CPA Attack to Embedded AES Algorithm

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HSES
Master in Cybersecurity

2022/2023 Q2

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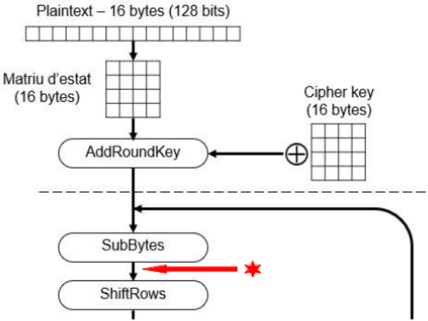
Introduction

Correlation Power Analysis

- Dataset 1 (well clocked)
- Dataset 2 (not well clocked)

- HW model
- Calculate correlation



Motivation

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- Dataset 2 is not 100% resistant to CPA

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Dataset 1

```
sbox = [0x63, ... , 0x16]
```

- Python implementation
- POWER α HW(**SBOX**(P $\oplus$ K))
- Correlation between the consumption and the model

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```
sbox = [0x63, ... , 0x16]

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xor = (cleartext[x][z])^(y)
HW = bin(sbox[xor]).count('1')
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- POWER α HW(SBOX(P $\oplus$ K))
- **Correlation between the consumption and the model**

```
sbox = [0x63, ... , 0x16]

...

xor = (cleartext[x][z])^(y)
HW = bin(sbox[xor]).count('1')

...

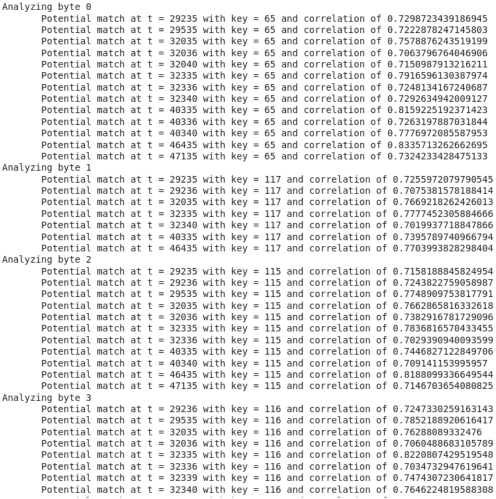
corr0 = np.corrcoef(trace_i,
    model_transposed[i])

value = abs(corr0[0][1])
if (value >= 0.7):

...
```

Dataset 1

- Computation time: 9 hours



```
Analyzing byte 0
        Potential match at t = 29235 with key = 65 and correlation of 0.7298723439186945
        Potential match at t = 29535 with key = 65 and correlation of 0.7222878247145803
        Potential match at t = 32035 with key = 65 and correlation of 0.7578876243519199
        Potential match at t = 32036 with key = 65 and correlation of 0.7063796764046906
        Potential match at t = 32040 with key = 65 and correlation of 0.7150987913216211
        Potential match at t = 32335 with key = 65 and correlation of 0.7916596130387974
        Potential match at t = 32336 with key = 65 and correlation of 0.7248134167240687
        Potential match at t = 32340 with key = 65 and correlation of 0.7292634942009127
        Potential match at t = 40335 with key = 65 and correlation of 0.8159225192371423
        Potential match at t = 40336 with key = 65 and correlation of 0.7263197887031844
        Potential match at t = 40340 with key = 65 and correlation of 0.7776972085587953
        Potential match at t = 46435 with key = 65 and correlation of 0.8335713262662695
        Potential match at t = 47135 with key = 65 and correlation of 0.7324233428475133
Analyzing byte 1
        Potential match at t = 29235 with key = 117 and correlation of 0.7255972079790545
        Potential match at t = 29236 with key = 117 and correlation of 0.7075381578188414
        Potential match at t = 32035 with key = 117 and correlation of 0.7669218262426013
        Potential match at t = 32335 with key = 117 and correlation of 0.7777452305884666
        Potential match at t = 32340 with key = 117 and correlation of 0.7019937718847866
        Potential match at t = 40335 with key = 117 and correlation of 0.7395789740966794
        Potential match at t = 46435 with key = 117 and correlation of 0.7703993828298404
Analyzing byte 2
        Potential match at t = 29235 with key = 115 and correlation of 0.7158188845824954
        Potential match at t = 29236 with key = 115 and correlation of 0.7243822759058987
        Potential match at t = 29535 with key = 115 and correlation of 0.7748909753817791
        Potential match at t = 32035 with key = 115 and correlation of 0.7662865816332618
        Potential match at t = 32036 with key = 115 and correlation of 0.7382916781729096
        Potential match at t = 32335 with key = 115 and correlation of 0.7836816570433455
        Potential match at t = 32336 with key = 115 and correlation of 0.7029390940093599
        Potential match at t = 40335 with key = 115 and correlation of 0.7446827122849706
        Potential match at t = 40340 with key = 115 and correlation of 0.709141153995957
        Potential match at t = 46435 with key = 115 and correlation of 0.8188099336649544
        Potential match at t = 47135 with key = 115 and correlation of 0.7146703654080825
Analyzing byte 3
        Potential match at t = 29236 with key = 116 and correlation of 0.7247330259163143
        Potential match at t = 29535 with key = 116 and correlation of 0.7852188920616417
        Potential match at t = 32035 with key = 116 and correlation of 0.76288089332476
        Potential match at t = 32036 with key = 116 and correlation of 0.7060488683105789
        Potential match at t = 32335 with key = 116 and correlation of 0.8220807429519548
        Potential match at t = 32336 with key = 116 and correlation of 0.7034732947619641
        Potential match at t = 32339 with key = 116 and correlation of 0.7474307230641817
        Potential match at t = 32340 with key = 116 and correlation of 0.7646224819588308
```

Key for dataset 1

[65, 117, 115, 116, 114, 97, 108, 111, 112, 105, 116, 104, 101, 99, 117, 115]

Whose values add to the checksum, 1712.

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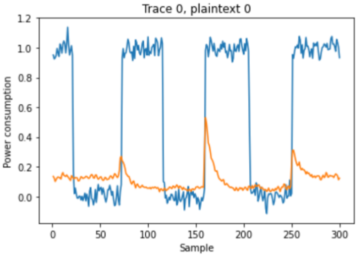
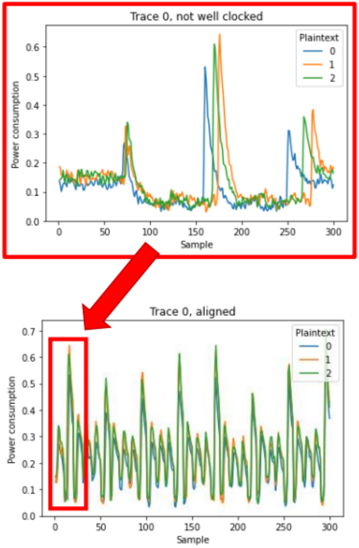
Dataset 2





- Computation time: 1 hour

Key for dataset 2

[84, 104, 97, 116, 115, 32, 109, 121, 32, 75, 117, 110, 103, 32, 70, 117]

Whose values add to the checksum, 1434.

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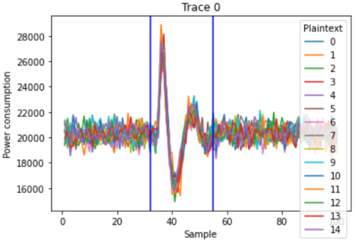
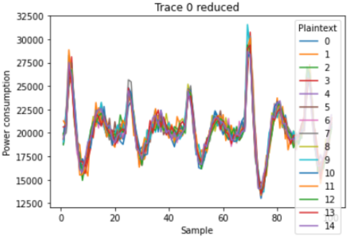
Dataset 1 improvement





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Improvement using Rust

- Python version was really slow (hours)
- Port python version to rust
- Computation time decreased to seconds
- **157x** on dataset1
- **210x** on dataset2

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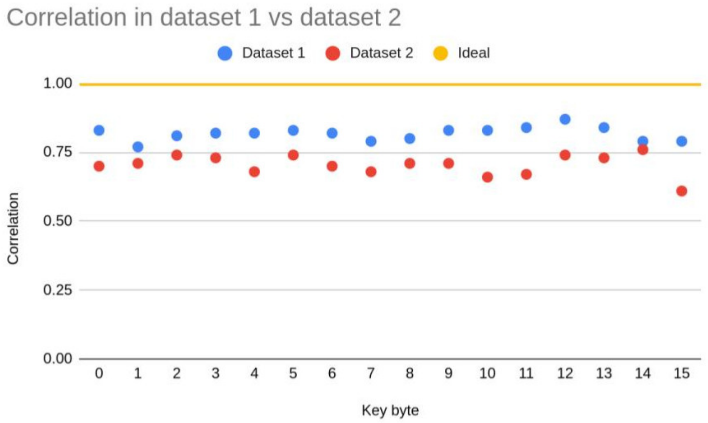
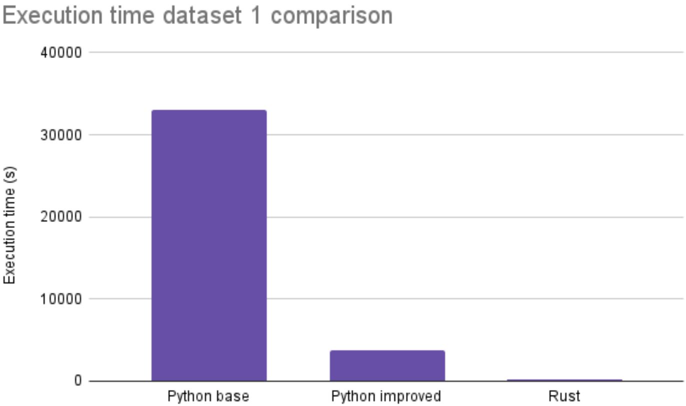
Correlation between the datasets

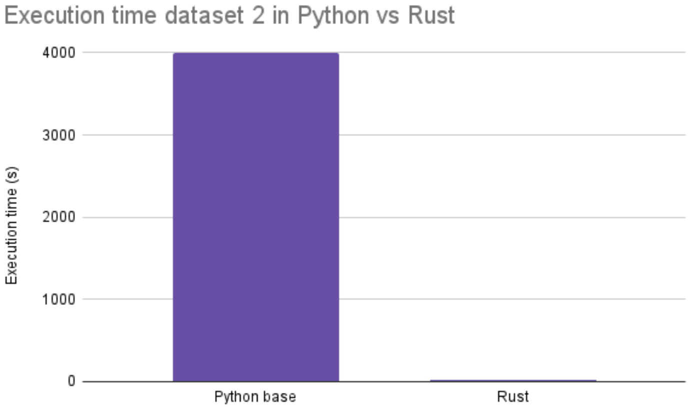


- Dataset 2 obtains correlations that are **smaller** than in dataset 1.

Performance: Dataset 1



Performance: Dataset 2



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We have obtained the keys. We have improved the performance by a factor of **157x** and **210x** by using Rust instead of Python.

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