Development of a statistics-based IDS for automotive security

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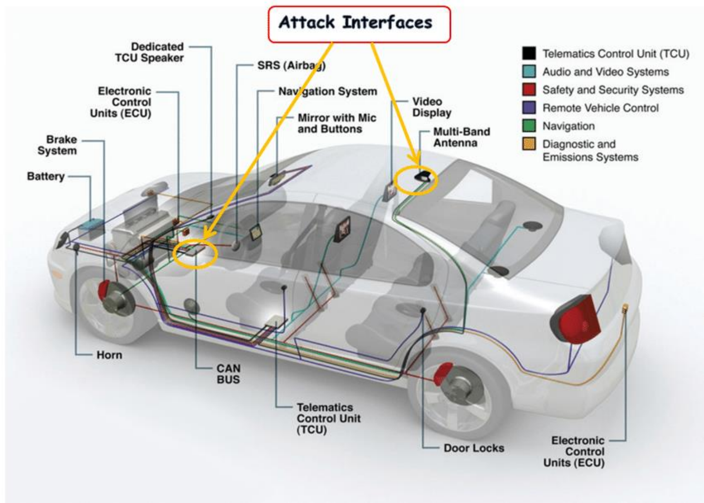
Attack Interfaces
Dedicated TCU Speaker
SRS (Airbag)
Navigation System
Mirror with Mic and Buttons
Video Display
Multi-Band Antenna
Electronic Control Units (ECU)
Brake System
Battery
Horn
CAN BUS
Telematics Control Unit (TCU)
Door Locks
Electronic Control Units (ECU)
■ Telematics Control Unit (TCU)
■ Audio and Video Systems
■ Safety and Security Systems
■ Remote Vehicle Control
■ Navigation
■ Diagnostic and Emissions Systems

Reviewing the questions from the preparation

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Q1: What do messages on the CAN-bus look like, and how can these be parsed with pandas in Python?

Reviewing the questions from the preparation

Q2: What kind of attacks can be performed on CAN networks?

Reviewing the questions from the preparation

Q3: Which statistical parameters can be derived from certain fields in network frames, to detect attacks on CAN?

Reviewing the questions from the preparation

Q4: How do you extract statistical parameters from a dataset?

Short overview of CAN-bus

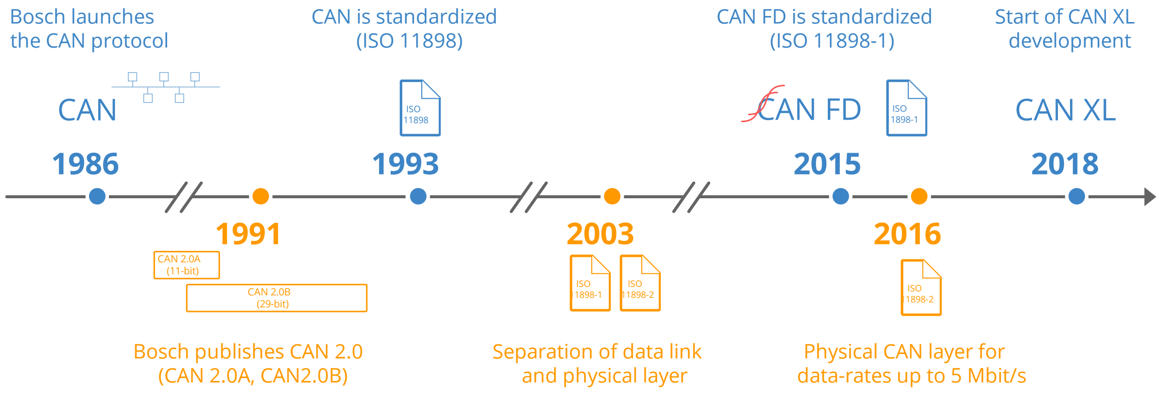
… and the frames that use it

Short overview of CAN-bus

Modern cars can contain up to 150 **Electronic Control Units (ECUs)**

Controller Area Network (CAN): protocol for ECU-to-ECU communication

- 3 generations: CAN CC, CAN FD, and CAN XL
- IP of Robert Bosch GmbH



Bosch launches the CAN protocol

CAN

1986

CAN is standardized (ISO 11898)

1993

CAN FD is standardized (ISO 11898-1)

CAN FD

2015

Start of CAN XL development

CAN XL

2018

1991

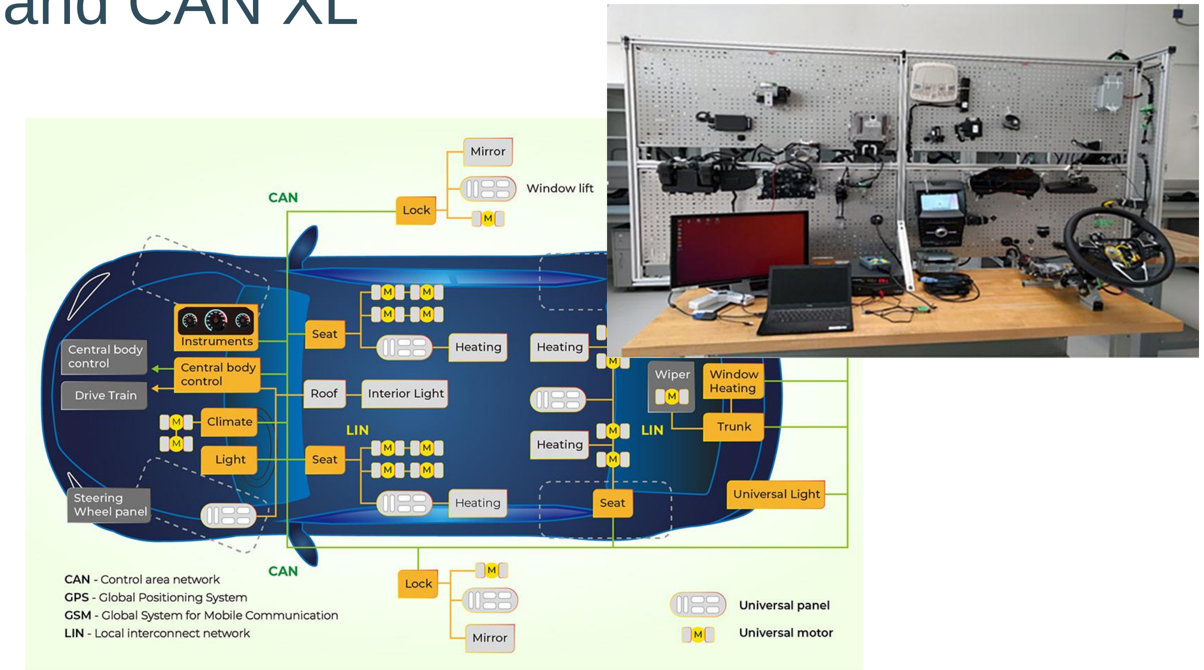
Bosch publishes CAN 2.0 (CAN 2.0A, CAN2.0B)

2003

Separation of data link and physical layer

2016

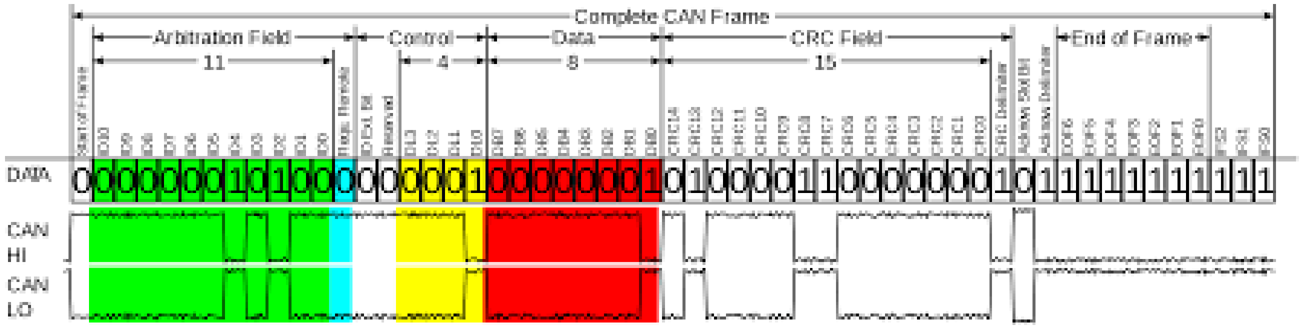
Physical CAN layer for data-rates up to 5 Mbit/s



CAN - Control area network
GPS - Global Positioning System
GSM - Global System for Mobile Communication
LIN - Local interconnect network

… and the frames that use it

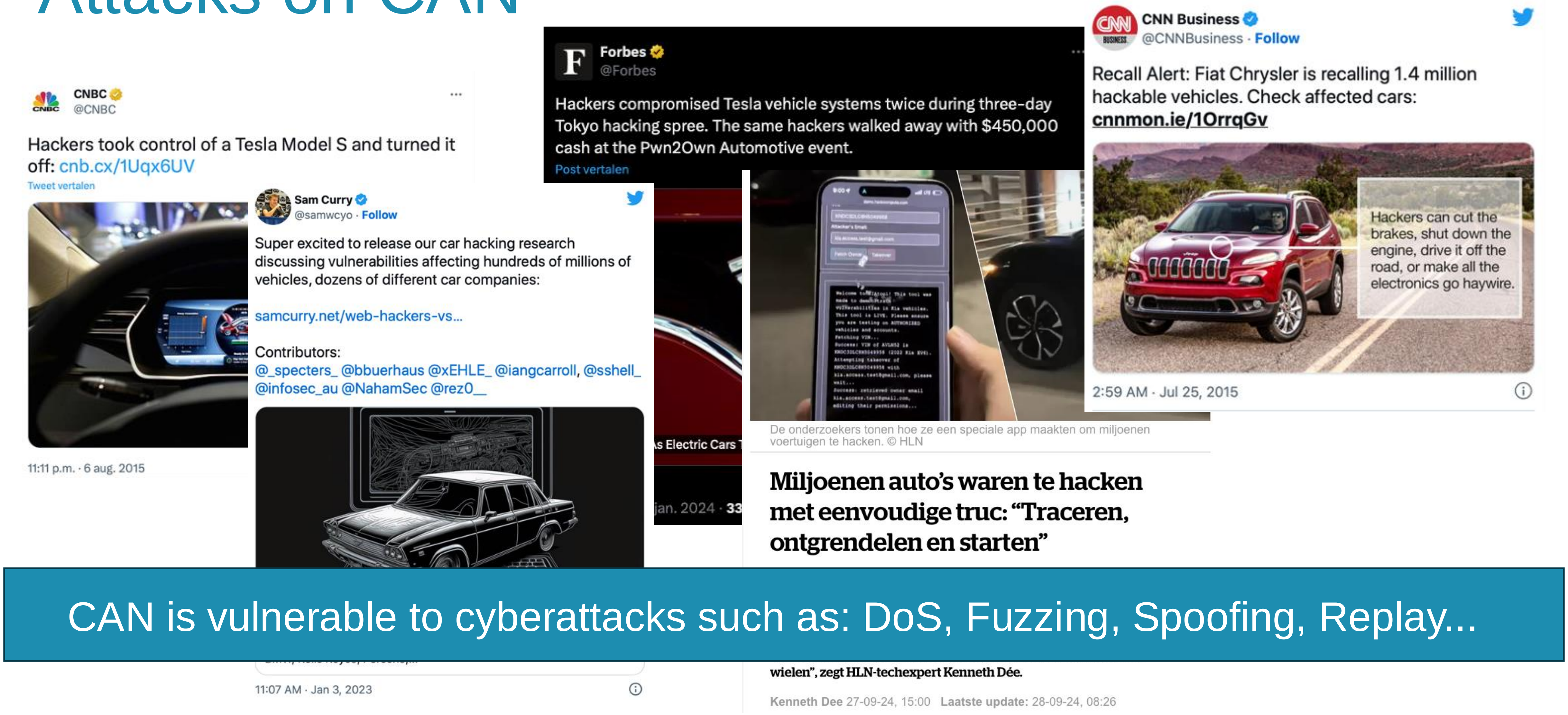
A message on the CAN bus is called a **frame**



A frame consists (mainly) of 3 fields

- The identifier (Identifier)
- Metadata concerning the length of the message (DLC)
- The actual data (Data)

Attacks on CAN



CNBC @CNBC

Hackers took control of a Tesla Model S and turned it off: cnb.cx/1Uqx6UV

Tweet vertalen

11:11 p.m. · 6 aug. 2015

Forbes @Forbes

Hackers compromised Tesla vehicle systems twice during three-day Tokyo hacking spree. The same hackers walked away with $450,000 cash at the Pwn2Own Automotive event.

Post vertalen

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Sam Curry @samwcyo · Follow

Super excited to release our car hacking research discussing vulnerabilities affecting hundreds of millions of vehicles, dozens of different car companies:

samcurry.net/web-hackers-vs...

Contributors:
@_specters_ @bbuerhaus @xEHLE_ @iangcarroll, @sshell_ @infosec_au @NahamSec @rez0__

11:07 AM · Jan 3, 2023

CNN Business @CNNBusiness · Follow

Recall Alert: Fiat Chrysler is recalling 1.4 million hackable vehicles. Check affected cars: cnnmon.ie/1OrrqGv

Hackers can cut the brakes, shut down the engine, drive it off the road, or make all the electronics go haywire.

2:59 AM · Jul 25, 2015

De onderzoekers tonen hoe ze een speciale app maakten om miljoenen voertuigen te hacken. © HLN

Miljoenen auto's waren te hacken met eenvoudige truc: "Traceren, ontgrendelen en starten"

wielen", zegt HLN-techexpert Kenneth Dée.

Kenneth Dee 27-09-24, 15:00 Laatste update: 28-09-24, 08:26

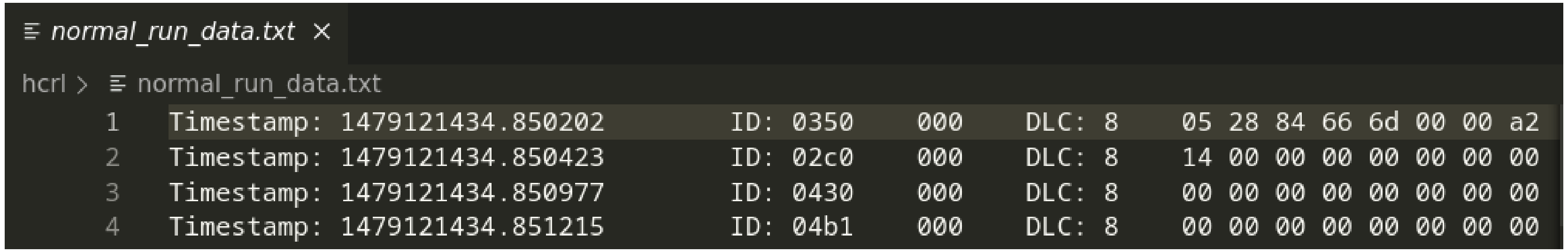
CAN is vulnerable to cyberattacks such as: DoS, Fuzzing, Spoofing, Replay...

Datasets & analysis

Datasets

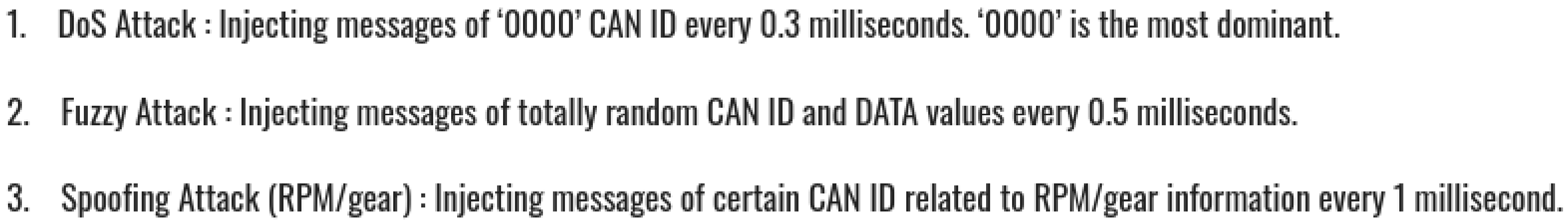
We'll be doing experiments on a **dataset** from HCRL (Hacking and Countermeasure Research Lab):

A "normal_data_set" is available in .txt format.



```
Timestamp: 1479121434.850202        ID: 0350    000    DLC: 8    05 28 84 66 6d 00 00 a2
Timestamp: 1479121434.850423        ID: 02c0    000    DLC: 8    14 00 00 00 00 00 00 00
Timestamp: 1479121434.850977        ID: 0430    000    DLC: 8    00 00 00 00 00 00 00 00
Timestamp: 1479121434.851215        ID: 04b1    000    DLC: 8    00 00 00 00 00 00 00 00
```

Also "attacked" datasets can be found:



1. DoS Attack : Injecting messages of '0000' CAN ID every 0.3 milliseconds. '0000' is the most dominant.
2. Fuzzy Attack : Injecting messages of totally random CAN ID and DATA values every 0.5 milliseconds.
3. Spoofing Attack (RPM/gear) : Injecting messages of certain CAN ID related to RPM/gear information every 1 millisecond.

Datasets

We'll be doing experiments on a **dataset** from HCRL (Hacking and Countermeasure Research Lab).

The dataset can be downloaded from this URL:

https://drive.google.com/drive/folders/1ed2PlvcSu9ONt-8KK3sgG4Qw1Bp0ccOr?usp=sharing

Example – How to detect malicious frames?

Maybe the Hamming distance between 2 subsequent frames might be an indicator?

Hamming distance = number of positions in which two (equally sized) inputs differ. For example:

-
  ```
  Hello Jim
  Hello Tim
  ```
  Hamming distance: 1

-
  ```
  31 = 0b01 1111
  32 = 0b10 0000
  ```
  Hamming distance: 6

Example – How to detect malicious frames?

Maybe the Hamming distance between 2 subsequent frames might be an indicator?

The two messages:

```
0350_8_052884666d0000a2
02c0_8_1400000000000000
```

The two messages, in binary:

```
0000001101010000_1000_0000010100101000100001000110011001101101000000000000000010100010
0000001011000000_1000_0001010000000000000000000000000000000000000000000000000000000000
```

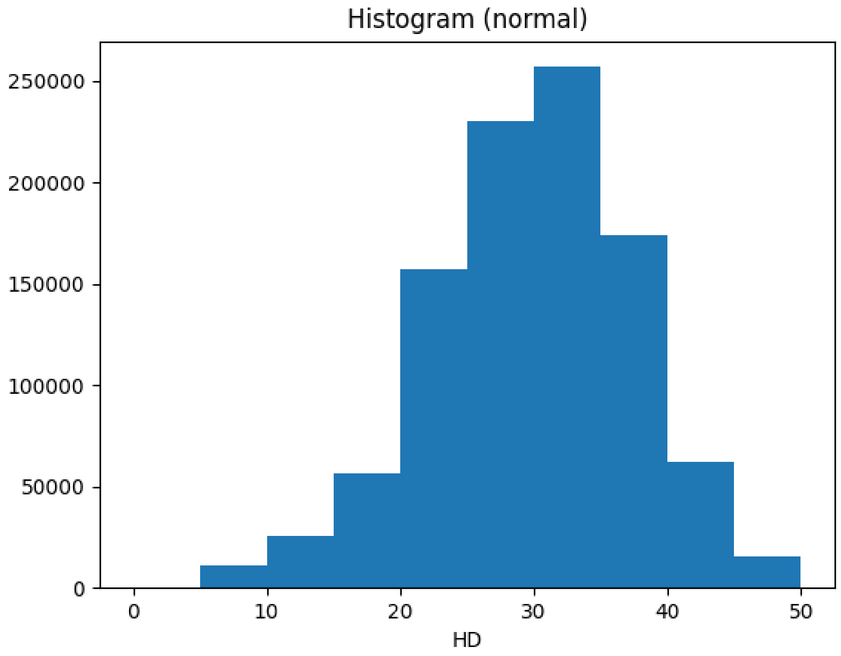
… and exored …

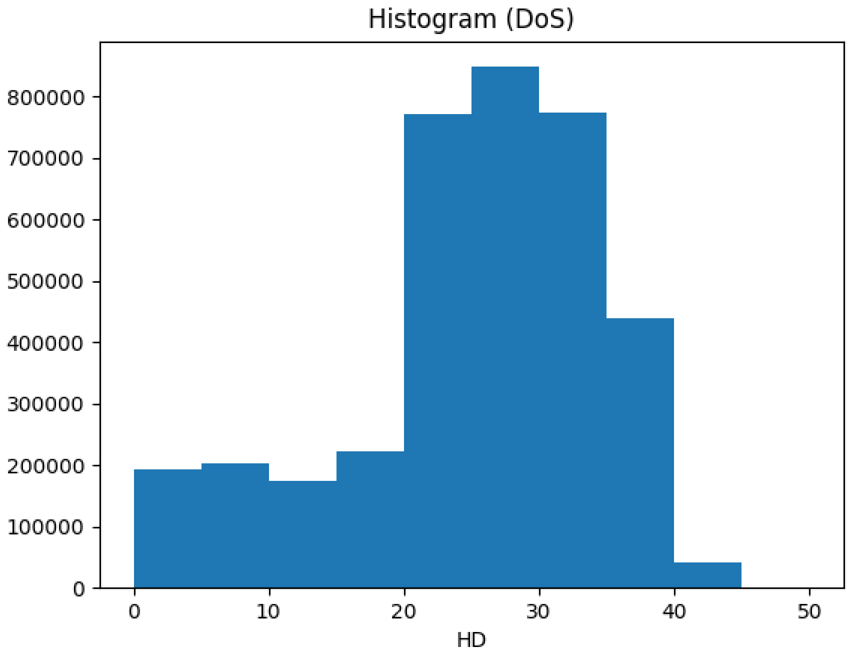
```
0000000110010000_0000_0001000100101000100001000110011001101101000000000000000010100010
```

… shows 21 bits of value '1', so the Hamming distance is **21**

Example – How to detect malicious frames?

Maybe the Hamming distance between 2 subsequent frames might be an indicator?





Hmm, there is "something"

… now you try

Can you find a statistical feature that ***MIGHT*** be an indication?

Example

Our "*hypothesis"* is that if the HD with the previous frame is < 10, the message is classified as "malicious"

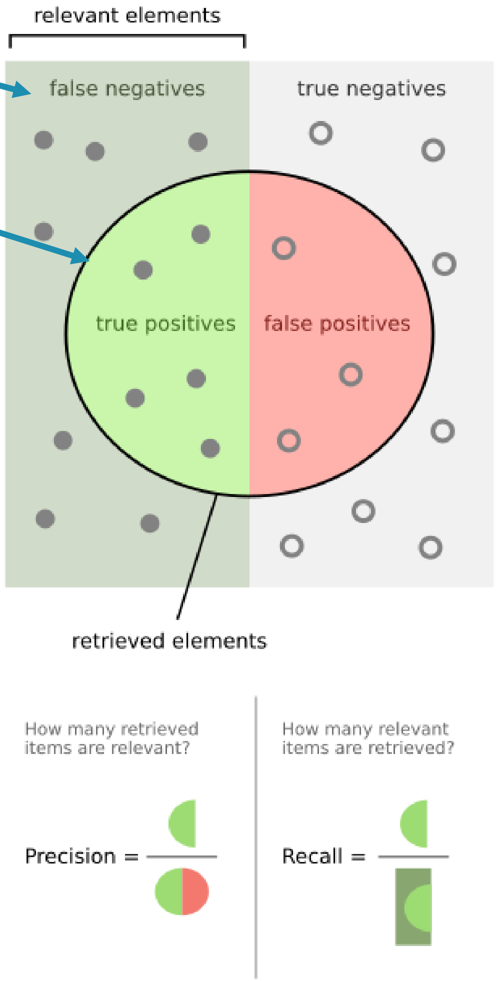
When applied to the first 100 frames of the DoS dataset, two frames are marked as "malicious".

How to evaluate the <u>performance</u> of our IDS?

Evaluation

malicious

classified as malicious



The dataset comes with the "correct" answer, per frame

T: injected message

R: normal message

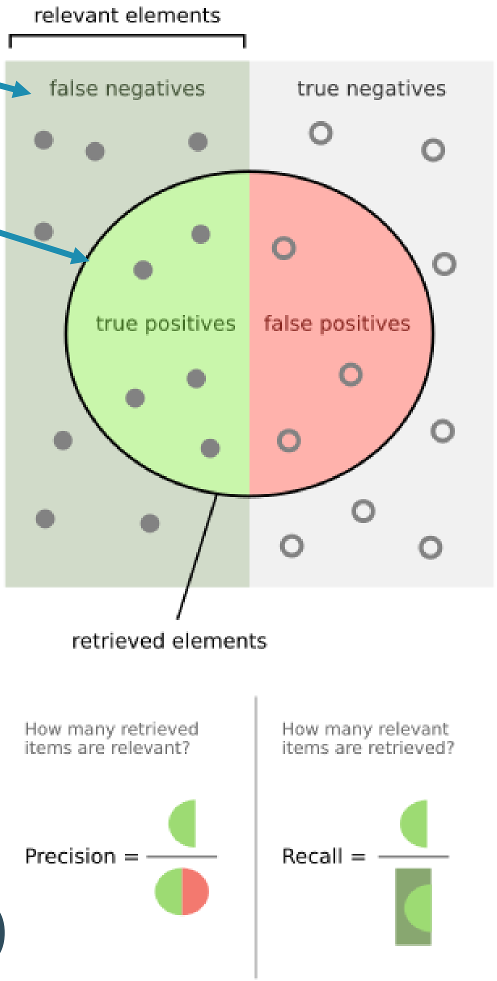
For every frame, the datasets also provides: ok / not ok

	T	R
Ok	False postive	True positive
Not ok	True negative	False negative

Evaluation

malicious

classified as malicious



The dataset comes with the "correct" answer, per frame

	T	R
Ok	False postive	True positive
Not ok	True negative	False negative

Precision: how good are your positives ? Tp / (Tp + Fp)

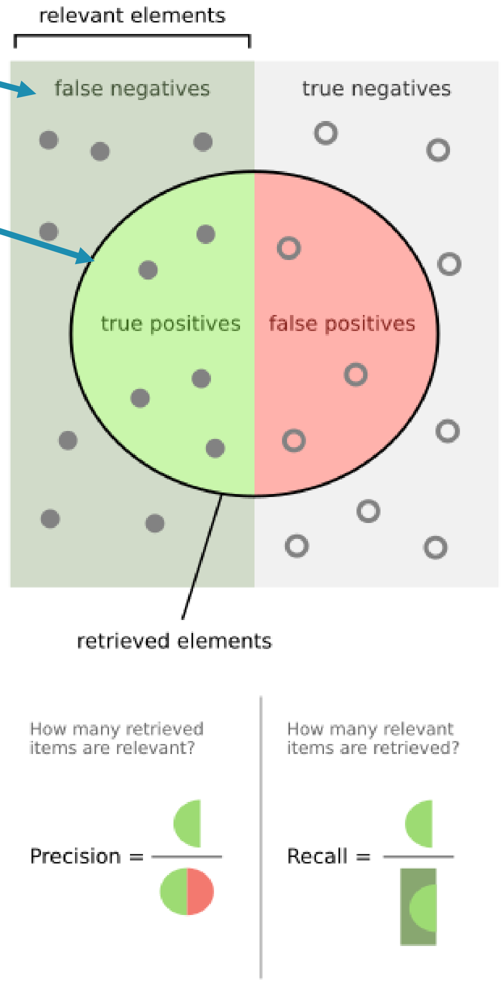
Accuracy: how good are your decisions, overall? (Tp + Tn) / (Tp + Tf + Fp + Fn)

Recall: how good did you cover all positives? Tp / (Tp + Fn)

Evaluation

malicious

classified as malicious



If we experiment with different parameters:

HD	Accuracy	Precision	Recall
5	0.884785	0.882467	0.995365
10	0.873942	0.900210	0.955839
15	0.848938	0.907834	0.912773

… now you try

How do your hypotheses score?

Combined decision making

How would make a decision when multiple models are at work ?

- Classify as malicious when **1 out of n** models classifies as malicious
- Classify as malicious when **all n** models classify as malicious
- Classify as malicious when **≥ n/2 out of n** models classify as malicious

Q&A

That's it

We hope you had fun (and have learned something :))