Where in the World Is Carmen Sandiego?

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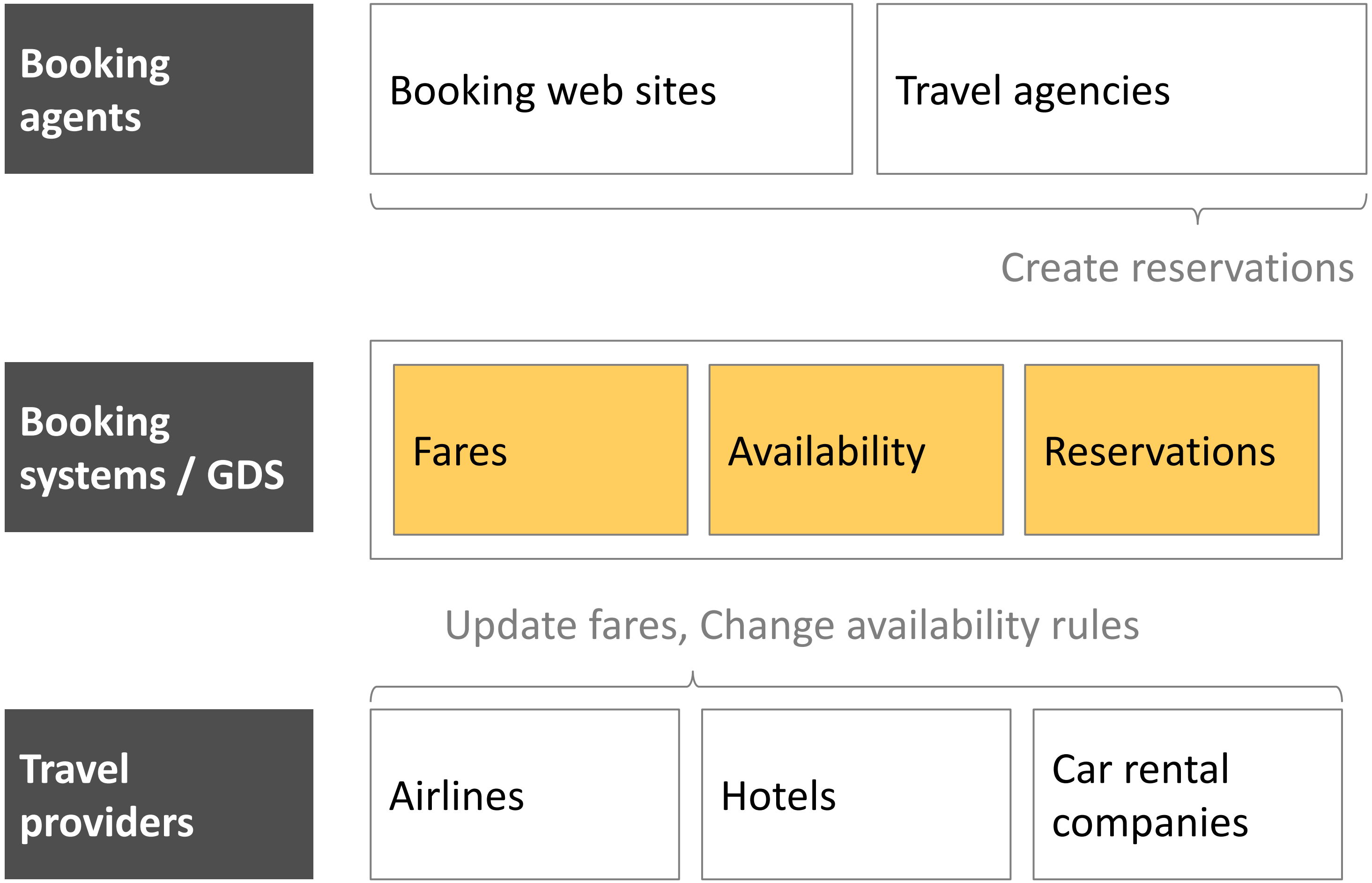
Security
Research
Labs

Global booking systems store data from airlines and passengers



Booking agents

Booking web sites

Travel agencies

Create reservations

Booking systems / GDS

Fares

Availability

Reservations

Update fares, Change availability rules

Travel providers

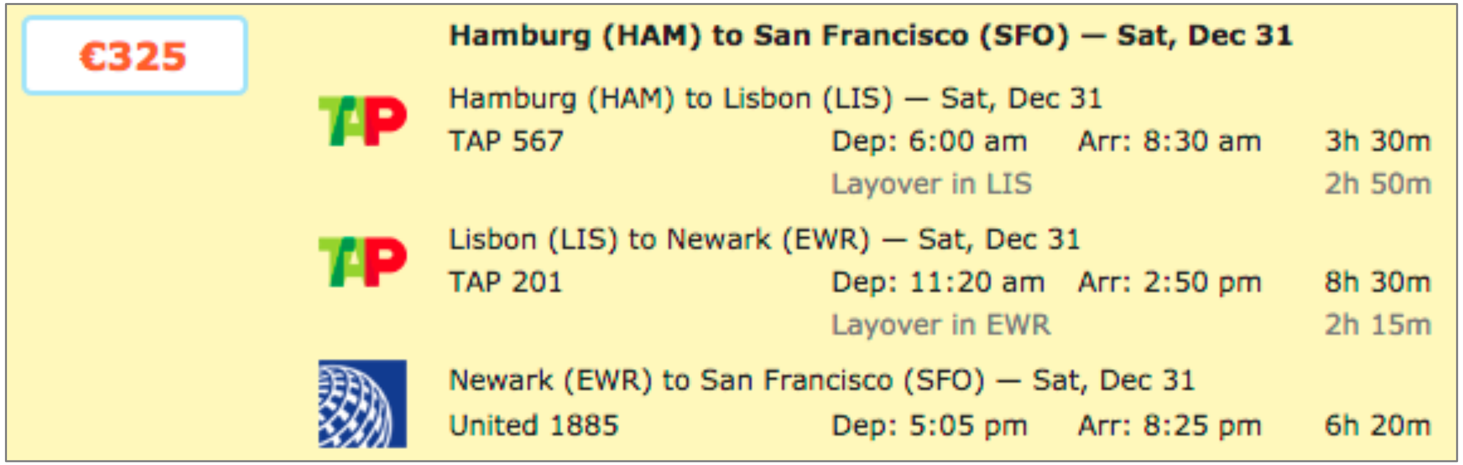
Airlines

Hotels

Car rental companies

GDS store price and availability rules

Fare



€325

Hamburg (HAM) to San Francisco (SFO) — Sat, Dec 31

Hamburg (HAM) to Lisbon (LIS) — Sat, Dec 31
TAP 567 Dep: 6:00 am Arr: 8:30 am 3h 30m
Layover in LIS 2h 50m

Lisbon (LIS) to Newark (EWR) — Sat, Dec 31
TAP 201 Dep: 11:20 am Arr: 2:50 pm 8h 30m
Layover in EWR 2h 15m

Newark (EWR) to San Francisco (SFO) — Sat, Dec 31
United 1885 Dep: 5:05 pm Arr: 8:25 pm 6h 20m

TAP (TP) OLDEUSTP HAM to SFO

General notes

```
BASIC SEASON ECONOMY ONE WAY SPECIAL
EXCURSION FARES
Between EUROPE and THE UNITED STATES
APPLIES FOR ONE WAY FARES
```

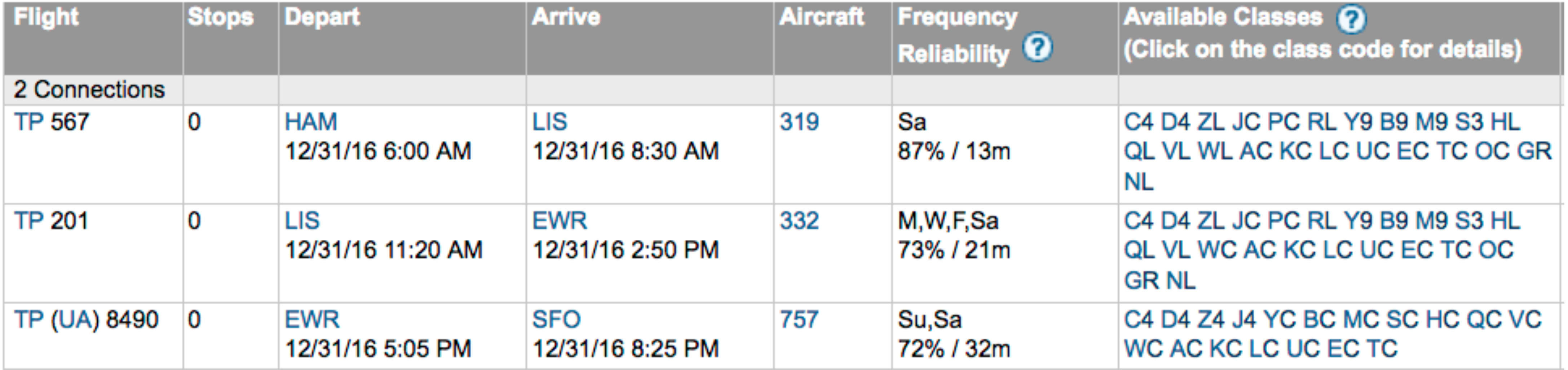
Category 3: Seasonal restrictions

```
PERMITTED 01NOV THROUGH 15DEC OR 31DEC
THROUGH 12MAY FOR EACH TRIP.
```

Category 4: Flight restrictions

```
IF THE FARE COMPONENT INCLUDES TRAVEL
WITHIN EUROPE
      THEN THAT TRAVEL MUST BE ON
      ONE OR MORE OF THE FOLLOWING
        ANY TP FLIGHT OPERATED BY TP …
```

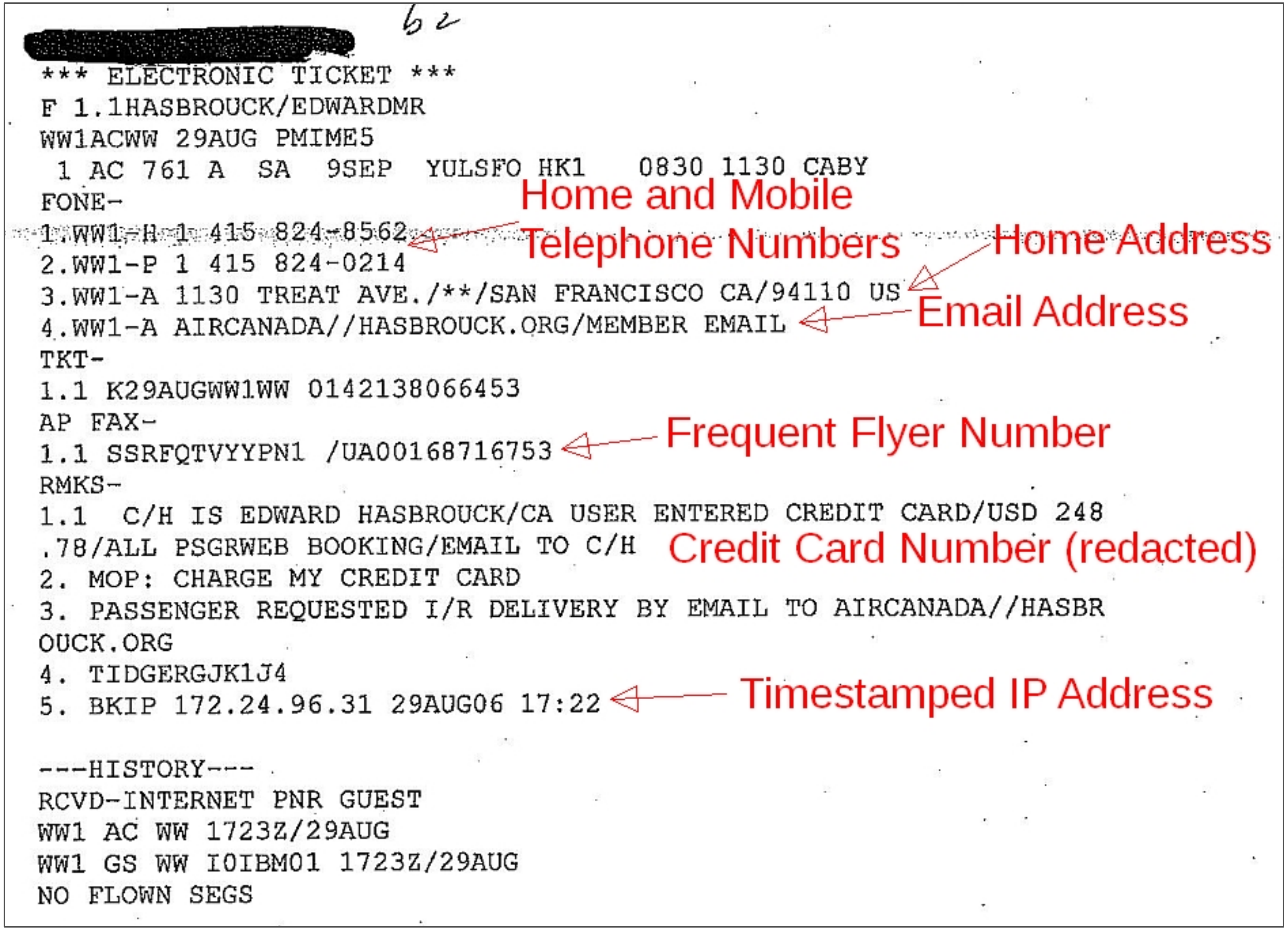
Availability



Flight	Stops	Depart	Arrive	Aircraft	Frequency Reliability ?	Available Classes ? (Click on the class code for details)
2 Connections						
TP 567	0	HAM 12/31/16 6:00 AM	LIS 12/31/16 8:30 AM	319	Sa 87% / 13m	C4 D4 ZL JC PC RL Y9 B9 M9 S3 HL QL VL WL AC KC LC UC EC TC OC GR NL
TP 201	0	LIS 12/31/16 11:20 AM	EWR 12/31/16 2:50 PM	332	M,W,F,Sa 73% / 21m	C4 D4 ZL JC PC RL Y9 B9 M9 S3 HL QL VL WC AC KC LC UC EC TC OC GR NL
TP (UA) 8490	0	EWR 12/31/16 5:05 PM	SFO 12/31/16 8:25 PM	757	Su,Sa 72% / 32m	C4 D4 Z4 J4 YC BC MC SC HC QC VC WC AC KC LC UC EC TC

GDS also store reservations including personal information

Reservation / PNR



62

[redacted]

```
*** ELECTRONIC TICKET ***
F 1.1HASBROUCK/EDWARDMR
WW1ACWW 29AUG PMIME5
 1 AC 761 A  SA  9SEP  YULSFO HK1   0830 1130 CABY
FONE-
1.WW1-H 1 415 824-8562
2.WW1-P 1 415 824-0214
3.WW1-A 1130 TREAT AVE./**/SAN FRANCISCO CA/94110 US
4.WW1-A AIRCANADA//HASBROUCK.ORG/MEMBER EMAIL
TKT-
1.1 K29AUGWW1WW 0142138066453
AP FAX-
1.1 SSRFQTVYYPN1 /UA00168716753
RMKS-
1.1  C/H IS EDWARD HASBROUCK/CA USER ENTERED CREDIT CARD/USD 248
.78/ALL PSGRWEB BOOKING/EMAIL TO C/H
2. MOP: CHARGE MY CREDIT CARD
3. PASSENGER REQUESTED I/R DELIVERY BY EMAIL TO AIRCANADA//HASBR
OUCK.ORG
4. TIDGERGJK1J4
5. BKIP 172.24.96.31 29AUG06 17:22

---HISTORY---
RCVD-INTERNET PNR GUEST
WW1 AC WW 1723Z/29AUG
WW1 GS WW IOIBM01 1723Z/29AUG
NO FLOWN SEGS
```

Home and Mobile Telephone Numbers

Home Address

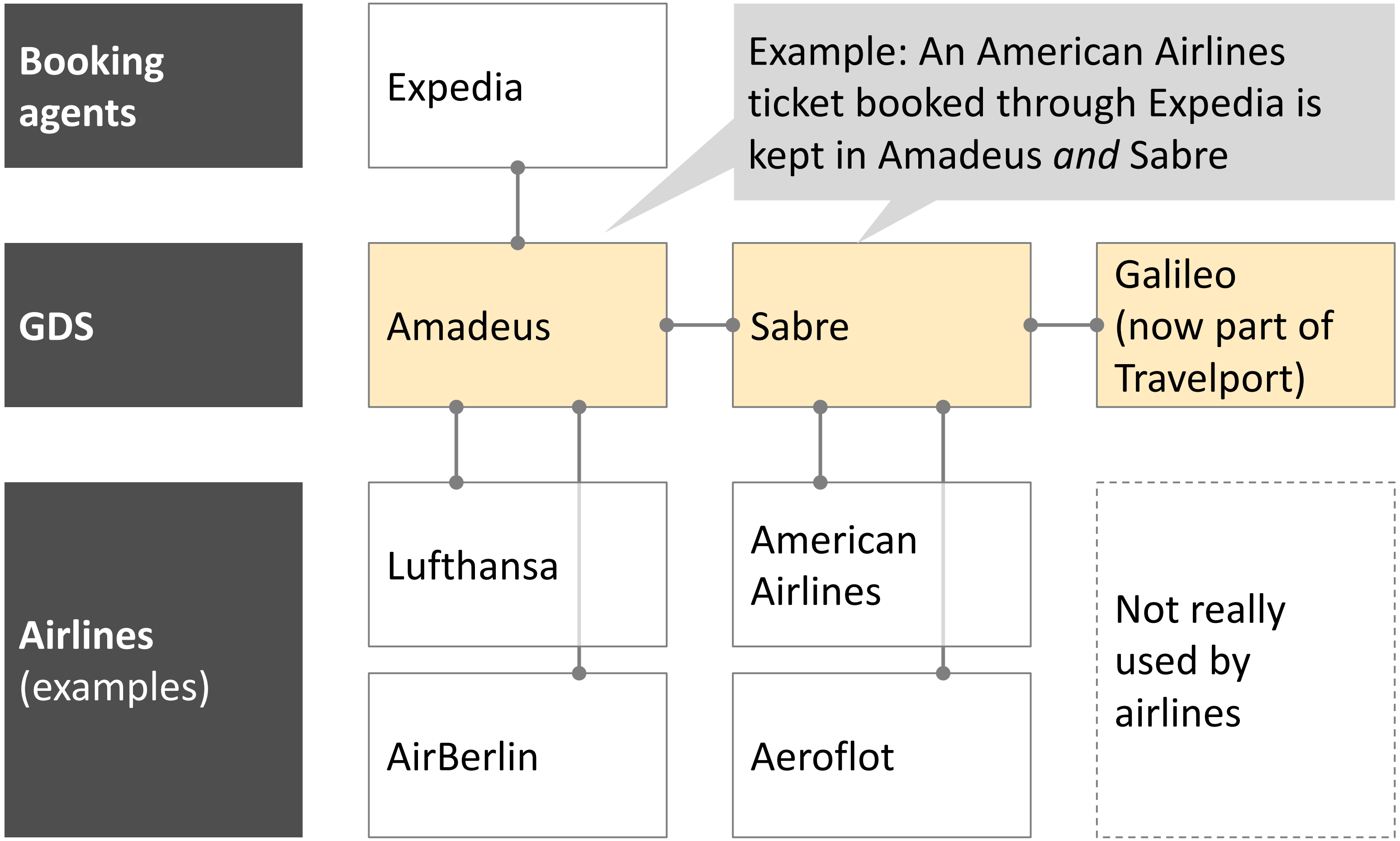
Email Address

Frequent Flyer Number

Credit Card Number (redacted)

Timestamped IP Address

Three GDS dominate the market



Booking agents

Expedia

Example: An American Airlines ticket booked through Expedia is kept in Amadeus *and* Sabre

GDS

Amadeus

Sabre

Galileo (now part of Travelport)

Airlines (examples)

Lufthansa

American Airlines

Not really used by airlines

AirBerlin

Aeroflot

We were curious about the protection of passenger information

Our research motivation

GDS may be insecure:

- Booking systems (GDS) go back to the 70s and 80s
- They were the first “cloud” before the term (or the Internet) existed
- Can such systems have modern security?

GDS may be secure:

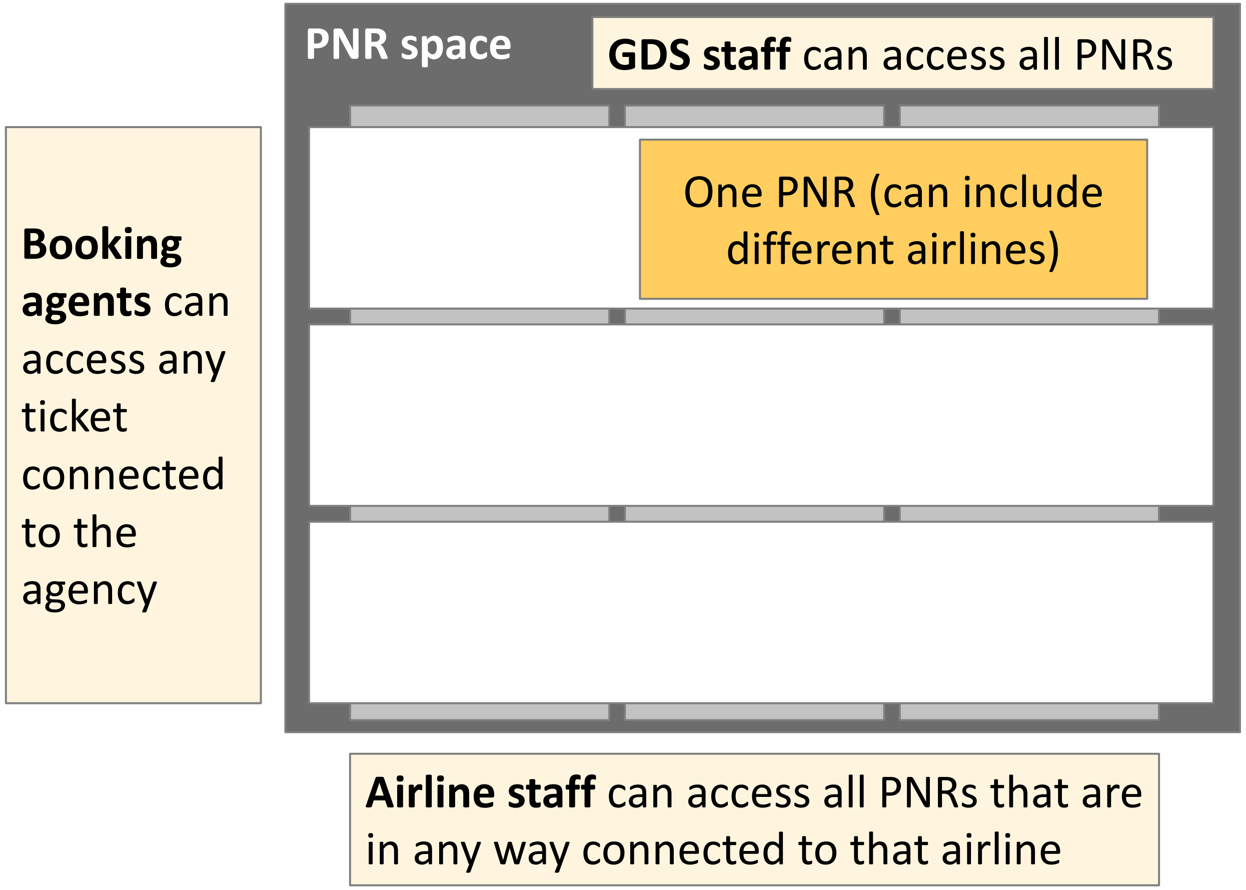
- Passenger data has been in dispute between governments for years
- Especially the EU expressed strong political will to protect traveler data

Which **web service security basics** are implemented in GDS?

Fine-grained access control	?
Strong authentication	?
Rate-limiting	?
Logging	?

GDS have very coarse access restrictions

Access control: Very little



PNR space

GDS staff can access all PNRs

One PNR (can include different airlines)

Booking agents can access any ticket connected to the agency

Airline staff can access all PNRs that are in any way connected to that airline

Too much access – plenty of people have access to private booking details:

1. Employees of the travel agency/website that created the booking
2. Employees of the travel providers included on the PNR
3. Employees of any of the GDS involved in any part of the PNR, including external support companies
4. Allegedly the US DHS

Too much information –

- The PNR includes all info from different providers (flight, hotel, car) for providers to see
- Includes payment information address, credit card incl. expiry

Are booking systems protected with basic security controls?

Web service security basics

Fine-grained access control	☒
Strong authentication	?
Rate-limiting	?
Logging	?

Authentication options range from weak to very weak

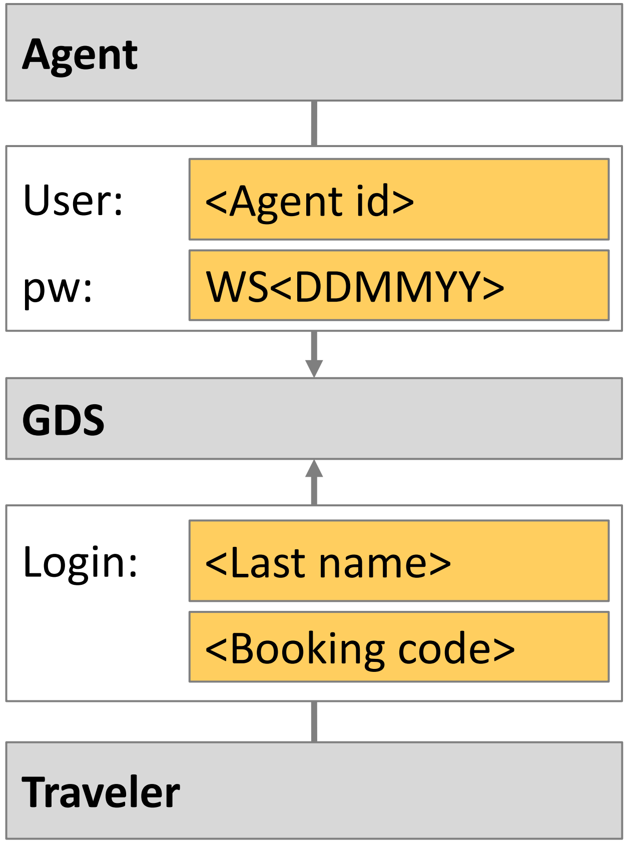
Authentication: Fail

Travel/airline agent access

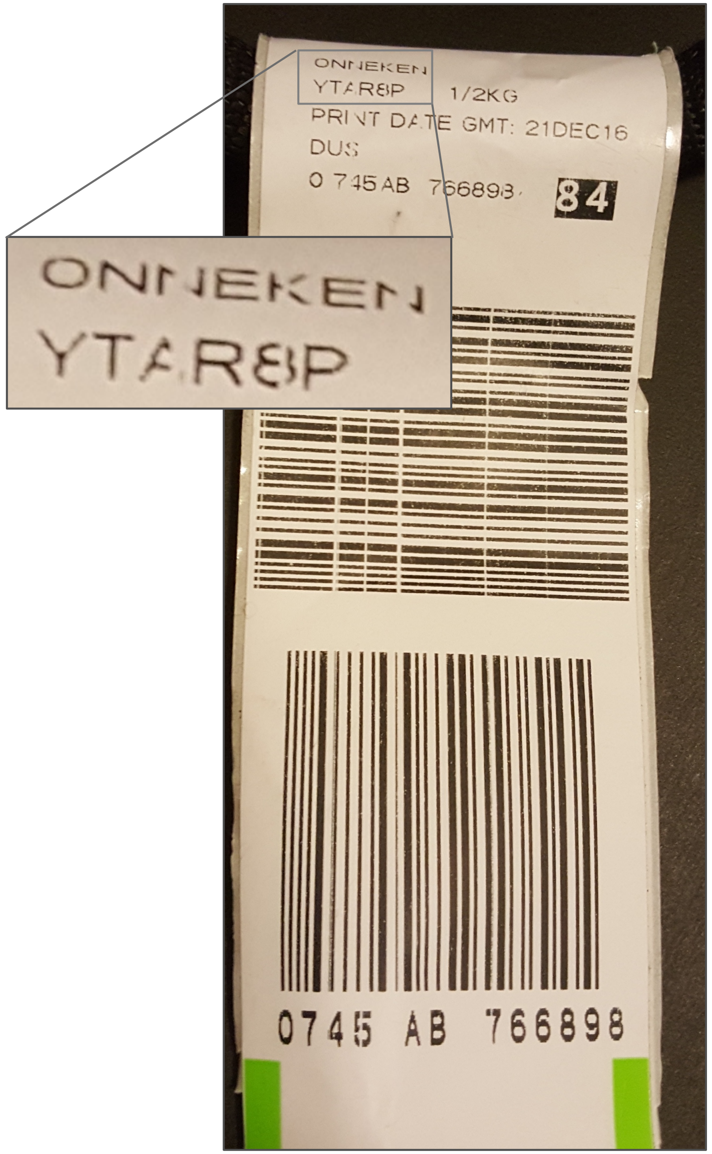
- Traditionally over direct connections
- Today as web service that connects over the open Internet
- Passwords often terrible

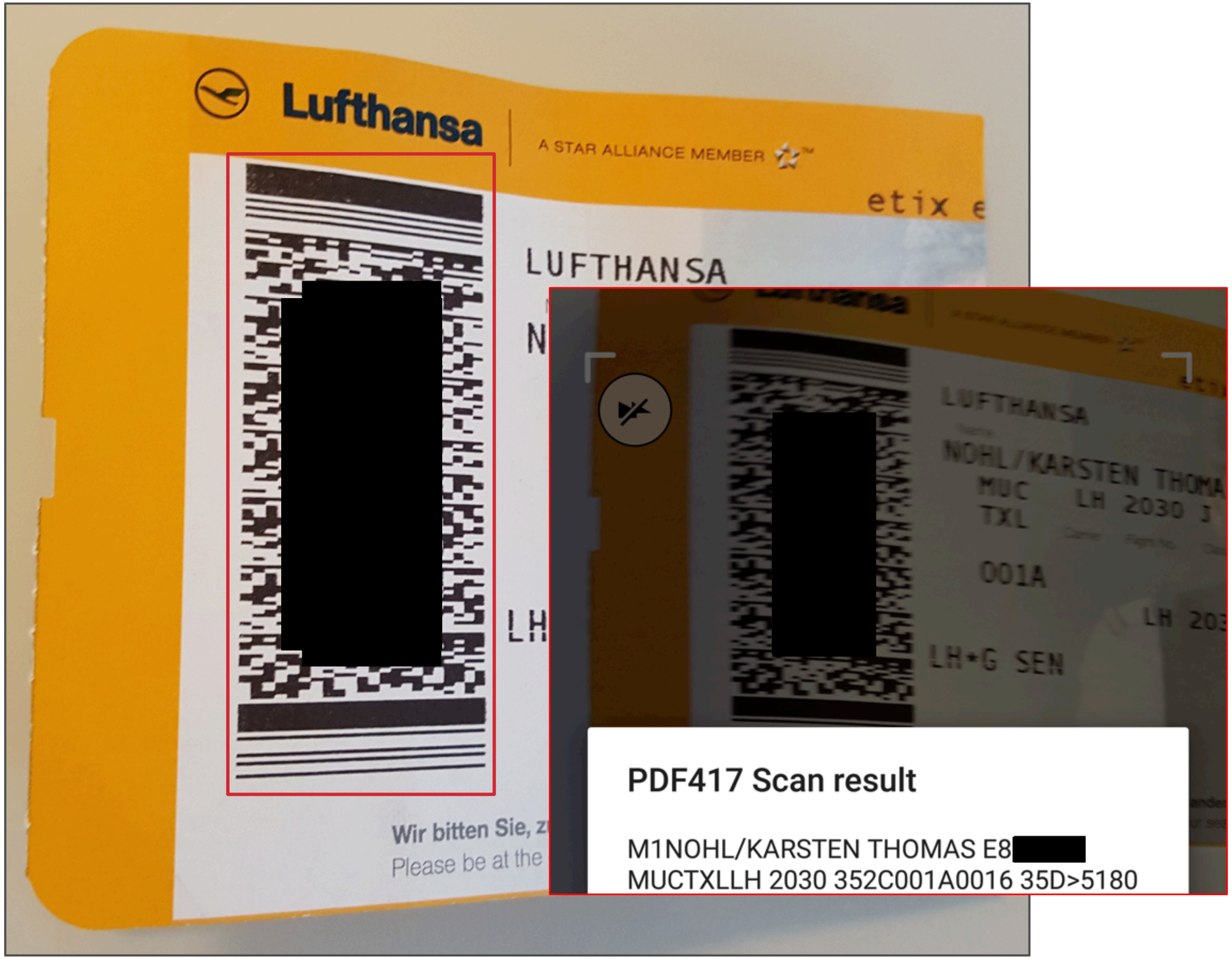
Traveler access

- Forgot to assign user names or passwords, oops!
- Let’s use last name as user name; and booking code / PNR locator as password
- These “passwords” cannot be changed and are widely shared between operators



PNRs can be gathered offline





[redacted]

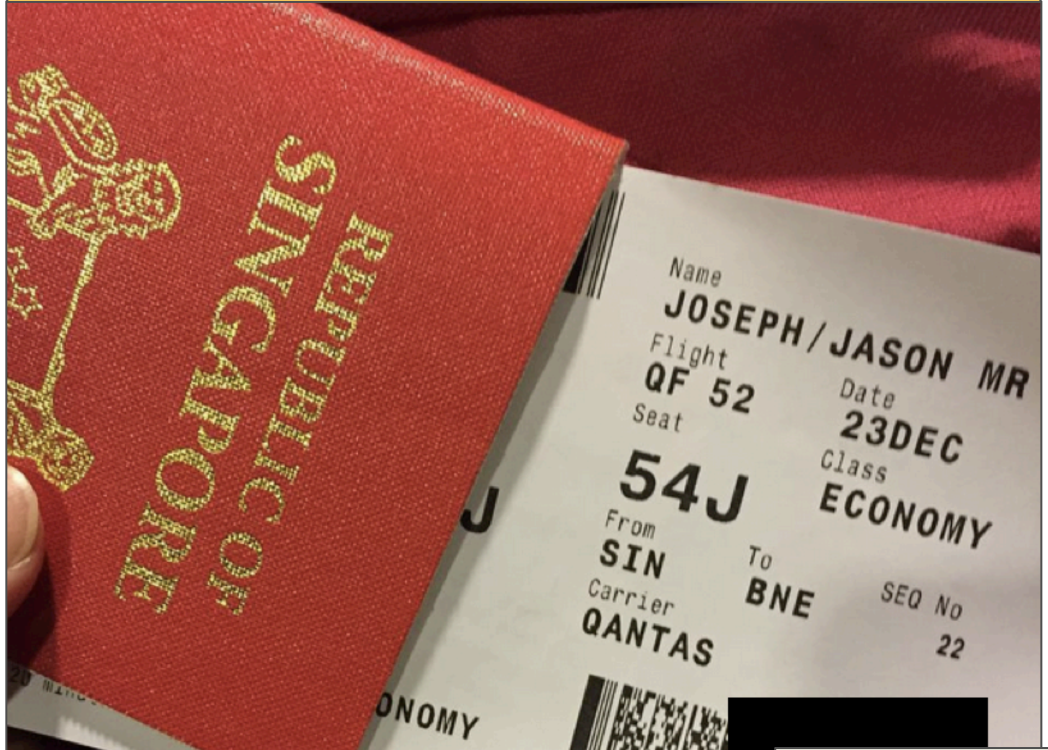
[redacted]

PDF417 Scan result

M1NOHL/KARSTEN THOMAS E8[redacted]
MUCTXLLH 2030 352C001A0016 35D>5180

PNRs can be gathered online

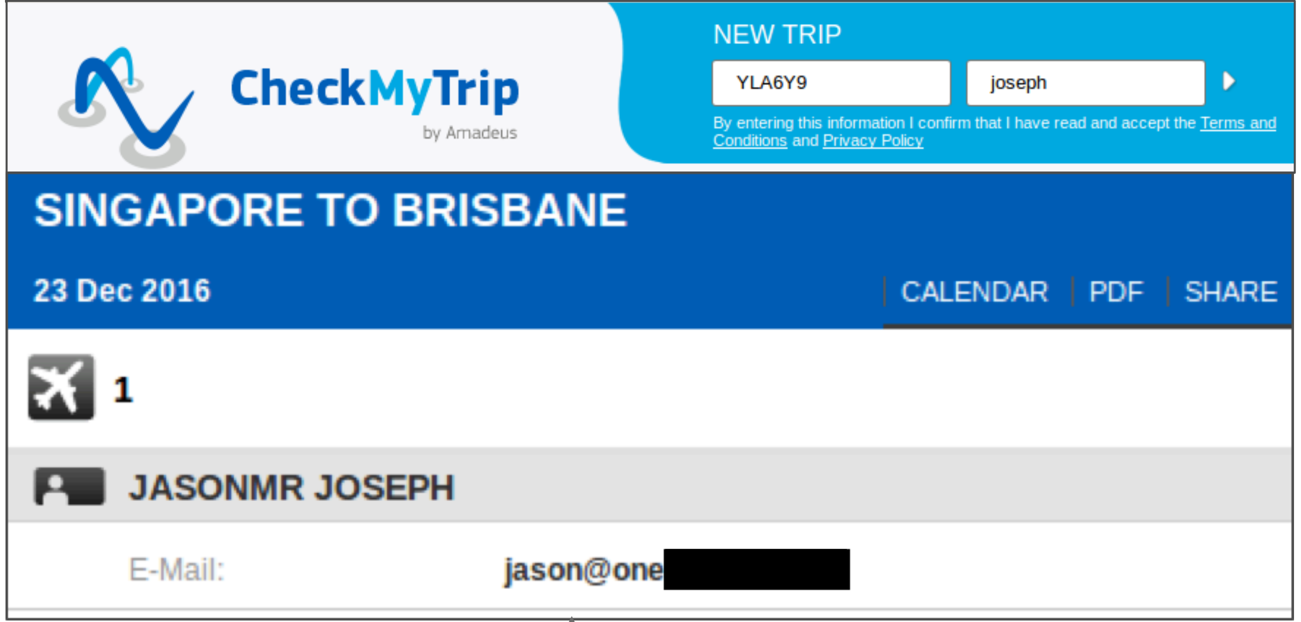
Instagram



Name
JOSEPH/JASON MR
Flight
QF 52
Date
23DEC
Seat
54J
Class
ECONOMY
From
SIN
To
BNE
Carrier
QANTAS
SEQ No
22

[redacted]

Travel details



CheckMyTrip by Amadeus

NEW TRIP

YLA6Y9 | joseph

By entering this information I confirm that I have read and accept the Terms and Conditions and Privacy Policy

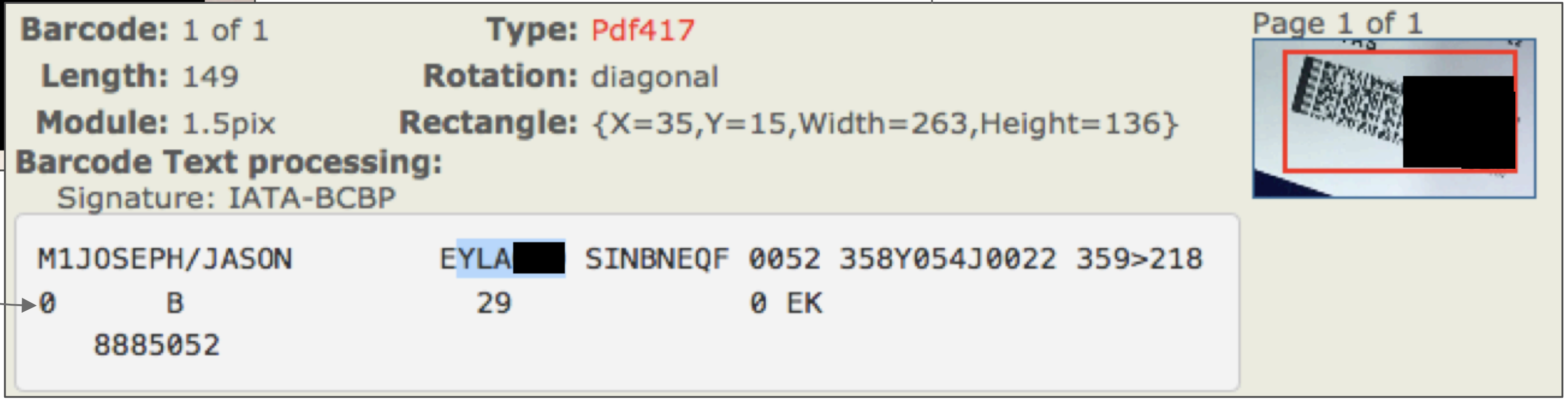
SINGAPORE TO BRISBANE

23 Dec 2016

✈ 1

JASONMR JOSEPH

E-Mail: jason@one[redacted]



Barcode: 1 of 1 **Type:** Pdf417
Length: 149 **Rotation:** diagonal
Module: 1.5pix **Rectangle:** {X=35,Y=15,Width=263,Height=136}
Barcode Text processing:
Signature: IATA-BCBP

```
M1JOSEPH/JASON          EYLA[redacted] SINBNEQF 0052 358Y054J0022 359>218
0        B               29              0 EK
    8885052
```

Page 1 of 1

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Are booking systems protected with basic security controls?

Web service security basics

- Fine-grained access control ☒
- Strong authentication ☒
- Rate-limiting ?
- Logging ?

Travelers’ private information is accessible

PNR abuse

Privacy intrusion

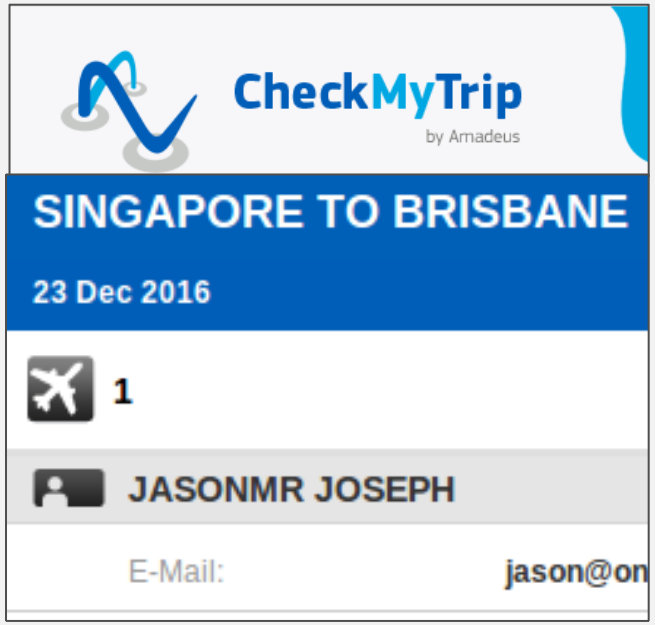
Flight theft

Mile diversion

Phishing

Anybody with access to the PNR locator (6-digit number) and last name can access:

- Identity details; possibly including hotels and car rentals
- Frequent flyer details
- Contact information: Phone number, e-mail address, often postal address
- Often date of birth and passport details



CheckMyTrip by Amadeus

SINGAPORE TO BRISBANE

23 Dec 2016

✈ 1

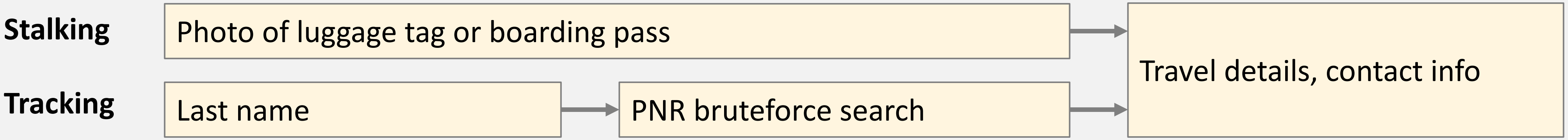
JASONMR JOSEPH

E-Mail: jason@on

Agents (or hackers) with direct GDS access also see:

- Payment information: Credit card # and expiry
- IP address (if booked online)

Abuse Scenarios



Stalking: Photo of luggage tag or boarding pass → Travel details, contact info

Tracking: Last name → PNR bruteforce search → Travel details, contact info

Fraudsters can possibly steal flights

PNR abuse

Privacy intrusion

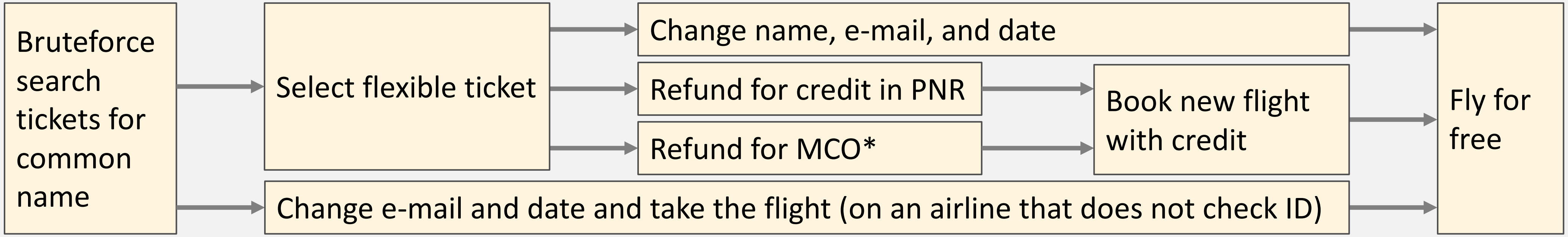
Flight theft

Mile diversion

Phishing

- Airlines typically only authenticate passengers with the PNR locator, even for ticket changes
- Different airlines allow different actions:
  - All allow date and flight changes (at least on some tickets)
  - Few allow name changes
  - Most allow some form of refund, often for a coupon

Abuse Scenarios


Bruteforce search tickets for common name
Select flexible ticket
Change name, e-mail, and date
Refund for credit in PNR
Refund for MCO*
Book new flight with credit
Change e-mail and date and take the flight (on an airline that does not check ID)
Fly for free

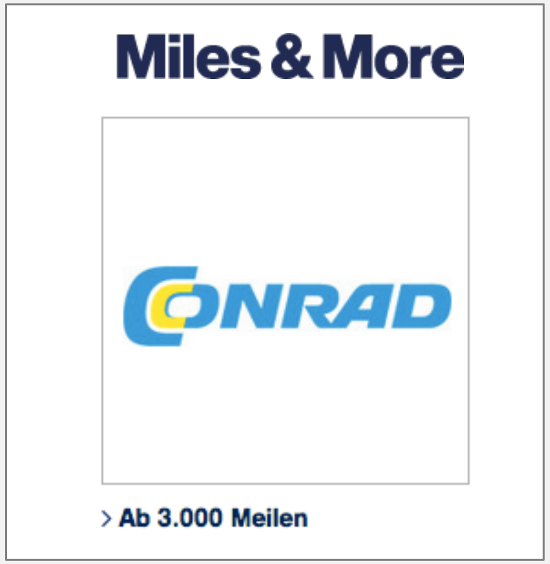
* Miscellaneous charges order

Miles can be stolen, fully remotely

PNR abuse

- Privacy intrusion
- Flight theft
- **Mile diversion**
- Phishing

- Adding a miles number (with the right name) to a booking diverts a victim's miles
- Miles can be redeemed for free flights, hotel nights, or gift certificates



Abuse Scenario

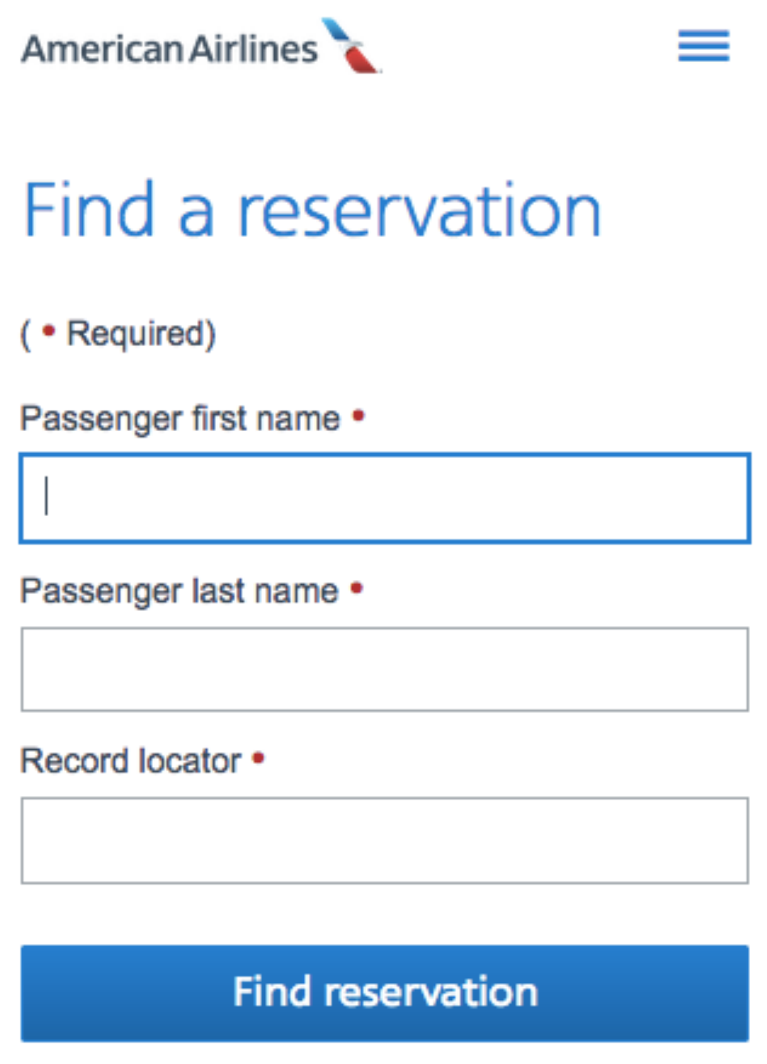
Bruteforce search for common name → Selects expensive tickets → Create miles account in passenger name → Add or change miles account in booking → Convert on redeem collected miles

Example

EU-Australia	10,000 miles
Round-trip	x 2
First class	x 3
	60,000 miles
	~ 900 USD

All path to a booking need to be secured

American Airlines asks for first name



American Airlines

Find a reservation

(• Required)

Passenger first name •

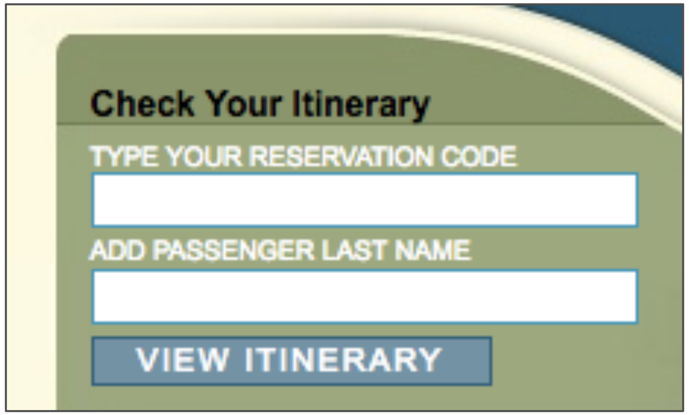
Passenger last name •

Record locator •

Find reservation

ViewTrip + TripCase provide alternative path w/o first name

1. Brute-force PNR + last name on ViewTrip



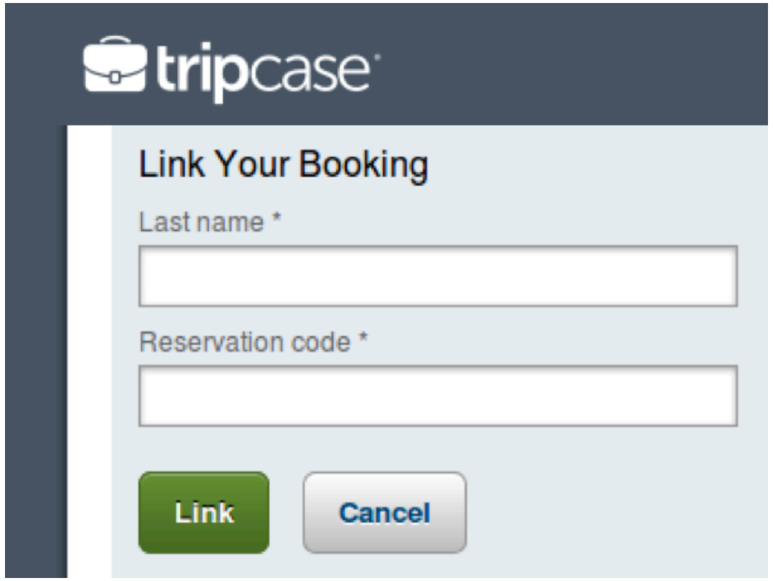
Check Your Itinerary

TYPE YOUR RESERVATION CODE

ADD PASSENGER LAST NAME

VIEW ITINERARY

2. Check details on TripCase



tripcase

Link Your Booking

Last name *

Reservation code *

Link

Cancel

PNRs can be guessed

	Guessability		Brute-force susceptibility	
	Entropy	**Sequential**	**GDS-provided**	**Airlines (examples)**
Amadeus	**28.6 bits:** 1st digit: 2-8, X-Z 2nd: Depends on 1st (38 of 340 combinations invalid) 2nd-6th: 2-9, A-Z	✓	CheckMyTrip Classic: ✓ → killed Current: ✓ → ineffective Captcha, max 1,000 requests/IP	Lufthansa Standard: Captcha Mobile: max 30 rqs/IP Air Berlin max 1,000 rqs → Captcha
Sabre	**28.2 bits:** 1st-6th: A-Z (Namespace split by airline)	✗ Helps against targeted privacy intrusion, but not fraud	Virtually There Direct PNR access for some airlines (e.g. Etihad), for others: redirect to airline website (e.g. AA, Aeroflot) ✓	American Airlines ✓ + First name Aeroflot ✓
Galileo	**28.9 bits:** 1st: 1-9, A-Z (except F-I, O, U, Y) 2nd -5th: 0-9, B-Z (except E, I, O,U,Y) 6th: 0-9, A-Z, but last bit ignored!	✓	View Trip ✓	Not really used by airlines, but instead by booking agents

Are booking systems protected with basic security controls?

Web service security basics

- Fine-grained access control ☒
- Strong authentication ☒
- Rate-limiting ☒
- Logging ?

Data disclosure exposes travelers to targeted attacks

PNR abuse

Privacy intrusion

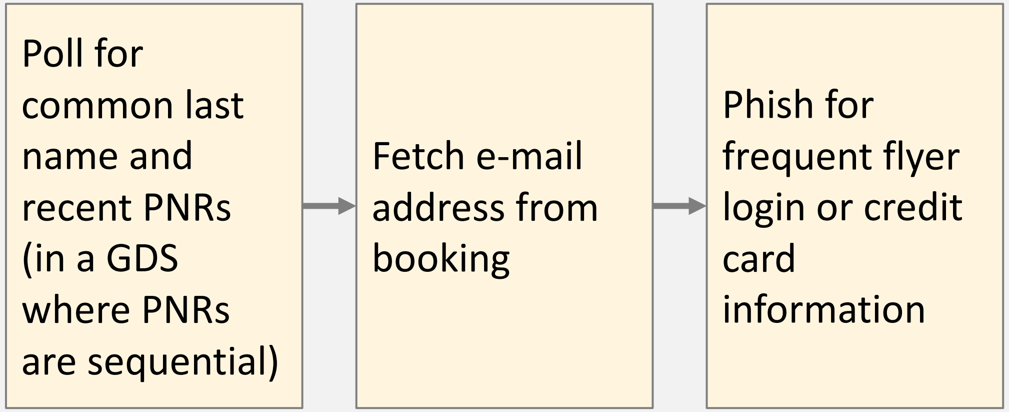
Flight theft

Mile diversion

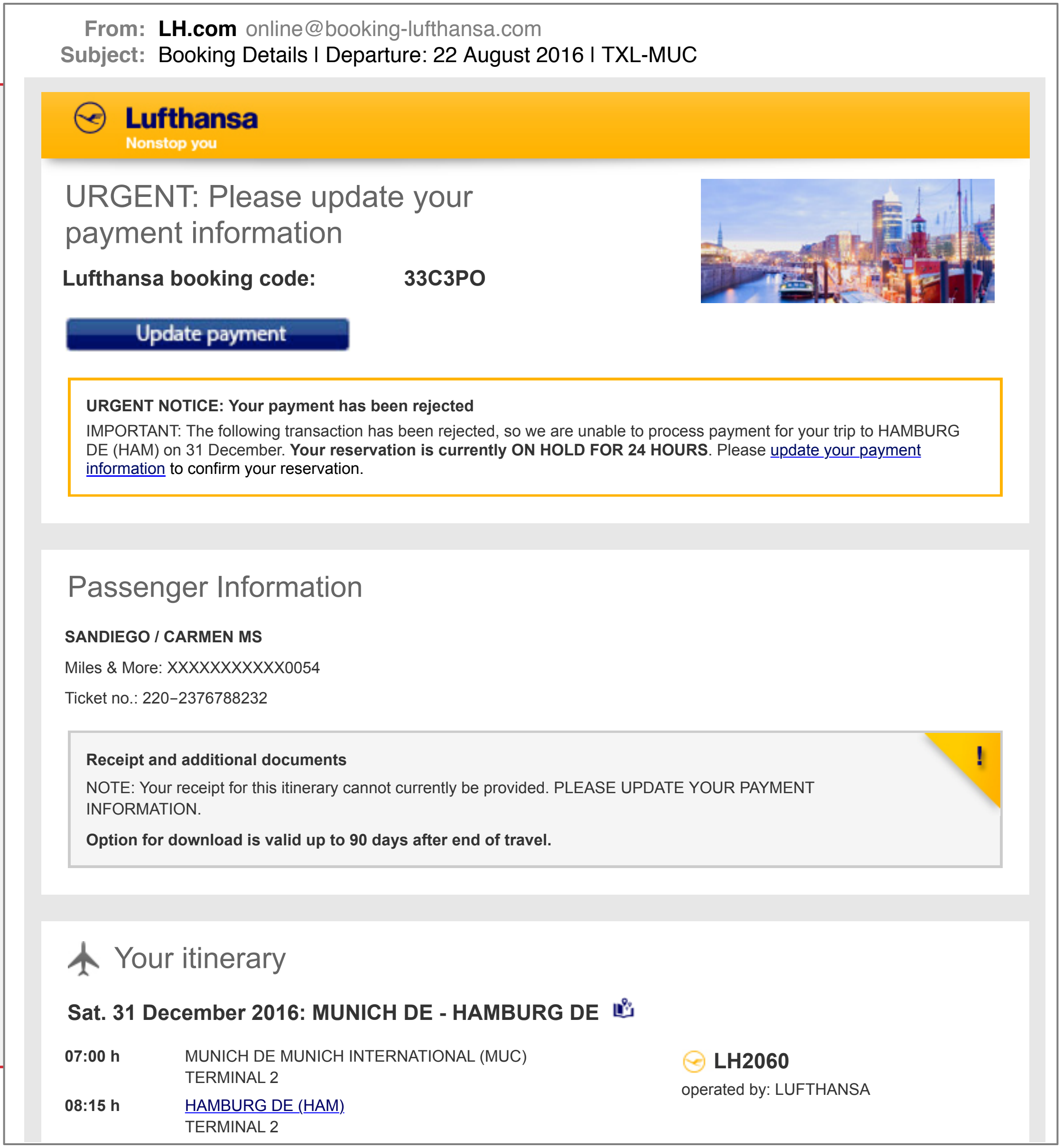
Phishing

- Due to their sequential nature, fraudsters can find recently created PNRs
- And then send very targeted phishing e-mails

Abuse Scenario



Poll for common last name and recent PNRs (in a GDS where PNRs are sequential) → Fetch e-mail address from booking → Phish for frequent flyer login or credit card information



From: **LH.com** online@booking-lufthansa.com
Subject: Booking Details I Departure: 22 August 2016 I TXL-MUC

URGENT: Please update your payment information

Lufthansa booking code: **33C3PO**

URGENT NOTICE: Your payment has been rejected

IMPORTANT: The following transaction has been rejected, so we are unable to process payment for your trip to HAMBURG DE (HAM) on 31 December. **Your reservation is currently ON HOLD FOR 24 HOURS**. Please update your payment information to confirm your reservation.

Passenger Information

SANDIEGO / CARMEN MS

Miles & More: XXXXXXXXXXX0054

Ticket no.: 220–2376788232

Receipt and additional documents

NOTE: Your receipt for this itinerary cannot currently be provided. PLEASE UPDATE YOUR PAYMENT INFORMATION.

Option for download is valid up to 90 days after end of travel.

Your itinerary

Sat. 31 December 2016: MUNICH DE - HAMBURG DE

07:00 h MUNICH DE MUNICH INTERNATIONAL (MUC)
TERMINAL 2

08:15 h HAMBURG DE (HAM)
TERMINAL 2

LH2060
operated by: LUFTHANSA

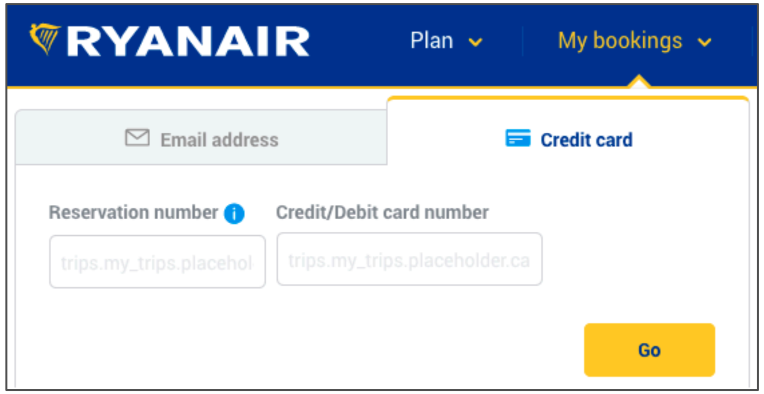
Guessability issues are not limited to large GDS

SITA

- Only 4 digits to guess, plus one digit for airline

Ryan Air (Navitaire, an Amadeus subsidiary)

- Uneven distribution makes it easier to guess PNR
- Guess 4 credit card digits instead of last name



Email address | Credit card

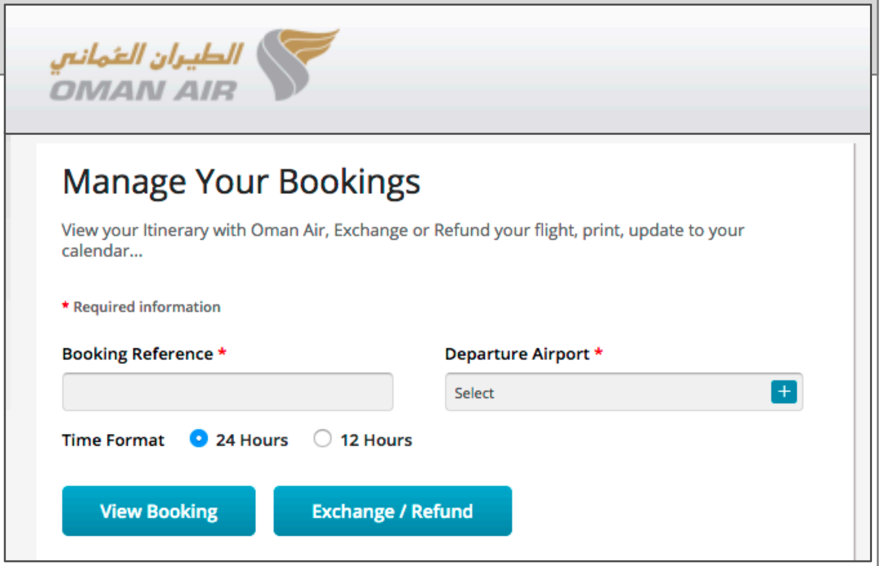
Reservation number: trips.my_trips.placehol

Credit/Debit card number: trips.my_trips.placeholder.ca

Go

Oman Air (Sabre)

- Guess one city in itinerary instead of last name (Muscat, duh!)



Manage Your Bookings

View your Itinerary with Oman Air, Exchange or Refund your flight, print, update to your calendar...

* Required information

Booking Reference *

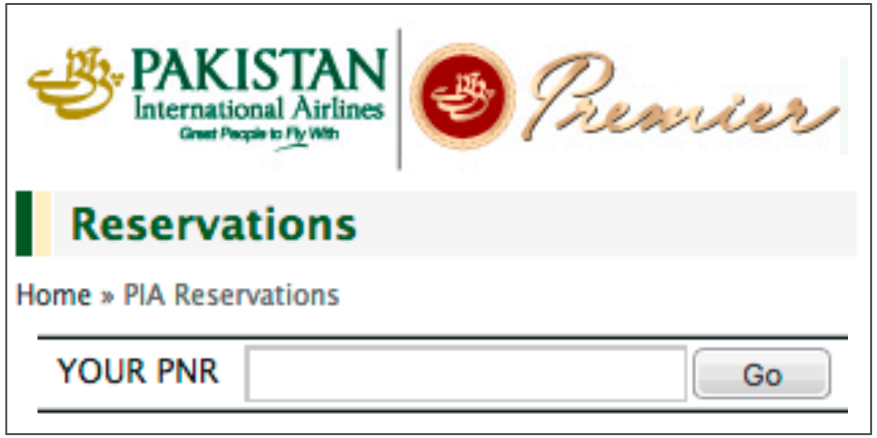
Departure Airport * Select

Time Format ● 24 Hours ○ 12 Hours

View Booking | Exchange / Refund

Pakistan International Airlines (Sabre)

- Won the race for easiest guessability



Reservations

Home » PIA Reservations

YOUR PNR

Go

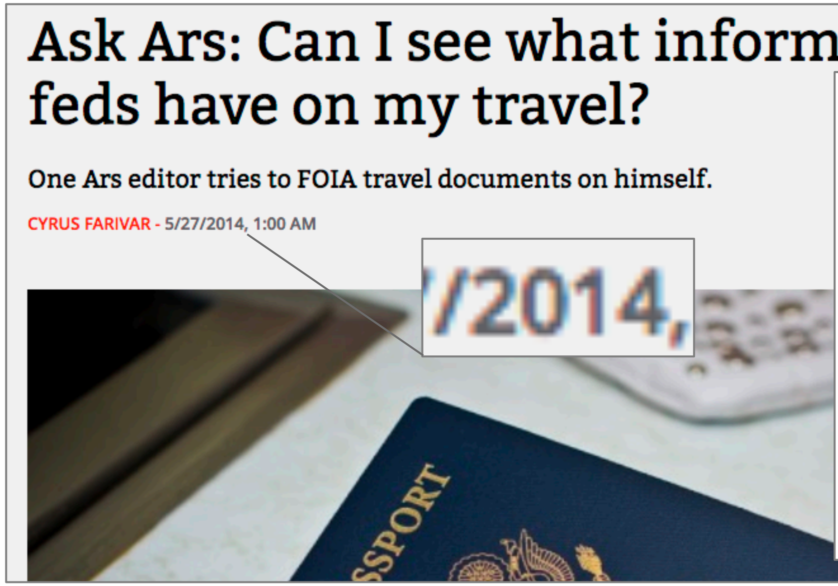
Other noteworthy systems we did not look at:

- MACS (Emirates)
- Troya (Turkish Airlines)
- HP Shares (United, and others)

PNR access is not logged

Logging/accountability: Fail

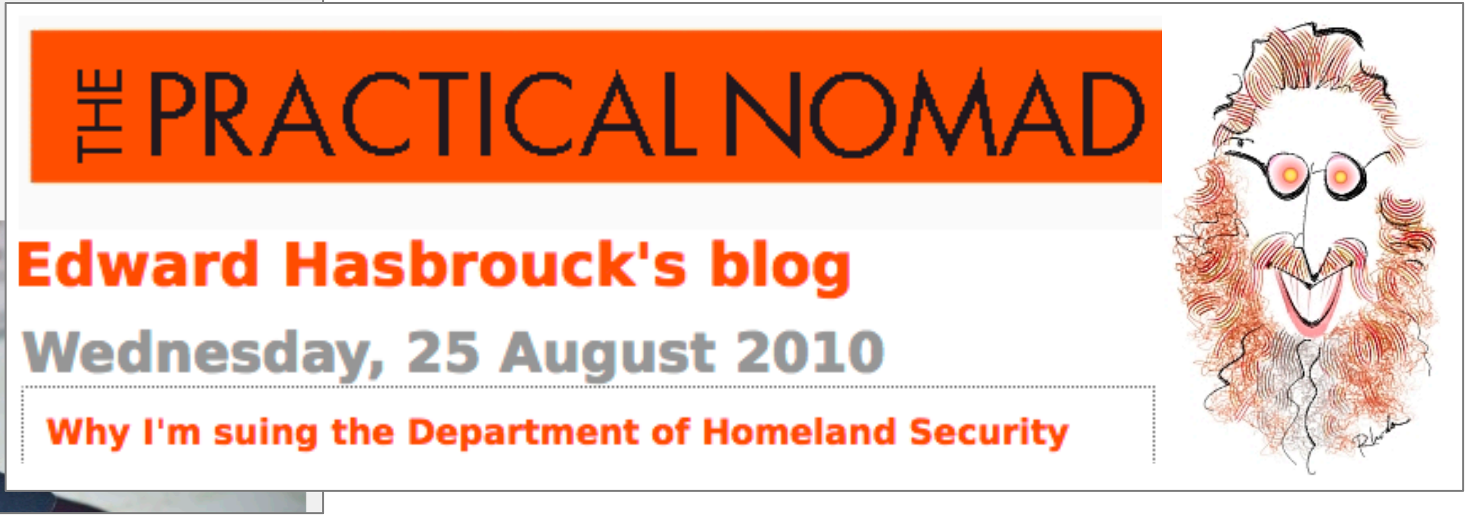
arstechnica



Ask Ars: Can I see what information the feds have on my travel?

One Ars editor tries to FOIA travel documents on himself.

CYRUS FARIVAR - 5/27/2014, 1:00 AM



THE PRACTICAL NOMAD

Edward Hasbrouck's blog

Wednesday, 25 August 2010

Why I'm suing the Department of Homeland Security

- For years, questions were raised over who is accessing PNRs
- Until today, GDS providers refuse to log read access to this private data (write access has always been logged)
- Can more research motivate finally adding logging and make transparent to travelers who accesses their information?

Booking systems lack basic security controls

Web service security basics

- Fine-grained access control ☒
- Strong authentication ☒
- Rate-limiting ☒
- Logging ☒

We need better protected booking systems

	In summary	What we need
Coarse access control	A few global databases keep information on travelers, in systems that have grown for decades and now lack modern IT security	Limitations on which agents (and governments!) can access what information
Weak authentication	Passengers authenticate only with their last name and a low-entropy (often sequential) booking code, which is also printed on passes and tags	Passwords for bookings
Insufficient rate limiting	Numerous web interfaces permit brute-forcing of these booking codes, putting travelers' privacy at risk	Minimum web service security for **all** exposed interfaces
No logging	Travelers will never know who accessed their information, since PNR access is intentionally not logged	Strict logging of any access to personal information

Thank you!

Many thanks to **Luca Melette, Sebastian Götte,** and **Patrick Lucey** for making this research possible!

Thank you **Ed Hasbrouck, Hendrik Scholz,** and **Seth Miller** for very valuable feedback!

Questions?

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Nemanja Nikodijević <nemanja@srlabs.de>