An Upcycling Tokenization Method for Credit Card Numbers

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GDR Sécurité

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REDOCS : On the paper

Organisation

- 3 companies propose a challenge to solve.
- The doctoral students form 3 teams, one per company, depending on the subject that interests them.
- Each team is supervised by one or more members of the company.
- Each team then has four and a half days to work on the problem.
- 40 hours of work in the week.

REDOCS : In practice

Work

- Discovery of new topics.
- Learn to use academic skills for solving real problems.
- Learning new things.
- Work in sprint mode.
- Much more than 40 hours of work.
- 40 hours of scientific courses for the doctoral school.

REDOCS : In practice

Real life

- Meet new people.
- Learning new ways of thinking.
- Very pleasant environment.
- Seriousness but also a lot of fun.
- Social event.
- A productive week.

Outline

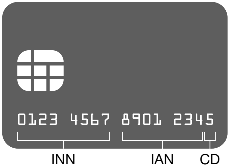
Challenges of online payments by credit card

Latest attacks

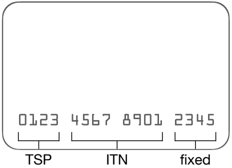
- Davinci breach, February 2019 (2.15 M stolen credit cards number).
- The Bigbadaboom-II[1], March 2018.
- The Bigbadaboom-III, January 2020 (30 M stolen credit cards number).

[1] Compromised details released by FIN7 threat group.

Credit card Number formation (CCN)

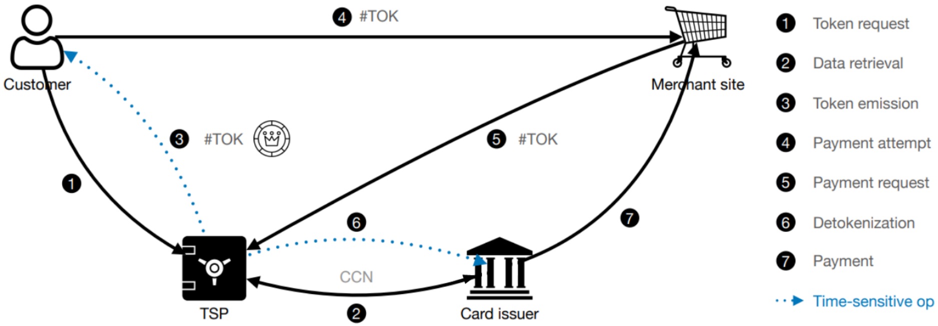


Credit Card Numbers format.



Possible token format.

Tokenisation System



Life Cycle of a Token.

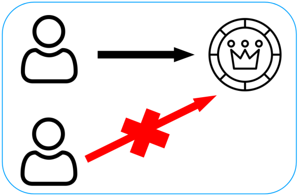
Specifications

Functional

- **Unicity**
- Uniformity
- Unlinkability
- Unforgeability

Technical

- Expiry
- Formatting
- Timeframe
- Reusability
- Auditability



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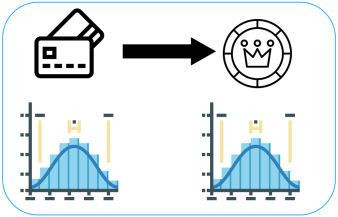

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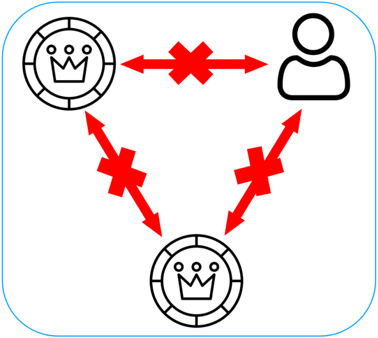

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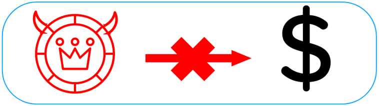

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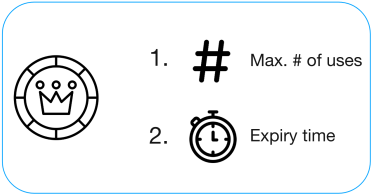

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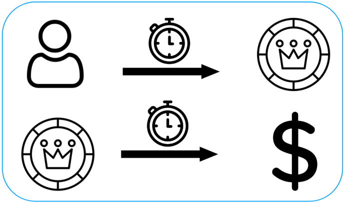

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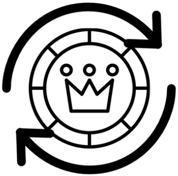

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Static pre-computed table

Defintion

Table of all possible token values computed in advance.

Problems

- No mechanism avoids the saturation of the table.
- Obligation to create a new table when the previous one is saturated.
- Lower performances over time.
- More and more memory needed.
- No encryption of the table.

Our Solution : Upcycling Token Table

Fixed size table

- Cleaning mechanism.
- Index by token number: Very fast (constant time lookup).
- Reusable token.

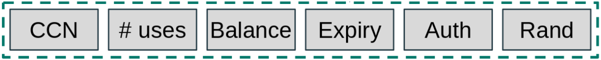
Lifespan and maximum number of use

- Maximum number of use for each token (clean once the maximum is reached).
- Lifespan (useful in cases of forgetfulness for example).
- Second database for a trace of all operations.

Encrypt

Each row encrypted with AES 256.

Content of a row



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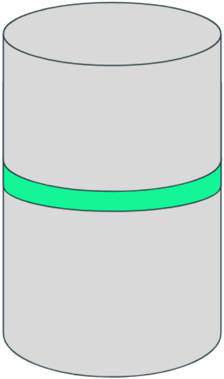
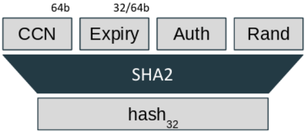


Tokenisation



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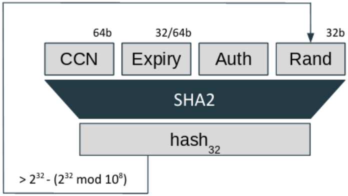

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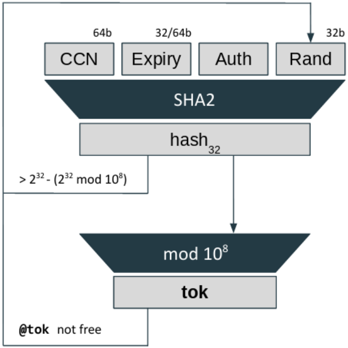

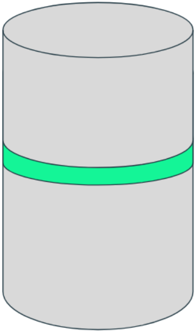

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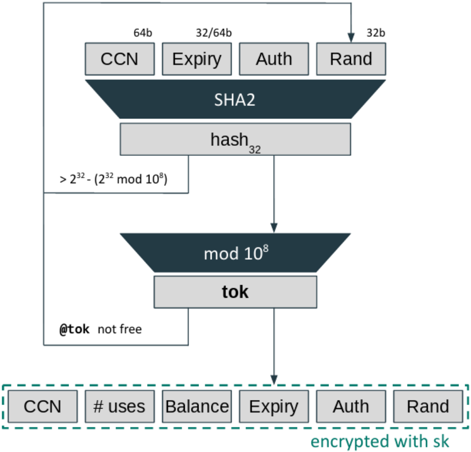

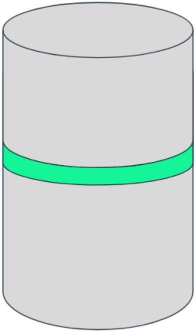

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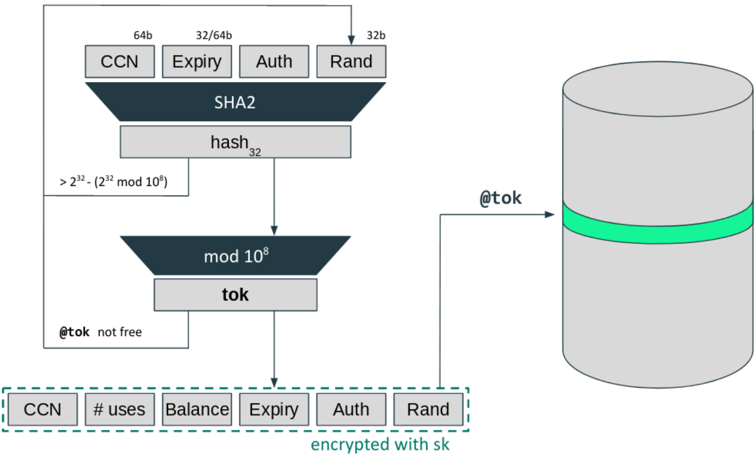

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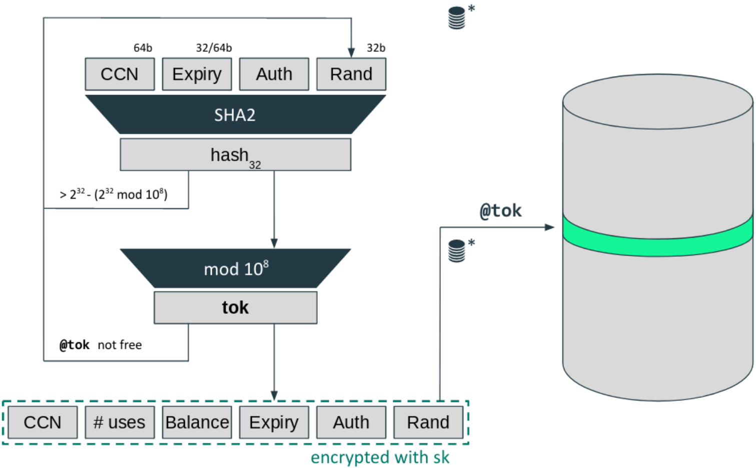
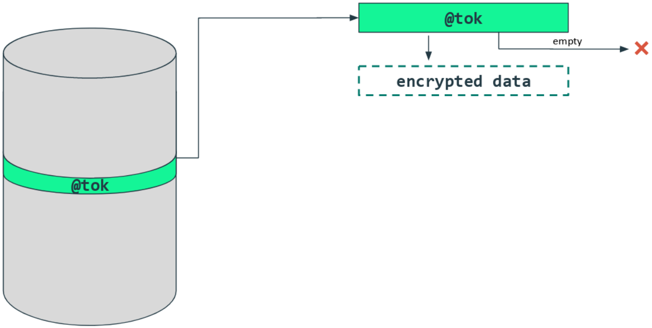


Tokenisation.

Detokenisation



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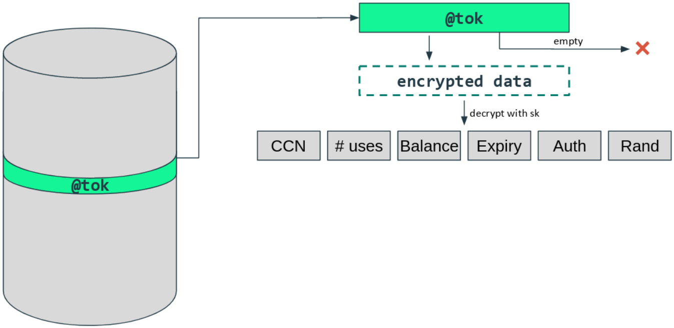

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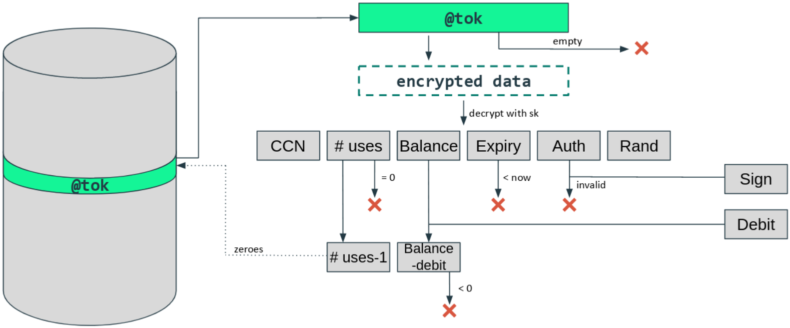

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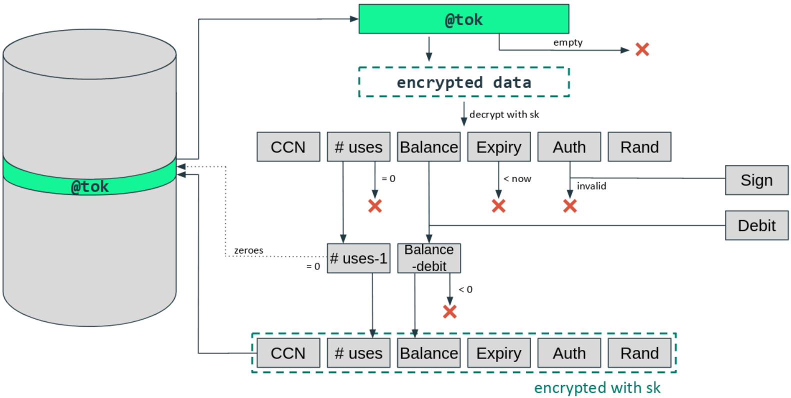

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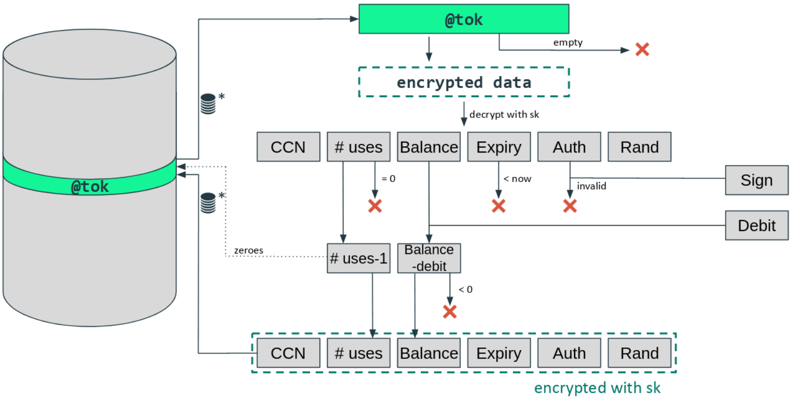

Detokenisation.

Clean table

Clean table.

Probability of failure

Number of token according to λ

- T Number of tries per timeframe.
- n_{max} Number of available tokens (10^8).
- n Number of token inserted.

Probability of failure given a fixed threshold :

$$\left(\frac{n}{n_{\max}}\right)^T < \frac{1}{2^\lambda} \iff n < 2^{\log_2(n_{\max}) - \frac{\lambda}{T}}.$$

Probability of failure lower than $\frac{1}{2^{128}}$

With $T = 70\ 000$, maximum table fill rate: **99.8733%**
→ The limit is the 8-digit model, not the implementation

Experiments

Environment

- AMD EPYC 7742 Processor.
- 3240.029MHz.

Results

- table fill rate : $> 99.987\%$.
- Tries before first failure : $\approx 70\ 250$.
- Detokenisation time : 6μ per token.
- RAM used : 25 GB.

Take away

Significant improvement

- Average of 1 billion credit card transactions per day worldwide (i.e., 11 574 transactions per second, 7M per 10 min).
- Our construction covers **6.5 times** the current number of transactions.
- With a 10-minute token lifespan, at maximum token creation speed: maximum of 45 million valid tokens can be in the table at any given time.

Thank you for you attention

Do you have any questions?

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