 1 requested for class 2; Let $x=(1, 1, 0, 0, 0)$ for the request.
 - ◆ Since $b_2-B_2-x_2=67 \geq 0$ and $b_1-B_1-x_1=94 \geq 0$, accept the request.
 - ◆ Set the current bookings to $B=(6, 6, 0, 0, 0)$.
- ◆ 1 requested for class 4; Let $x=(1, 1, 1, 1, 0)$ for the request.
 - ◆ Since $b_4-B_4-x_4=3 \geq 0$, $b_3-B_3-x_3=11 \geq 0$, $b_2-B_2-x_2=66 \geq 0$ and $b_1-B_1-x_1=93 \geq 0$, accept the request.
 - ◆ Set the current bookings to $B=(7, 7, 1, 1, 0)$.
- ◆ 3 requested for class 3; Let $x=(3, 3, 3, 0, 0)$ for the request.
 - ◆ Since $b_3-B_3-x_3=8 \geq 0$, $b_2-B_2-x_2=63 \geq 0$ and $b_1-B_1-x_1=90 \geq 0$, accept the request.
 - ◆ Set the current bookings to $B=(10, 10, 4, 1, 0)$.
- ◆ 4 requested for class 4; Let $x=(4, 4, 4, 4, 0)$ for the request.
 - ◆ Since $b_4-B_4-x_4=-1 < 0$, $b_3-B_3-x_3=4 \geq 0$, $b_2-B_2-x_2=59 \geq 0$ and $b_1-B_1-x_1=86 \geq 0$, reject the request.
 - ◆ Keep the bookings as $B=(10, 10, 4, 1, 0)$.
- ◆ 2 requested for class 1; Let $x=(2, 0, 0, 0, 0)$ for the request.
 - ◆ Since $b-B-x=(88, 63, 8, 3, 0) \geq 0$, accept the request.
 - ◆ Set the bookings to $B=(10, 10, 4, 1, 0)+(2, 0, 0, 0, 0)=(12, 10, 4, 1, 0)$.

Example: Increasing Bookings while Keeping Booking Limits Constant

- ◆ $b=(b_1, b_2, b_3, b_4, b_5)=(100, 73, 12, 4, 0)$. $B=(B_1, B_2, B_3, B_4, B_5)=(12, 10, 4, 1, 0)$.
- ◆ 30 requested for class 2; Let $x=(x_1, x_2, x_3, x_4, x_5)=(30, 30, 0, 0, 0)$ for the request.
 - ◆ Since $b-B-x=(58, 33, 8, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(12, 10, 4, 1, 0)+(30, 30, 0, 0, 0)=(42, 40, 4, 1, 0)$.
- ◆ 20 requested for class 2; Let $x=(20, 20, 0, 0, 0)$.
 - ◆ Since $b-B-x=(38, 13, 8, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(42, 40, 4, 1, 0)+(20, 20, 0, 0, 0)=(62, 60, 4, 1, 0)$.
- ◆ 10 requested for class 3; Let $x=(10, 10, 10, 0, 0)$.
 - ◆ Since $b-B-x=(28, 3, -2, 3, 0) \geq 0$ fails, reject.
 - ◆ Keep $B=(62, 60, 4, 1, 0)$.
- ◆ 6 for class 3, $x=(6, 6, 6, 0, 0)$.
 - ◆ If $b-B-x=(32, 7, 2, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(62, 60, 4, 1, 0)+(6, 6, 6, 0, 0)=(68, 66, 10, 1, 0)$.
- ◆ 3 for class 3, $x=(3, 3, 3, 0, 0)$.
 - ◆ If $b-B-x=(29, 4, -1, 3, 0) \geq 0$ fails, reject.
 - ◆ Keep $B=(68, 66, 10, 1, 0)$.
- ◆ 6 for class 2, $x=(6, 6, 0, 0, 0)$.
 - ◆ If $b-B-x=(26, 1, 2, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(68, 66, 10, 1, 0)+(6, 6, 0, 0, 0)=(74, 72, 10, 1, 0)$.
- ◆ 1 for class 3, $x=(1, 1, 1, 0, 0)$.
 - ◆ If $b-B-x=(25, 0, 1, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(74, 72, 10, 1, 0)+(1, 1, 1, 0, 0)=(75, 73, 11, 1, 0)$.

Example: Increasing Bookings while Keeping Booking Limits Constant

- ◆ $b=(b_1, b_2, b_3, b_4, b_5)=(100, 73, 12, 4, 0)$. $B=(B_1, B_2, B_3, B_4, B_5)=(75, 73, 11, 1, 0)$.
- ◆ Since $b-B=(25, 0, 1, 3, 0)$, all low fare classes are closed. **Only the first class** can accept from now on.
- ◆ 1 for class 5, $x=(1, 1, 1, 1, 1)$.
 - ◆ If $b-B-x=(24, -1, 0, 2, -1) \geq 0$ fails, reject.
 - ◆ Keep $B=(75, 73, 11, 1, 0)$.
- ◆ 1 for class 4, $x=(1, 1, 1, 1, 0)$.
 - ◆ If $b-B-x=(24, -1, 0, 2, 0) \geq 0$ fails, reject.
 - ◆ Keep $B=(75, 73, 11, 1, 0)$.
- ◆ 1 for class 3, $x=(1, 1, 1, 0, 0)$.
 - ◆ If $b-B-x=(24, -1, 0, 3, 0) \geq 0$ fails, reject.
 - ◆ Keep $B=(75, 73, 11, 1, 0)$.
- ◆ 1 for class 2, $x=(1, 1, 0, 0, 0)$.
 - ◆ If $b-B-x=(24, -1, 1, 3, 0) \geq 0$ fails, reject.
 - ◆ Keep $B=(75, 73, 11, 1, 0)$.
- ◆ 25 for class 1, $x=(25, 0, 0, 0, 0)$.
 - ◆ If $b-B-x=(0, 0, 1, 3, 0) \geq 0$, accept.
 - ◆ Set $B=(75, 73, 11, 1, 0)+(25, 0, 0, 0, 0)=(100, 73, 11, 1, 0)$.
- ◆ Since $b-B=(0, 0, 1, 3, 0)$, all classes are closed.
- ◆ Recover bookings
 - First class: $B_1-B_2=27$; Second class: $B_2-B_3=62$; Third class: $B_3-B_4=10$; Fourth class: $B_4-B_5=1$; Fifth class: $B_5=0$.

Booking Algorithm with Booking Limits

{Initialization}

$B := \mathbf{0}$. Booking limit b is given.

{Both B and b are vectors of length n .}

{Iterative step}

While Remaining_capacity= $b_1 - B_1 > \mathbf{0}$ **do**

Suppose m requests for class i : $x = [m, \dots, m, \mathbf{0}, \dots, \mathbf{0}]$.

{ x is a vector (of length number of classes)}

whose only first i elements are nonzero and equal to m .

$m < 0$ denotes a cancellation.}

If $b \geq B + x$, Accept the request and set $B := B + x$;

else Reject the request.

EndWhile

Tactical Revenue Management

- ◆ Tactical RM is calculating and updating booking limits.
 - Periodic updates: Daily when 15 or fewer days until departure. Less frequently if more days until departure.
 - Event-driven updates: NBA all-star game in Dallas in 2010; Aircraft change.
- ◆ Some terminology
 - Resources: Units of capacity managed by a supplier
 - Products: What customers want to purchase.
 - Fare class: Group or resources allocated to a segment of customers.

	Passenger Airline	SOM
Resource unit	Seat	Course
Resource types	Service classes	OM, SCM, Finance, ...
Number of types	1-3	Many
Products	Itineraries	Degrees
Products/resource	Many for hub-and-spoke airlines ; A few for point-to-point airlines.	Many for core courses; A few for electives.

- Load factor: Utilization of resources. Increase by booking more.
- Yield: Revenue per passenger mile. Increase by booking less.
- RASM/CASM: Revenue/Cost per available seat mile. $RASM = \text{Net yield} * \text{Load factor}$.
- REVPAR: Revenue per available room night.

Tactical Revenue Management

- ◆ Capacity Allocation: Booking for various fare classes.
- ◆ Network management: Booking across a network.
 - Club-Med Resorts accepts check-in only on Sundays and a minimum stay of at least 7 days. This limits the relevance of network management.
 - Network management is not relevant for point-to-point airlines.
 - Cruise lines depart on a certain day and everybody on-board remains on the ship for the same number of days. Network management is not relevant for cruise lines.
 - Concert and sport events are similar to cruise lines, the start and ending time of the event is the same for everybody.
 - » Exception: Some jaz clubs run multiple sittings on a single night. Some patrons may stay for two sittings in a row.
- ◆ Overbooking: Booking extra to compensate for no-shows.
 - Resorts, cruise lines, events are not overbooked. In these industries, there is no compensation for not showing-up.
 - On the other hand, some airline tickets are refundable and parts of hotel costs can be recovered when one does not show up. Because of these, both airlines and hotels use overbooking.

Systematic View of Revenue Management

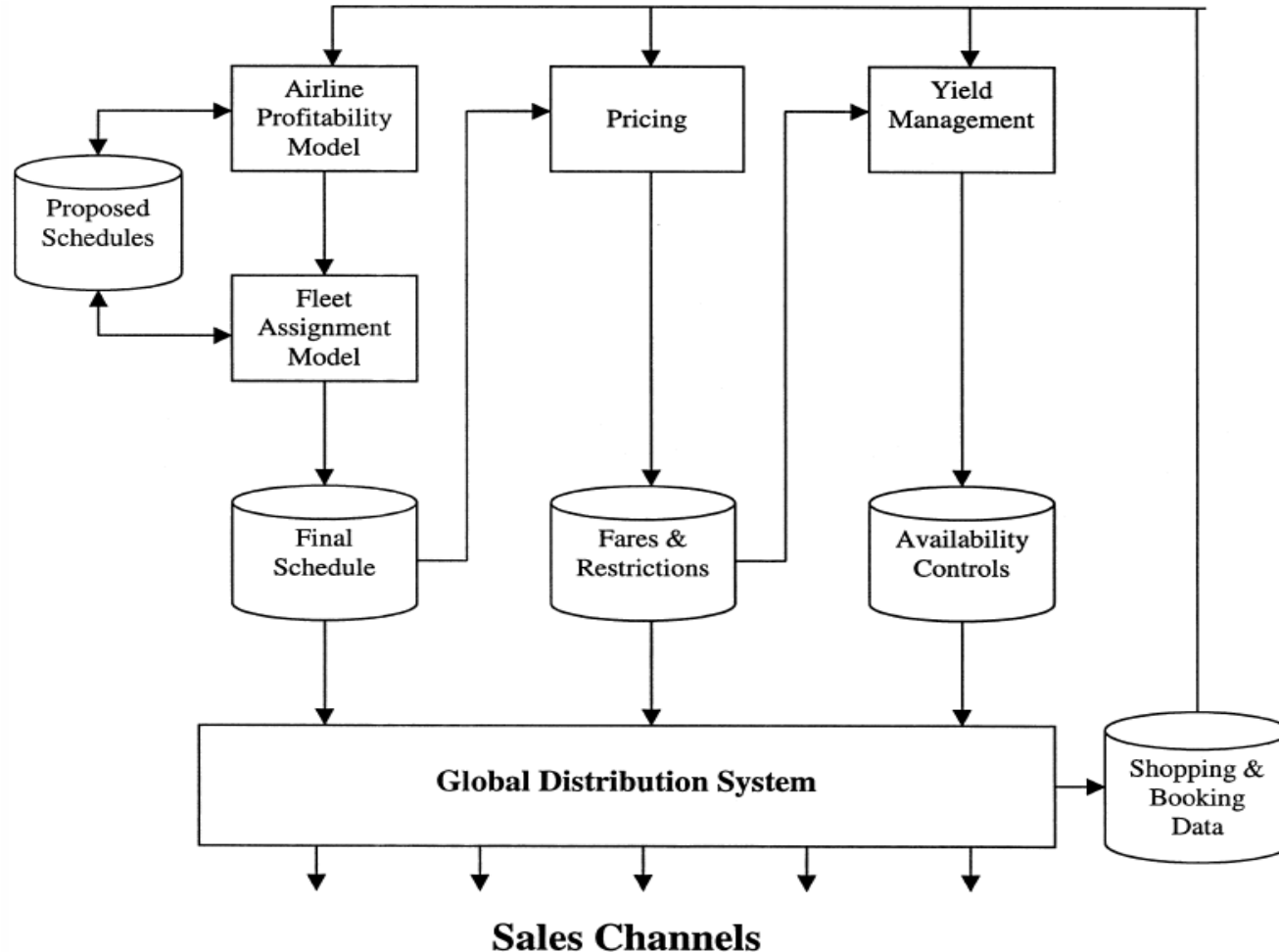


Figure 1: Data collected and stored using the e-commerce infrastructure drive airline scheduling and yield management. Airlines use the sales and marketing data to build “optimal” schedules. They also use the data to set “optimal” prices and yield-management controls.

Net Contribution=Price+Ancillary Fees-Incremental Cost

- ◆ Incremental costs and fee obtained from ancillary products/services can change make net contribution somewhat different from revenue (product price).
- ◆ Relative importance of incremental costs depends on the industry

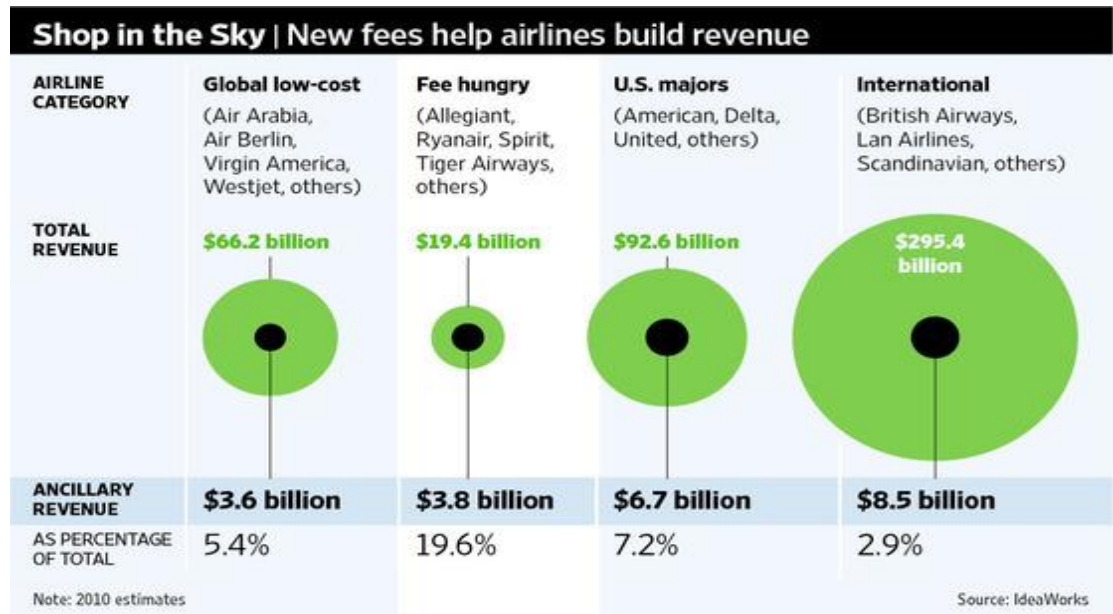
	Incremental Cost	Importance
Cruise lines	Commission, food, cleaning	High
Container shipping	Repositioning, handling, fuel	High
Passenger airlines	Commission, fuel, food, passenger fees	Moderate
Rental cars	Commission, processing, wear/tear	Moderate
University	Extra sessions, TAs, wear/tear	Moderate
Hotels	Commissions, cleaning, wear/tear	Low
Casinos	Commissions, cleaning, wear/tear	Low
Events	Commissions	Very low

Net Contribution=Price+Ancillary Fees-Incremental Cost

- ◆ Relative importance of ancillary fees depends on the industry

	Ancillary fees	Importance
Passenger airlines	Food, beverage, ear-phone, duty-free sales	Low
University	Activity fee, library fee	Low-Moderate
Hotels	Food, beverage, minibar, internet, phone fees	Moderate
Container shipping	Call before delivery, expediting	Moderate
Rental cars	Insurance, gasoline	Moderate
Cruise lines	Gambling, on-board sales	Moderate-High
Casinos	Gambling losses	High
Events	Food, beverage, merchandise, parking	Very high

- ◆ Ancillary fees becoming more important for airlines.



Recent Trends: RM in Practice

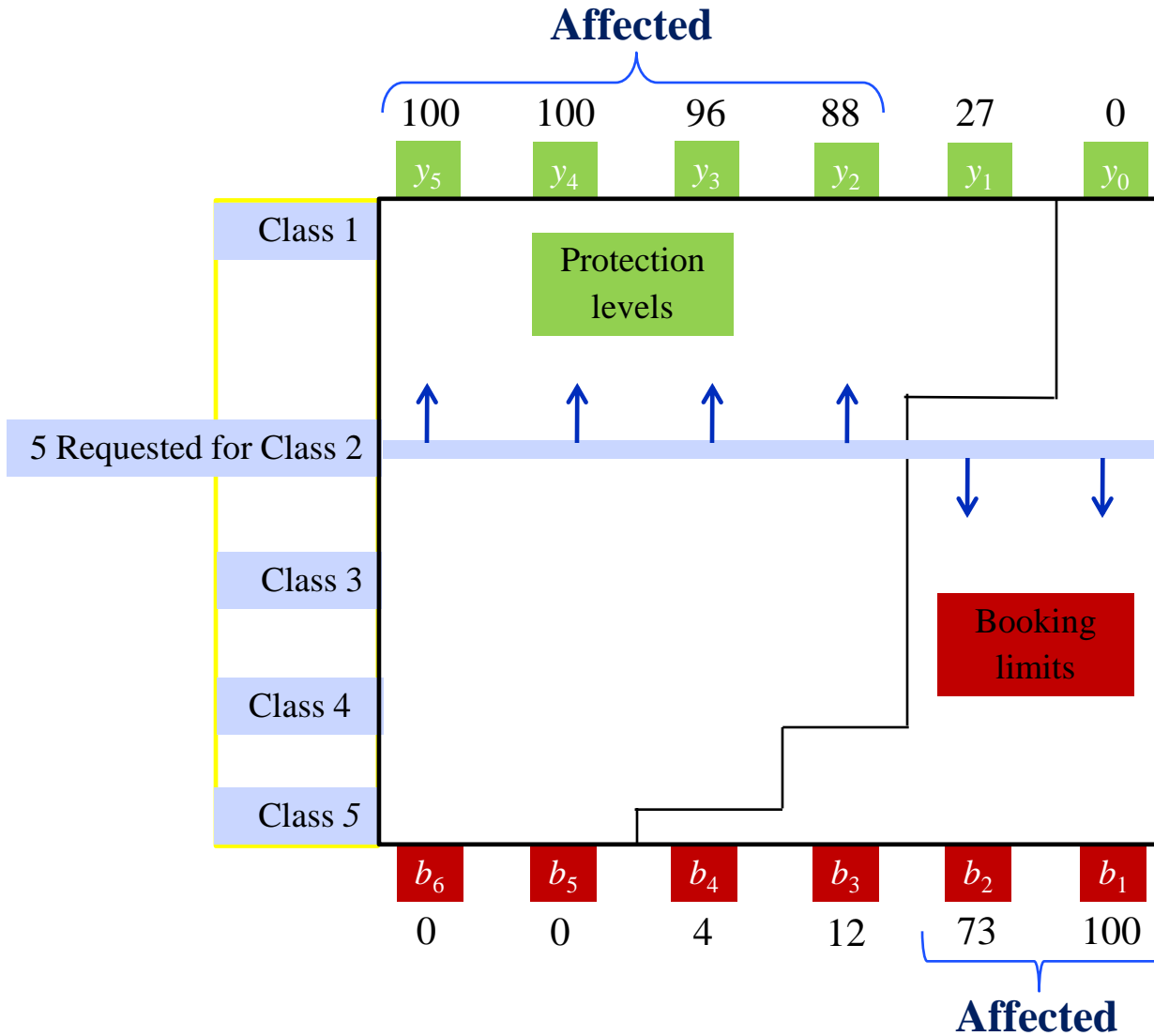
- ◆ Strategic customer: Because of fare visibility, ease of communication among customer groups, customers are better informed than ever before. They may optimize the timing, the amount of their purchases.
 - Case in point: Strategic retail customers wait for discounting season. A higher percentage of merchandise is sold every year through discounting. Can the retailers remain in business without resorting to discounts. Neiman Marcus (One Marcus Square, 1618 Main Street, Dallas) is trying.
- ◆ Online travel agents/intermediaries (Expedia, Travelocity and Priceline) provide cheaper distribution channels.
 - Attempting to book a hotel in San Diego: Google search for “cheap hotels San Diego” takes you to Expedia.com. You book a hotel with Expedia and pay Expedia not the hotel. Expedia pays a wholesale rate to the hotel. The hotel will not reveal the wholesale rate to customers unless you insist. If you insist after the check-out, you will see that Expedia charges about 20% premium as distribution/commission fee.
- ◆ Opaque products: Hidden product attributes.
 - Go to priceline.com bid for a hotel in San Diego for three nights, starting on coming Saturday.
 - » 1. Choose location: Downtown San Diego & Harbor Island.
 - » 2. Choose star level: 3.5 stars or more.
 - » 3. Name your price: \$70 per night. (You are prompted with a median price of \$187 per night – reference price.)
 - » 4. Enter name/credit card info. What exactly did you buy?
- ◆ Last-minute deals: See <http://lastminute.travelocity.com>

Summary

- ◆ **History**
- ◆ **Levels of Decisions**
 - Strategy
 - Tactics
- ◆ **Net Contribution**

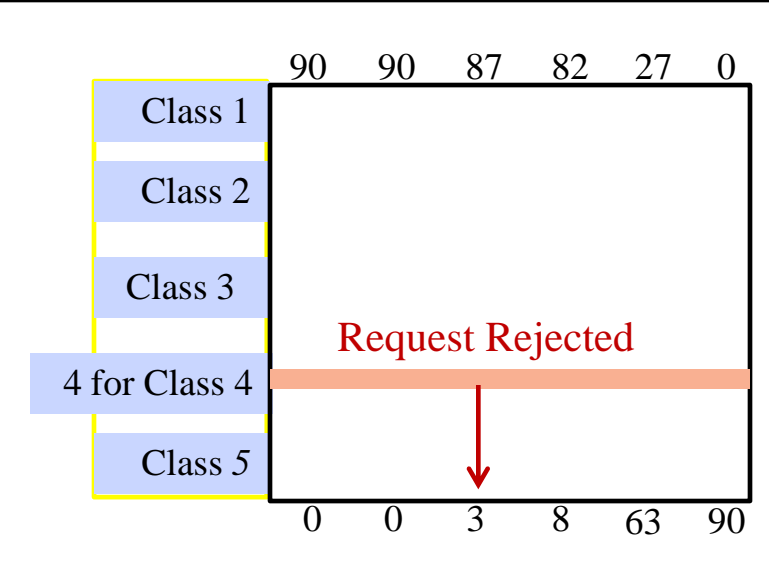
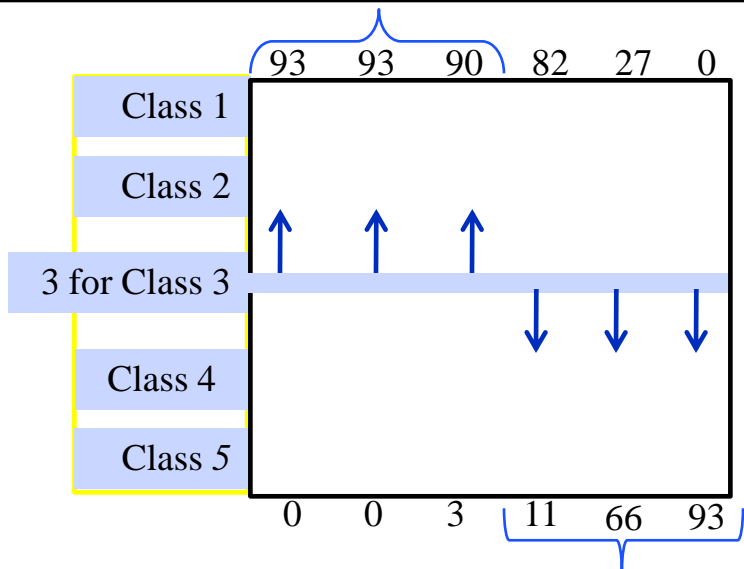
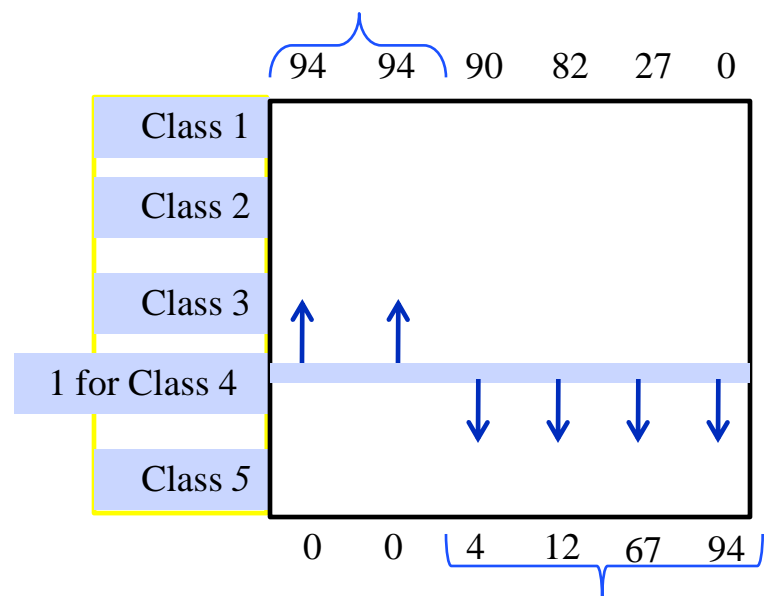
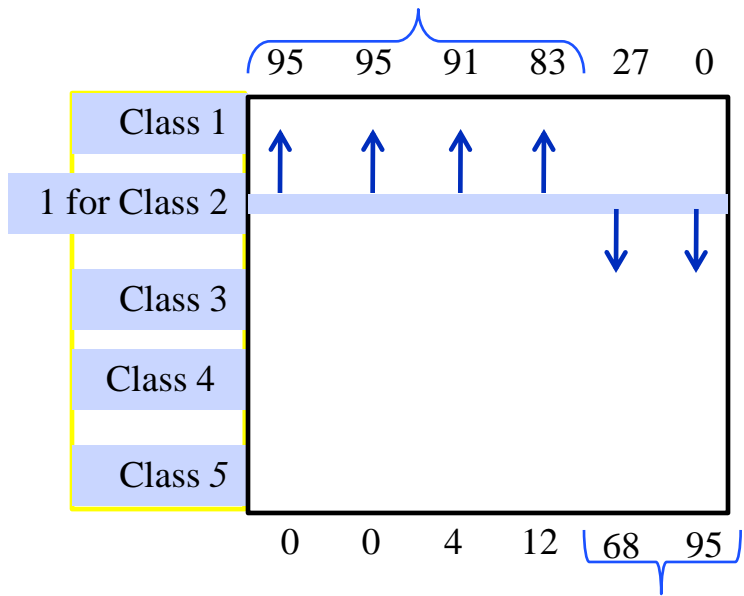
Example: Decreasing Limits & Levels

5 Fare Classes



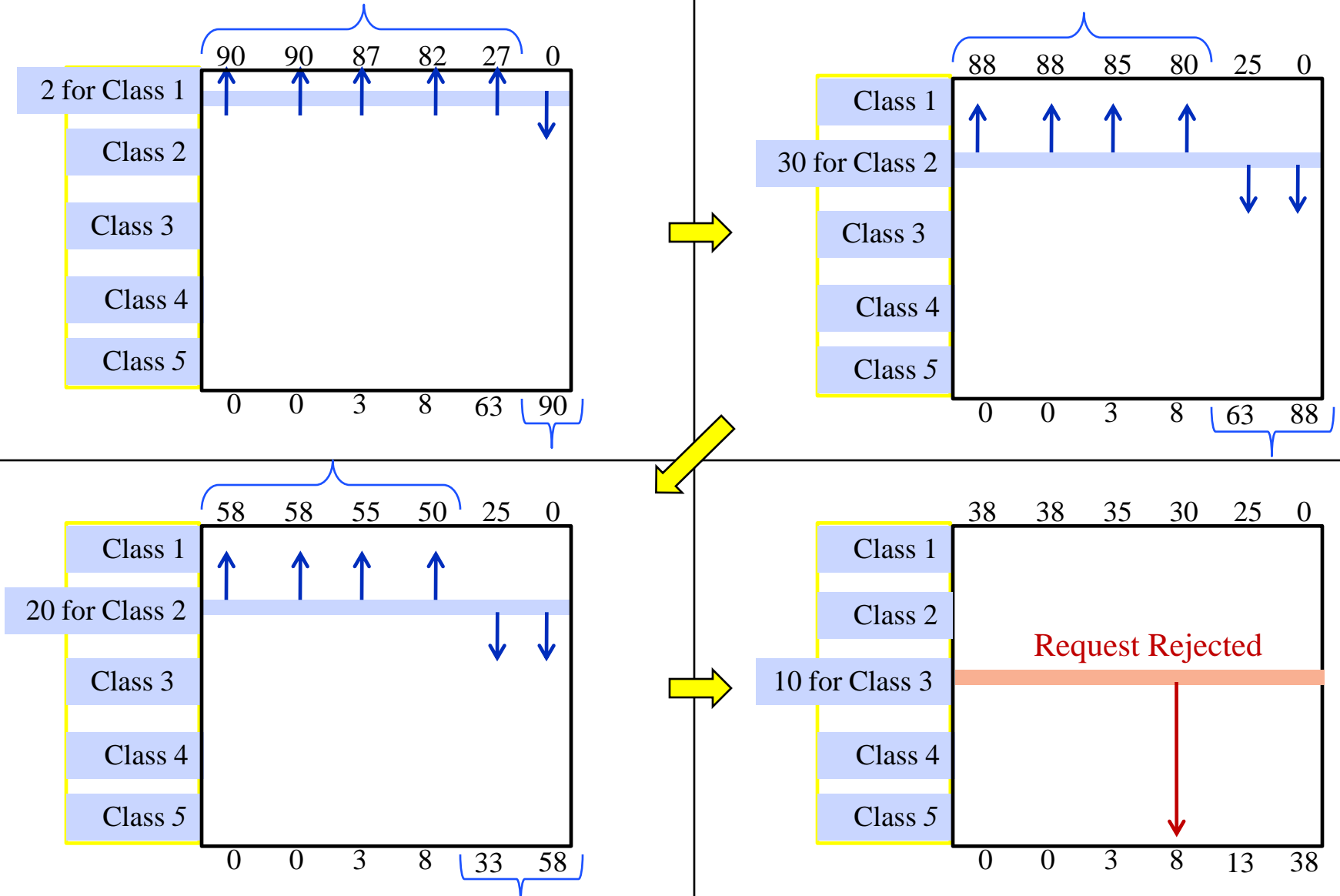
Example: Booking Limits and Protection Levels

5 Classes



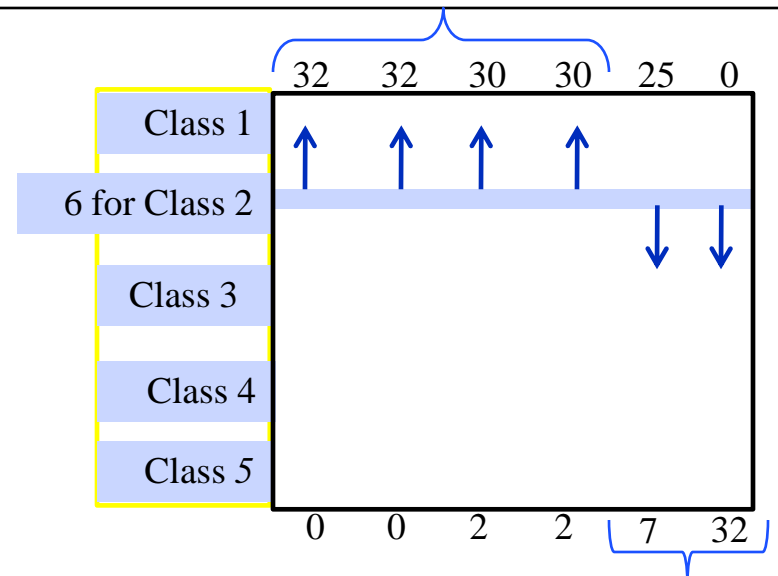
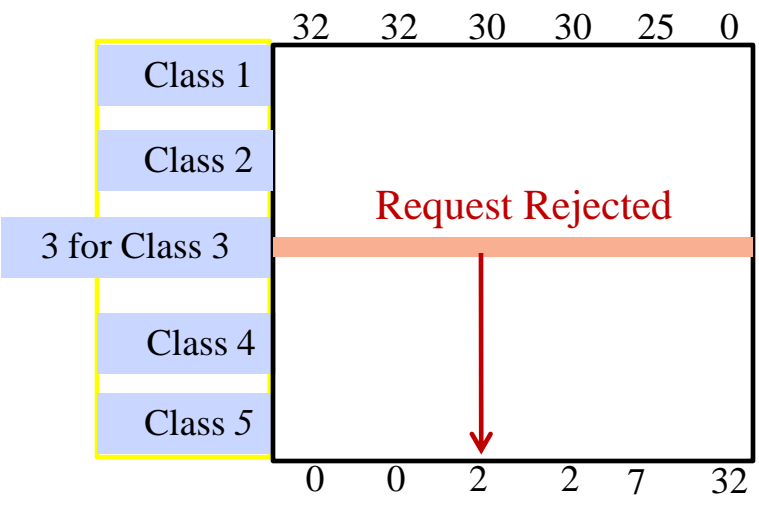
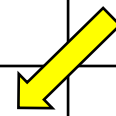
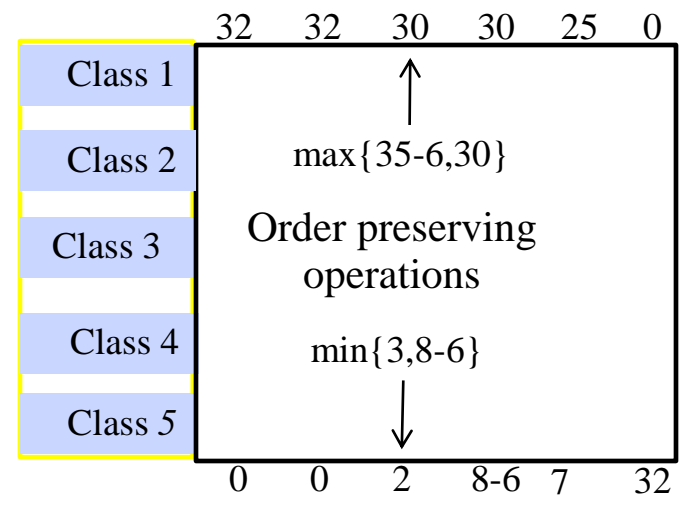
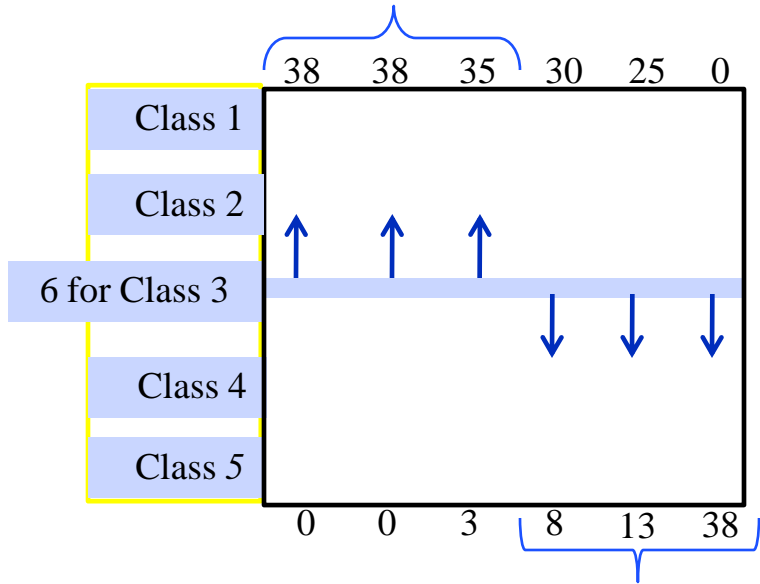
Example: Booking Limits and Protection Levels

5 Classes

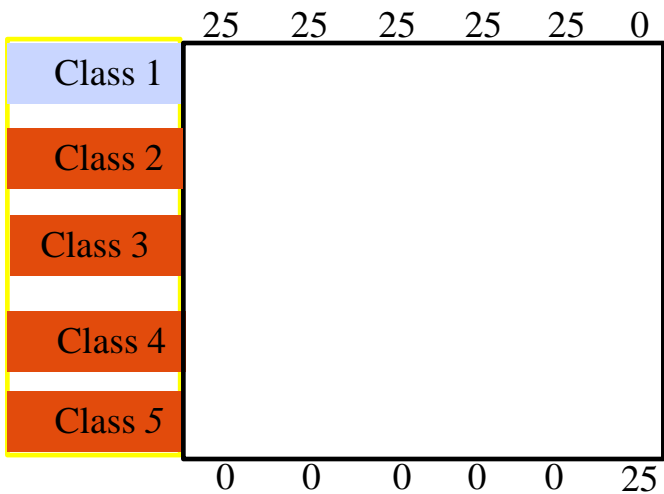
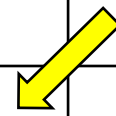
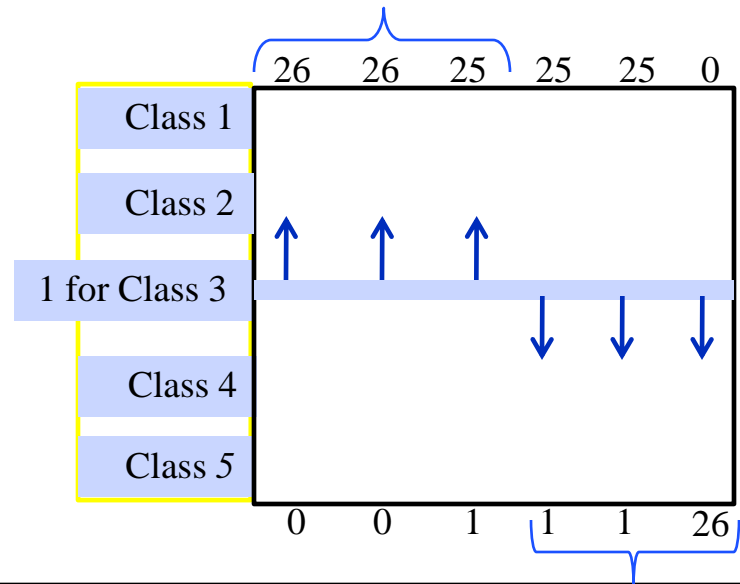
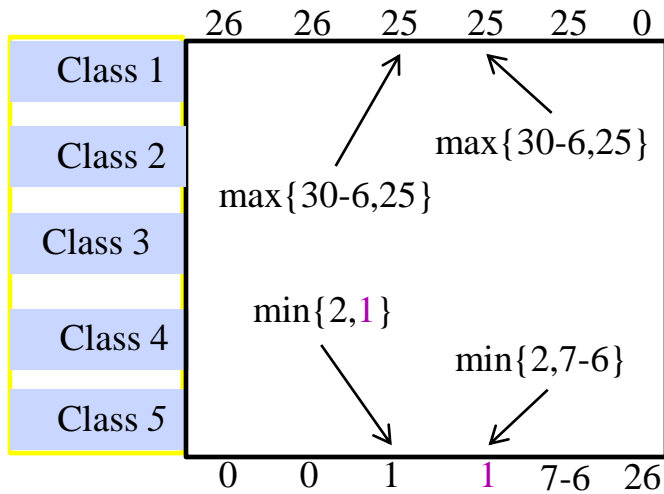


Example: Booking Limits and Protection Levels

5 Classes



Example: Booking Limits and Protection Levels 5 Classes



All low-fare classes are closed.
 From now on accept only the first class.
 Recover bookings by accumulating accepted bookings.

We must make order preserving operations to preserve nestedness. These are cumbersome. Why not to keep booking limits constant and increase bookings?