Security I: Introduction & Threat Model

Suman Jana

Columbia University

*some slides are borrowed from Vitaly Shmatikov and Ari Juels

Course goals

- Understand the fundamental principles of security
  - What are the common security mechanisms? Why they often go wrong?
  - What are the underlying principles behind building secure systems?
  - Why building secure systems is hard?

Logistics

- No text book but assigned readings from different sources
- Grading
  - Four programming assignments in C/C++ (56%)
  - Midterm (20%)
  - Non-cumulative final (20%)
  - Class participation (4%)
- Class webpage: http://sumanj.info/security_1_2019.html

The art of adversarial thinking

What’s adversarial thinking?

“Security requires a particular mindset. Security professionals -- at least the good ones -- see the world differently. They can't walk into a store without noticing how they might shoplift. They can't use a computer without wondering about the security vulnerabilities. They can't vote without trying to figure out how to vote twice. They just can't help it.”

- Bruce Schneier

Adversarial thinking disclaimer

Hopefully, you will learn to think like a criminal mastermind but behave like a gentleman/woman!

Adversarial thinking: key questions

- Security goal: what security policy to enforce?

- Threat model: who is the adversary? What actions can the adversary perform?

- Mechanisms: What security mechanisms can be used to achieve the security goals given the adversarial model

Key security goals

- Confidentiality: Data not leaked
- Integrity: Data not modified
- Availability: Data is accessible when needed
- Authenticity: Data origin cannot be spoofed

You can apply adversarial thinking anywhere

- Columbia ID cards
  - Can you fake an ID card?
- ATM machine
  - How does the service person gets access to refill it with cash?
- MTA metrocard
  - Can you increase the card balance without paying?

Example: air travel

Print boarding pass at home

→

ID check by TSA

→

Boarding pass check at the gate

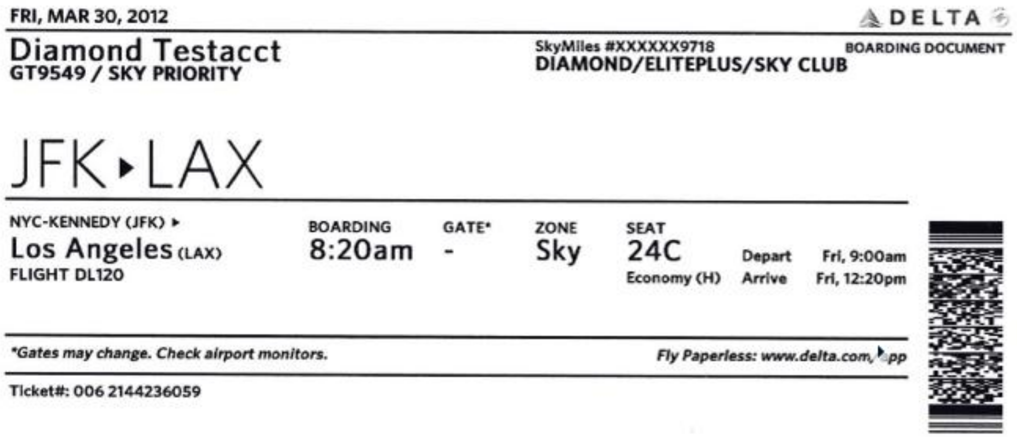
Adversarial thinking example: air travel

- Security goal: Ensure that each person getting inside an airport has a valid boarding pass and is authorized to fly (i.e., not on the no-fly list)
- Mechanisms
  - TSA checks validity of the ID (e.g., driver’s license) and the boarding pass How?
  - TSA matches name in the ID against the name in the boarding pass
  - TSA ensures that the name is not on the no-fly list
  - Gate agent checks whether the boarding pass is valid and has been checked by TSA How?

Can an attacker who is on the no-fly list fly?

What is the threat model?

- Can an attacker create a fake boarding pass?



FRI, MAR 30, 2012

DELTA

Diamond Testacct
GT9549 / SKY PRIORITY

SkyMiles #XXXXXX9718
DIAMOND/ELITEPLUS/SKY CLUB

BOARDING DOCUMENT

JFK ▸ LAX

NYC-KENNEDY (JFK) ▸
Los Angeles (LAX)
FLIGHT DL120

BOARDING
8:20am

GATE*
-

ZONE
Sky

SEAT
24C
Economy (H)

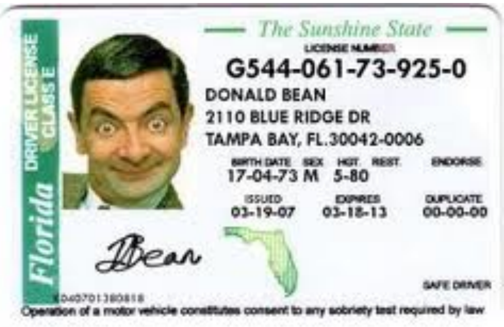
Depart Fri, 9:00am
Arrive Fri, 12:20pm

*Gates may change. Check airport monitors.

Fly Paperless: www.delta.com/app

Ticket#: 006 2144236059

- Can an attacker fake a driver's license?



Florida DRIVER LICENSE CLASS E

The Sunshine State

LICENSE NUMBER
G544-061-73-925-0

DONALD BEAN
2110 BLUE RIDGE DR
TAMPA BAY, FL.30042-0006

BIRTH DATE 17-04-73 SEX M HGT. 5-80 REST. ENDORSE

ISSUED 03-19-07 EXPIRES 03-18-13 DUPLICATE 00-00-00

Bean

SAFE DRIVER

040701380818

Operation of a motor vehicle constitutes consent to any sobriety test required by law

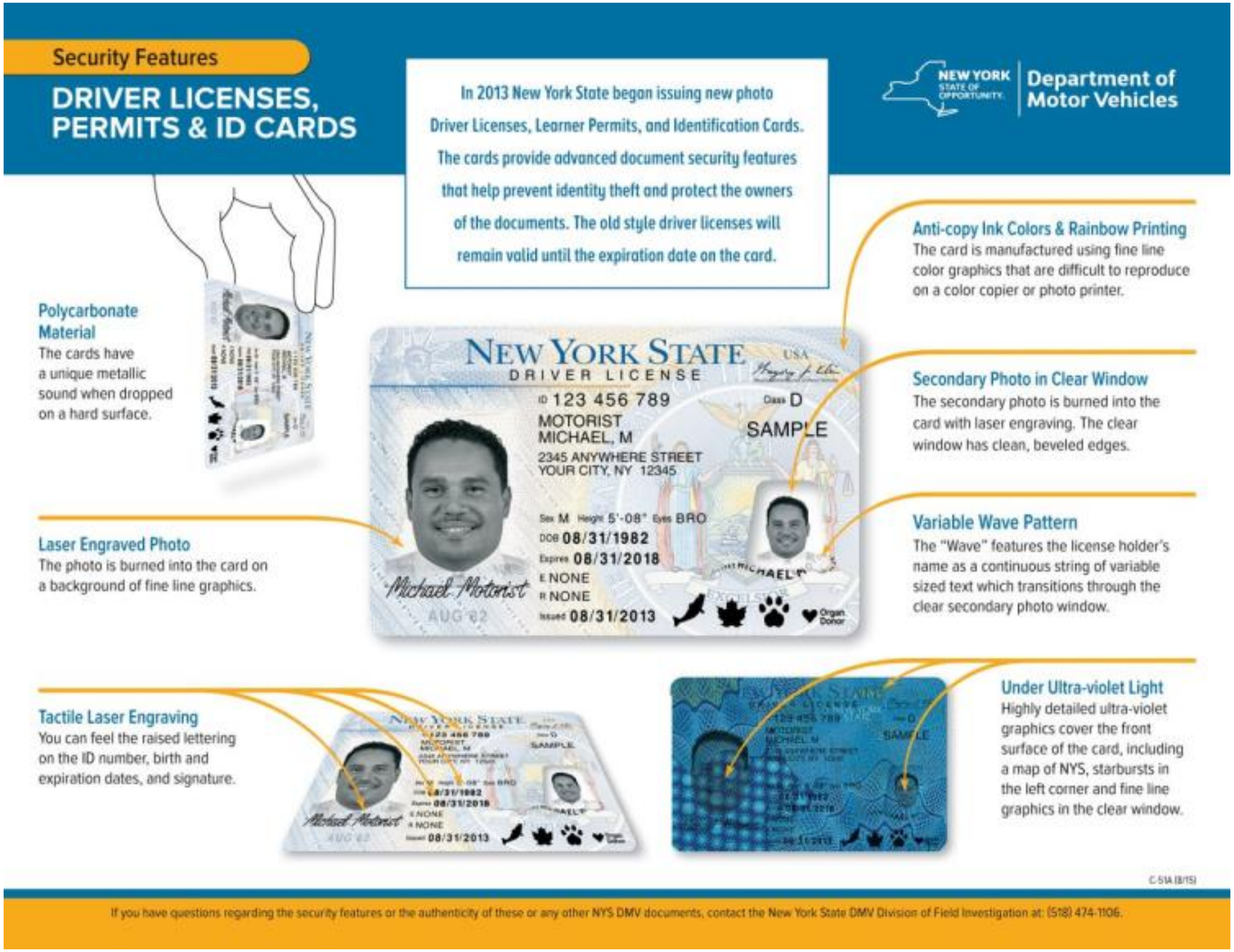
Security under different threat models

- Security goal: Ensure that each person getting inside an airport has a valid boarding pass and is authorized to fly (i.e., not on the no-fly list)
  - What are the minimum requirements for someone to violate this goal in the current TSA system?
  - The current TSA system is secure under which threat models?

Not all threat models are equal

- Which one is harder and why?
  - Creating a fake boarding pass
  - Creating a fake driver’s license

Security measures in a driver’s license?



Security Features

DRIVER LICENSES, PERMITS & ID CARDS

In 2013 New York State began issuing new photo Driver Licenses, Learner Permits, and Identification Cards. The cards provide advanced document security features that help prevent identity theft and protect the owners of the documents. The old style driver licenses will remain valid until the expiration date on the card.

NEW YORK STATE OF OPPORTUNITY. Department of Motor Vehicles

Polycarbonate Material
The cards have a unique metallic sound when dropped on a hard surface.

Laser Engraved Photo
The photo is burned into the card on a background of fine line graphics.

Anti-copy Ink Colors & Rainbow Printing
The card is manufactured using fine line color graphics that are difficult to reproduce on a color copier or photo printer.

Secondary Photo in Clear Window
The secondary photo is burned into the card with laser engraving. The clear window has clean, beveled edges.

Variable Wave Pattern
The “Wave” features the license holder’s name as a continuous string of variable sized text which transitions through the clear secondary photo window.

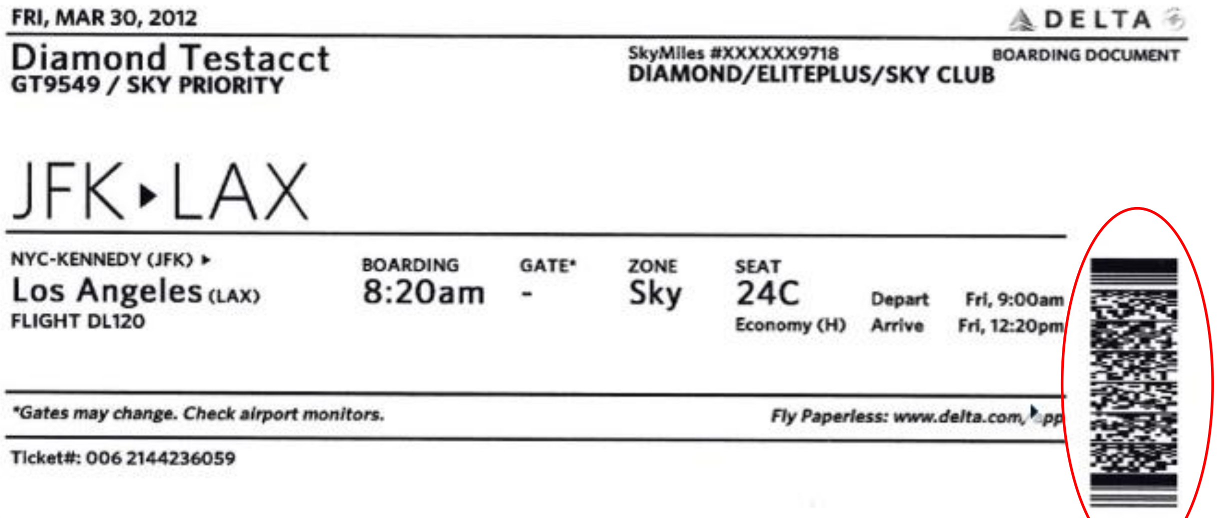
Tactile Laser Engraving
You can feel the raised lettering on the ID number, birth and expiration dates, and signature.

Under Ultra-violet Light
Highly detailed ultra-violet graphics cover the front surface of the card, including a map of NYS, starbursts in the left corner and fine line graphics in the clear window.

C-51A (8/15)

If you have questions regarding the security features or the authenticity of these or any other NYS DMV documents, contact the New York State DMV Division of Field Investigation at: (518) 474-1106.

Security measures in a boarding pass?



FRI, MAR 30, 2012

DELTA

Diamond Testacct
GT9549 / SKY PRIORITY

SkyMiles #XXXXXX9718
DIAMOND/ELITEPLUS/SKY CLUB

BOARDING DOCUMENT

JFK ▸ LAX

NYC-KENNEDY (JFK) ▸
Los Angeles (LAX)
FLIGHT DL120

BOARDING	GATE*	ZONE	SEAT		
8:20am	-	Sky	24C Economy (H)	Depart Arrive	Fri, 9:00am Fri, 12:20pm

*Gates may change. Check airport monitors.

Fly Paperless: www.delta.com/app

Ticket#: 006 2144236059

Can the barcode be faked?

Air travel revisited: a different security goal

Print boarding pass at home

→

ID check by TSA

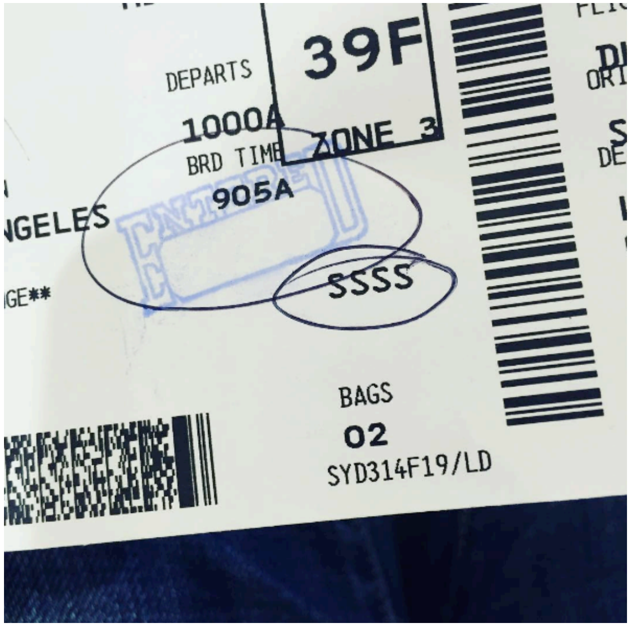
→

Boarding pass check at the gate

Security goal: everybody boarding an aircraft must pass through TSA security check

Everybody must go through TSA checks

- How does the current TSA system ensure this?
- What is an example threat model where this goal can be violated by an attacker?



DEPARTS
1000A
BRD TIME
905A

39F
ZONE 3

NGELES

GE**

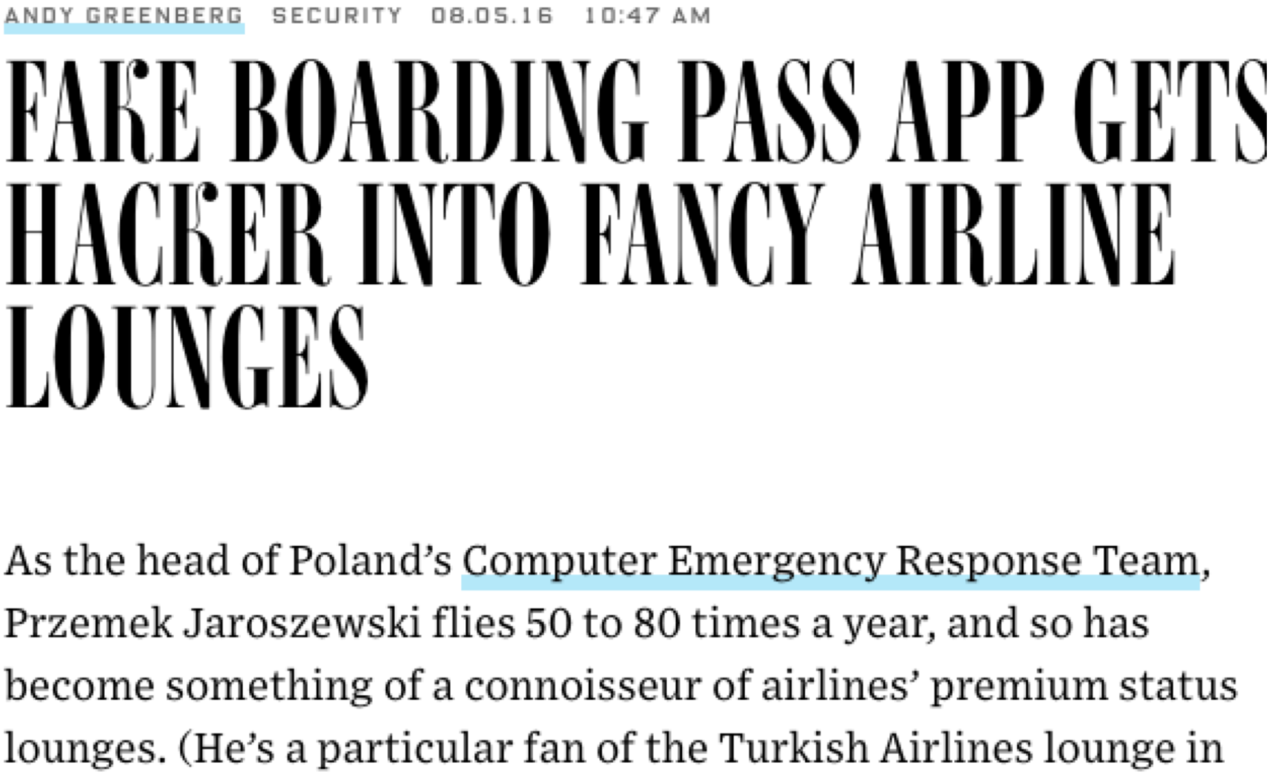
SSSS

BAGS
02
SYD314F19/LD

Yet another security goal

- Only authorized travelers should be allowed to enter premium lounges
  - How will the receptionist at the lounge know who is authorized?

What is the threat model for this attack?



ANDY GREENBERG SECURITY 08.05.16 10:47 AM

FAKE BOARDING PASS APP GETS HACKER INTO FANCY AIRLINE LOUNGES

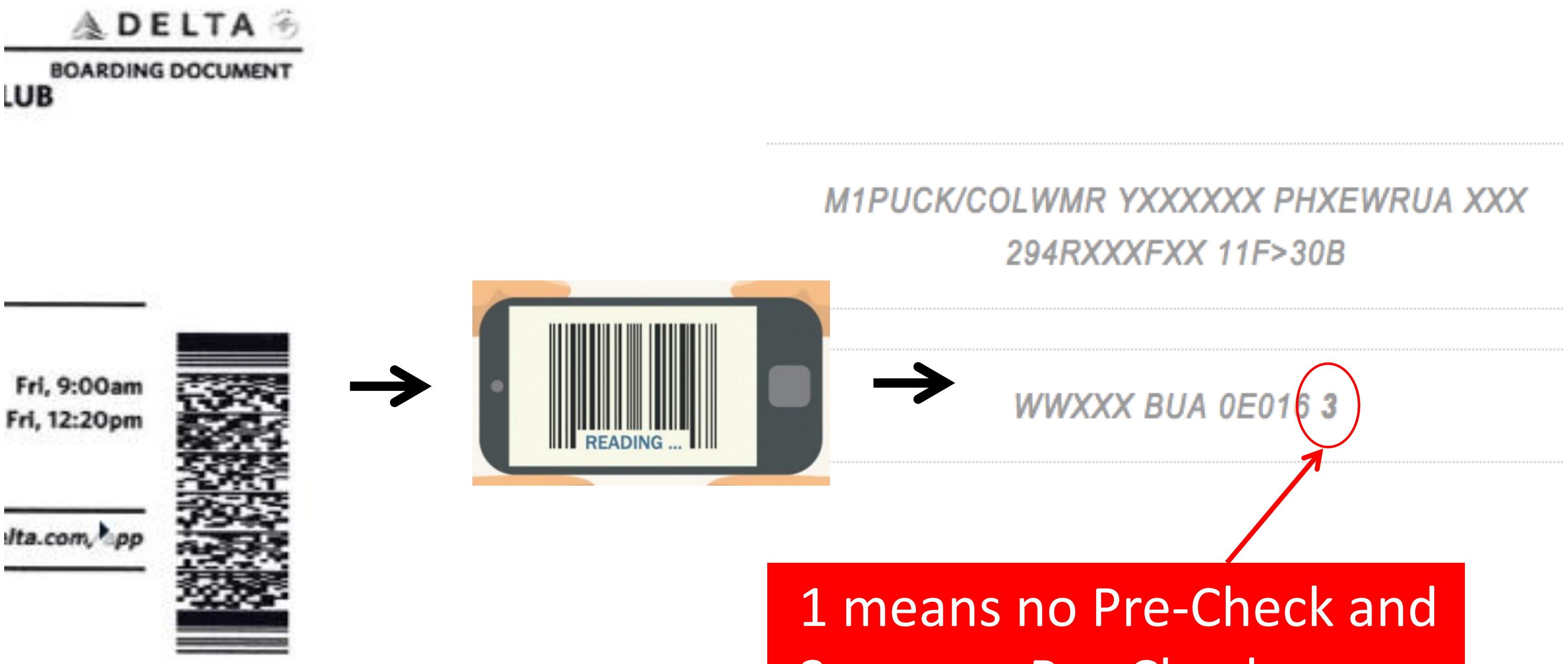
As the head of Poland's Computer Emergency Response Team, Przemek Jaroszewski flies 50 to 80 times a year, and so has become something of a connoisseur of airlines' premium status lounges. (He's a particular fan of the Turkish Airlines lounge in

How will you fix it?

What about TSA Pre-Check?

- How does TSA Pre-Check work?
  - Passengers apply for Pre-Check
  - TSA decide whether the passenger is eligible for Pre-Check or not and sends the information back to the Airline.
  - The Airline encodes that information in a barcode that is on the issued boarding pass.

Hacking TSA Pre-Check



```
M1PUCK/COLWMR YXXXXXX PHXEWRUA XXX
294RXXXFXX 11F>30B

WWXXX BUA 0E016 3
```

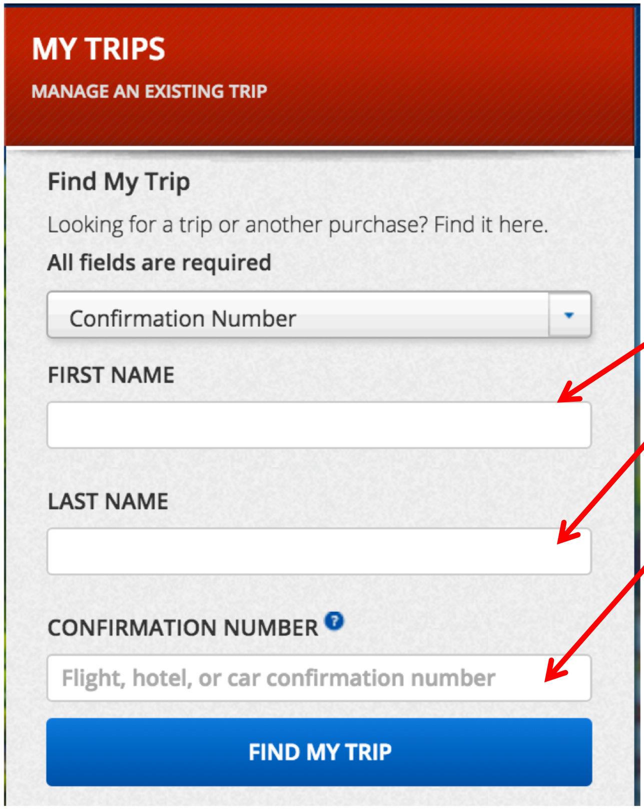
1 means no Pre-Check and
3 means Pre-Check

No encryption

Source: https://puckinflight.wordpress.com/2012/10/19/security-flaws-in-the-tsa-pre-check-system-and-the-boarding-pass-check-system/

Unintended side-effects of the boarding-pass design

- What happens if someone else gets hold of your boarding pass?



MY TRIPS

MANAGE AN EXISTING TRIP

Find My Trip

Looking for a trip or another purchase? Find it here.

All fields are required

Confirmation Number

FIRST NAME

LAST NAME

CONFIRMATION NUMBER

Flight, hotel, or car confirmation number

FIND MY TRIP

All this information is in the boarding pass in cleartext

A different setting: money

- Counting tokens must be kept in a safe place to prevent tampering
  - In a temple or in clay envelopes on shipping routes
- How to make counting tokens completely portable for trade?

A different setting: money

- Security goals
  - Tokens can only be created by a trusted authority
  - Authenticity of tokens should be easily verifiable by anyone
- Threat model
  - Attackers can forge or modify tokens
- Clay tokens can be easily forged!

A different setting: money

- Coins were introduced around 6/7th century BCE
  - Make tokens out of scarce resources(gold and silvers)
  - Apply a signature that is hard to copy (depends on the skills of the engravers)
  - Harsh penalty for forgers

Modern crypto-currencies

- Same principles!
  - – Scarce resource: computation
  - – Hard-to-forge data: cryptography

Who is the adversary?

depends on who you are

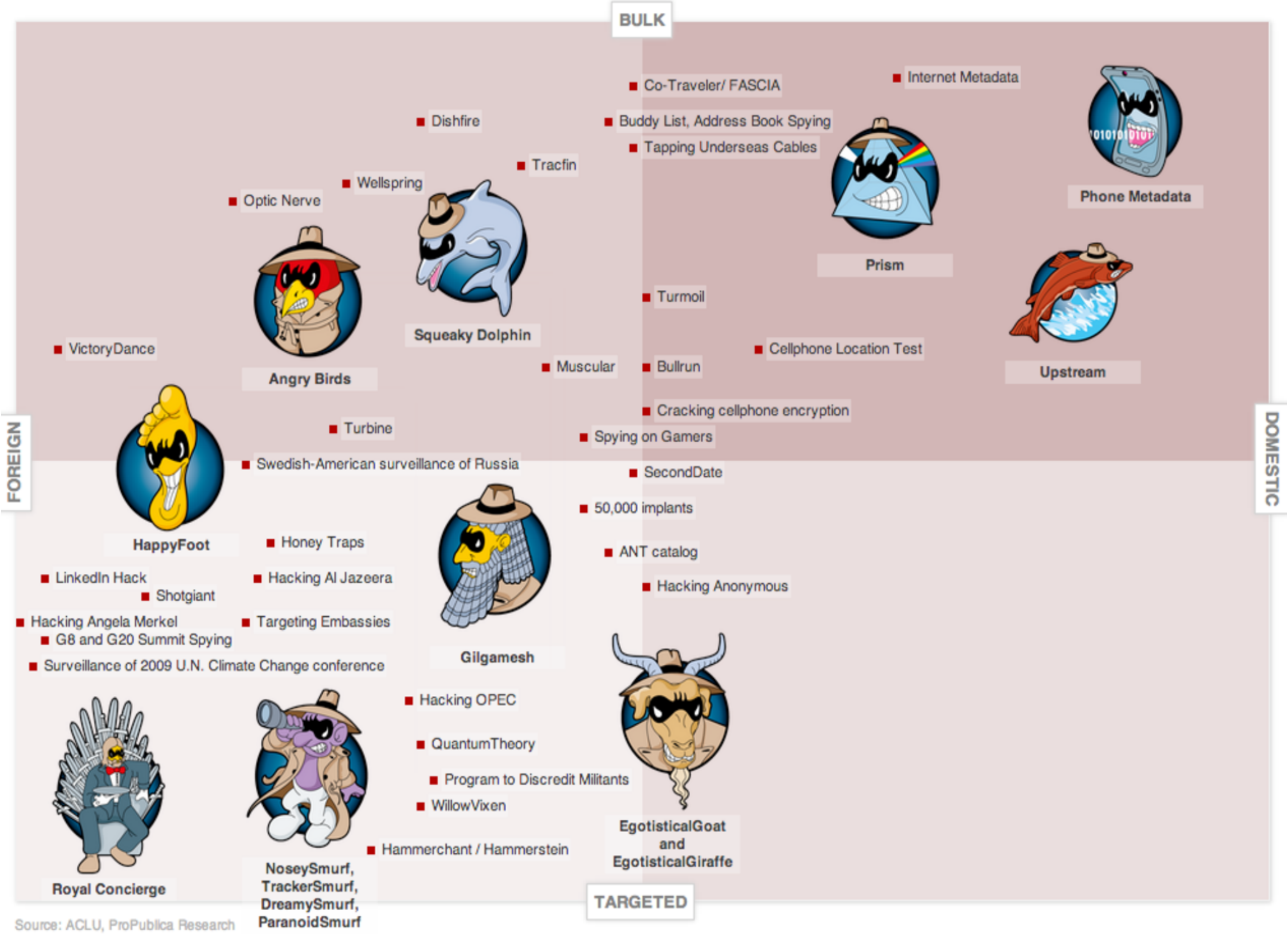
Hackers

- Evgeniy Mikhailovich Bogachev
  - Gameover Zeus botnet: banking fraud and ransomware distribution

Chinese government

- Censorship of materials critical to the current regime
- Monitoring dissidents

National Security Agency (NSA)



Source: ACLU, ProPublica Research