Processing PCI Track Data with CDPO

David Pany
David Pany

- Incident Response Consultant
  - Digital Forensics
  - Python Hobbyist
    - https://github.com/davidpany
    - Curator of bespoke and artisan artifacts

- Lover of payment card breach investigations

- @DavidPany

Image courtesy of Ian Ahl (@TekDefense, a Sigpedia LLC subsidiary)
NOT David Pany

- Not Lawyer
- Not PFI (PCI Forensic Investigator)
- Not QSA
- Not responsible for any errors that may occur using this information or tools I create
  - Neither is my employer!
CDPO, who dat???

- Magnetic Track Data Overview
- Card Data Breach Example
- Old Ways
- New Way – CDPO?
- Demo
Magnetic Track Data Overview

• Magnets!
  
  • Track 1
    • %B6471294619522549^DavidPany^21046721288?

  • Track 2
    • ;6471294619522549=80096721288?

  • Track 3?

http://www.generatedata.com/
Track Data Overview

• Cool Data
  • PAN 6471294619522549
    • Primary account number
  • Expiration Date 2104
    • YYMM
  • Name (Track1 only) DavidPany

https://en.wikipedia.org/wiki/Magnetic_stripe_card
Track Data Overview

• Less Cool Data
  • Service Code 672
    • Rules?

• Discretionary data 128
  • Security Code
  • Swipe vs. Print

• LRC 8

%B6471294619522549^DavidPany^21046721288?
Payment Card Process

- Swipe card on card reader
- Track data sent to POS application on cash register
- POS application sends track data to bank for approval
Card Data Breach Example
POS Malware Scraper Overview

• Malware reads POS system memory
  • All memory?
  • POS application memory?

• Malware regexes data for track data formats

• Malware outputs track data to file, registry key, network share, etc.
  • Likely encoded!
Output Files – What to do?

1. Find
2. Decode
3. Aggregate?
4. De-duplicate
5. Validate
6. Organize
7. Statistics?

Same old

We can do better!
Output Files – Find

- Know your threat actor
- Reverse engineer/test malware sample and run keyword search
- Check aggregation servers
- If other storage method such as registry keys, extract!
Output Files – Decode

- Attackers be stealthin
- Reverse engineer
- I have seen IR companies give up without a decoder
  - #NODATATHEFTCONFIRMED
- Not my expertise, good luck, #YOLO
Old Ways
Output Files – Aggregate

• Do you want to combine output files?
  • Reduce files to parse

• How do you aggregate them?
  • Location, timeframe, etc

• Old method:
  • cat
Output Files – De-duplicate

- Don’t count the same card as multiple stolen cards!
  - Client won’t like that $$

- Why duplicates?
  - Repeat customers
  - Copying output files

- Old method:
  - sort -u
Output Files – Validate

• Are the cards real?
• Validation options
  • Luhn
  • Brand
  • Expiration date
  • Track data format

• Old method:
  • Custom scripts to calculate Luhn
  • Regex format
  • Brand and Expiration Date are trickier
Output Files – Organization

- Keep track of these for each, possibly for each location
  - Encoded files
  - Decoded files
  - Aggregated files
  - De-duplicated files
  - Validated files

- Old method:
  - 1 billion files!
Output Files – Statistics

• Number of PANs
• Number of PAN+Exp combos
• Brands
• Valid expiration dates
  • Invalid expiration dates?

• Old method:
  • Custom scripts
New Way!
New Method – Why?

- Old methods of Linux commands and random scripts with no standardization
  - Difficult to reproduce consistently
  - Difficult for peer review
  - Difficult to keep track of files for progress
  - Difficult to organize, combine, de-duplicate
  - Excel only supports about 1,048,000 rows!

• OLD WAY SUCKS
Introducing CDPO
CDPO Concept

• Standardized, repeatable, and reviewable
• Portable – anyone can use anywhere
  • Python is only dependency
• Secure – encrypts data at rest
• Flexible – combine and subset data, output data for reports
• Fast – waaaaaay faster than old method
• Organized and EZ
CDPO Features

- Python script with its own terminal
- Input data from decoded track data files
- Input validated with regex, Luhn, simple brand matching
- Data stored RC4 encrypted in SQLite DB
  - Portable database file for convenience
CDPO Validation - Regex

```
([1-9][0-9]{11,18})(\^\.{,30}\^|\|=)(([0-9]{4})
```

• **Groups**
  • 12 to 19 numbers, starting with 1-9
  • = or ^name^  
  • 4 numbers for EXP date

• **Questions**
  • Do we care about discretionary data after EXP date?  
  • Can a PAN start with 0?
CDPO Validation - Luhn

• #MATH algorithm to check for accidental errors
  • https://en.wikipedia.org/wiki/Luhn_algorithm

1. From the rightmost digit, which is the check digit, and moving left, double the value of every second digit. If the result of this doubling operation is greater than 9 (e.g., 8 x 2 = 16), then add the digits of the product (e.g., 16: 1 + 6 = 7, 18: 1 + 8 = 9) or alternatively subtract 9 from the product (e.g., 16: 16 - 9 = 7, 18: 18 - 9 = 9).
2. Take the sum of all the digits.
3. If the total modulo 10 is equal to 0 (if the total ends in zero) then the number is valid according to the Luhn formula; else it is not valid.

• CDPO tests first regex group (PAN) for Luhn

• Questions
  • “Loon” or “Lun”?
  • Do all brands require Luhn?
  • What if malware doesn’t Luhn and accidentally grabs numbers before PAN?
    • CDPO will test substrings! Keep this in mind!
CDPO Validation - Brands

- First 1-8 digits of PAN
  - IIN/BIN
- Simple and fast table
- Not approved by academia – probably some inaccuracies!
- Provide recovered data to banks for full validation

<table>
<thead>
<tr>
<th>Issuing network</th>
<th>IIN ranges</th>
<th>Active</th>
<th>Length</th>
<th>Validation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankcard[2]</td>
<td>5610, 560221-560225</td>
<td>No</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Diners Club Carte Blanche</td>
<td>300-305</td>
<td>Yes</td>
<td>14</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Diners Club enRoute</td>
<td>2014, 2149</td>
<td>No</td>
<td>15</td>
<td>no validation</td>
</tr>
<tr>
<td>Diners Club International[7]</td>
<td>300-305, 309, 36</td>
<td>Yes</td>
<td>14</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Diners Club United States &amp; Canada[9]</td>
<td>54, 55 (MasterCard co-branded)</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>InterPayment</td>
<td>636</td>
<td>Yes</td>
<td>16-19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Laser</td>
<td>6504, 6706, 6771, 6709</td>
<td>No[12]</td>
<td>16-19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Maestro</td>
<td>50, 56-58, 6</td>
<td>Yes</td>
<td>12-13[13]</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Dankort</td>
<td>5019</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td></td>
<td>4XXX, 4175, 4571 (Visa co-branded)</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>MIR</td>
<td>2200 - 2204</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>MasterCard</td>
<td>2221-2720</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td></td>
<td>51-55</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Solo</td>
<td>6534, 6767</td>
<td>No</td>
<td>16, 18, 19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Switch</td>
<td>4900, 4905, 4911, 4906, 564182, 633110, 6333, 6759</td>
<td>No</td>
<td>16, 18, 19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Visa</td>
<td>4 (including related/partner brands: Dankort, Electron, etc.)</td>
<td>Yes</td>
<td>13, 16, 19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>UATP</td>
<td>1</td>
<td>Yes</td>
<td>15</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>Verve</td>
<td>506099-506196, 560002-560027</td>
<td>Yes</td>
<td>16, 19</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>TROY</td>
<td>975200-975295</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
<tr>
<td>CARDGUARD EAD 80 ILS</td>
<td>5592</td>
<td>Yes</td>
<td>16</td>
<td>Luhn algorithm</td>
</tr>
</tbody>
</table>

https://en.wikipedia.org/wiki/Payment_card_number
CDPO Validation Future – Brands

- [https://binlist.net/](https://binlist.net/)
  - Online database of IIN/BIN
  - Throttled API, manual lookup, premium API
  - Possible future implementation to build offline DB with throttled API and postprocess with CDPO
  - Time consuming but more accurate??
CDPO Troubleshooting

- Removing Track Data Throwaways (RTDT)
  - Still in development
- Separate Script to confirm why a line didn’t import
  - Formatting issues
  - Luhn fail
  - Invalid format
  - Find luhn substring?
CDPO Commands

- **import**
  - Load data into CDPO collection

- **combine**
  - Combine existing collections

- **query**
  - Create subset of existing collection

- **quit or exit**
  - Exit CDPO

- **show**
  - Simple stats for all loaded data

- **stat**
  - Detailed stats for one collection

- **csvstats**
  - Create a CSV of all stats

- **file**
  - Write decrypted data to a csv file
Demo!
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etc. that result from the use of this utility? Yes/No: Yes

Accepted. Please enjoy CDPO!

It appears a SANS DB.sqlite database already exists.
Please choose one of the following options (D, L, or I):
(D)elete the SANS DB.sqlite database and start over
(L)oad the existing SANS DB.sqlite database
(I)ncrement to a new SANS DB.sqlite database while preserving existing DB
Your choice: L
Do you accept the above license and terms that no person or entity (including David Pany) is responsible for any inaccuracies, bugs, errors, etc. that result from the use of this utility? Yes/No: Yes

Accepted. Please enjoy CDPO!

It appears a SANS DB.sqlite database already exists.
Please choose one of the following options (D, L, or I):
(D)elete the SANS_DB.sqlite database and start over
(L)oad the existing SANS DB.sqlite database
(I)ncrement to a new SANS_DB.sqlite database while preserving existing DB

Your choice: L

Password (masked):

Using SQLite DB file name: SANS_DB.sqlite

Hello, I am CDPO, PCI track data relations. How might I serve you?
Try 'help'

(CDPO):
Hello, I am CDPO, PCI track data relations. How might I serve you?
Try 'help'

(CDPO): show

Loaded Collections:

<table>
<thead>
<tr>
<th>Name</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>patient0 decoded</td>
<td>855</td>
</tr>
</tbody>
</table>

- Unique PANs: 855
- Unique pan+exp Dates: 855
  - pan+exp >= 1706: 242
  - pan+exp < 1706: 613
- track Counts:
  - track 1 Only: 417
  - track 2 Only: 340
  - Both Tracks: 98
- Brands:
  - MAESTRO: 74
  - AMEX: 88
  - VISA: 524
  - DISCOVER: 17
  - MASTERCARD: 152

(CDPO):
A while this may take. Patience you must have.
Loading file input/system2 decoded ...
File loaded in 0 seconds. Processing track data...
  track data processed in 14 seconds. Adding data to DB...
  Data added to DB in 70 seconds. Calculating stats...
  **224256 unique pan+exp combinations imported from system2_decoded in 87 seconds!**
  2653 unique lines did not contain track data.
  1199 valid PANs did not have valid Expiration Dates.

A while this may take. Patience you must have.
Loading file input/system3 decoded ...
File loaded in 0 seconds. Processing track data...
  track data processed in 14 seconds. Adding data to DB...
  Data added to DB in 67 seconds. Calculating stats...
  **217739 unique pan+exp combinations imported from system3_decoded in 84 seconds!**
  2710 unique lines did not contain track data.
  1192 valid PANs did not have valid Expiration Dates.

A while this may take. Patience you must have.
Loading file input/system4 decoded ...
File loaded in 0 seconds. Processing track data...
  track data processed in 14 seconds. Adding data to DB...
  Data added to DB in 62 seconds. Calculating stats...
  **219342 unique pan+exp combinations imported from system4_decoded in 78 seconds!**
  2799 unique lines did not contain track data.
  1201 valid PANs did not have valid Expiration Dates.

(CDPO):
track data processed in 14 seconds. Adding data to DB...
Data added to DB in 70 seconds. Calculating stats...
224256 unique pan-exp combinations imported from system2_decoded in 87 seconds!
  2653 unique lines did not contain track data.
  1199 valid PANs did not have valid Expiration Dates.

A while this may take. Patience you must have.
Loading file input/system3_decoded ...
File loaded in 0 seconds. Processing track data...
track data processed in 14 seconds. Adding data to DB...
Data added to DB in 67 seconds. Calculating stats...
217739 unique pan-exp combinations imported from system3_decoded in 84 seconds!
  2710 unique lines did not contain track data.
  1192 valid PANs did not have valid Expiration Dates.

A while this may take. Patience you must have.
Loading file input/system4_decoded ...
File loaded in 0 seconds. Processing track data...
track data processed in 14 seconds. Adding data to DB...
Data added to DB in 62 seconds. Calculating stats...
219342 unique pan-exp combinations imported from system4_decoded in 78 seconds!
  2799 unique lines did not contain track data.
  1201 valid PANs did not have valid Expiration Dates.

(CDPO): combine ALLTHEFILES
Please specify two or more existing collections to combine. (collection1 collection2)
Note that ALL will combine all loaded collections. Your choices are:
  ALL patient0 decoded system2_decoded system3_decoded system4_decoded

Collections to add to the Super collection, QUIT to exit [default]: all
combine ALLTHEFILES

Please specify two or more existing collections to combine. (collection1 collection2)
Note that ALL will combine all loaded collections. Your choices are:
   ALL patient0_decoded system2_decoded system3_decoded system4_decoded

Collections to add to the Super collection, QUIT to exit [default]: all

A very, very long time this may take. Patience you must have.
   Adding patient0_decoded to ALLTHEFILES combination. Patience you must have.
   patient0_decoded processed in 0 seconds.
   Adding system2_decoded to ALLTHEFILES combination. Patience you must have.
   system2_decoded processed in 20 seconds.
   Adding system3_decoded to ALLTHEFILES combination. Patience you must have.
   system3_decoded processed in 31 seconds.
   Adding system4_decoded to ALLTHEFILES combination. Patience you must have.
   system4_decoded processed in 33 seconds.
   All collections have been added to the ALLTHEFILES super collection. Saving to .sqlite file...
   The super collection has been saved in 0 seconds. Calculating stats now...

622291 unique pan-exp combinations added to ALLTHEFILES in 90 seconds!
statistics for: allthefiles

unique pan: 619557
unique pan+exp dates: 622291
  pan+exp \geq 1706: 169678
  pan+exp < 1706: 452613

track counts:
  track 1 only: 2038
  track 2 only: 17319
  both tracks: 602934

brands:
  chinaunionpay: 24
  dinersclub: 2
  bankcard: 1
  interpayment: 2
  discover: 16109
  amex: 61581
  visa: 371742
  cardguard: 2
  mastercard: 113658
  unknown: 51
  maestro: 59003
  uatp: 116

components: patient0_decoded, system2_decoded, system3_decoded, system4_decoded

expiration date counts:
  2000: 4
    01:3 08:1
  2001: 1
    11:1
  2002: 1
    12:1
  2004: 1
    04:1
2012: 2
   07:1 08:1
2013: 12
   01:4 08:1 09:1 11:4 12:2
2014: 11
   01:1 02:2 05:1 06:1 08:1 09:1 10:1 11:1 12:2
2015: 23
   01:1 02:1 03:1 04:2 05:2 08:5 09:4 10:2 11:2 12:3
2016: 44221
2017: 125971
   01:7171 02:10050 03:10208 04:9805 05:10106 06:10105 07:10951 08:11107 09:10701 10:12082 11:117750
2018: 177150
   01:15180 02:15101 03:15913 04:13874 05:14321 06:13807 07:13183 08:13844 09:13884 10:15252 11:111788
2019: 162856
   01:19578 02:22056 03:25269 04:19762 05:18544 06:15596 07:10762 08:7618 09:6667 10:5838 11:5397
2020: 45077
   01:6766 02:3407 03:12734 04:7457 05:6125 06:4552 07:1020 08:1103 09:474 10:414 11:441 12:584
2021: 6595
2022: 337
   01:18 02:11 03:5 04:9 05:24 06:18 07:65 08:81 09:20 10:24 11:20 12:42
2023: 526
   01:33 02:30 03:22 04:21 05:75 06:56 07:46 08:75 09:65 10:45 11:36 12:22
2024: 1071
2089: 1
   10:1
2090: 1
   10:1
2091: 6
   03:1 08:3 11:1 12:1
2092: 8
   01:3 02:1 03:1 10:1 12:2
2093: 1
   01:1
2098: 7
   02:1 03:1 05:1 08:1 09:3
2099: 13
   01:1 12:12

(CDPO): query ALLTHEFILES
You can filter on Expiration date. Here are your options:
(G)reater than OR equal to YYMM
(L)ess than OR equal to YYMM
(E)qual to YYMM
(B)etween AND including YYMM and YYMM
(N)o Expiration date filter [default]

Your Choice: G
What year must all Expiration Dates be greater than OR equal to? YYMM: 1706
2093: 1
  01:1
2098: 7
  02:1 03:1 05:1 08:1 09:3
2099: 13
  01:1 12:12

(CDPO): query ALLTHEFILES
You can filter on Expiration date. Here are your options:
  (G)reater than OR equal to YYMM
  (L)ess than OR equal to YYMM
  (E)qual to YYMM
  (B)etween AND including YYMM and YYMM
  (N)o Expiration date filter [default]

Your Choice: G
What year must all Expiration Dates be greater than OR equal to? YYMM: 1706

Please choose brands (separated by space) that you would like to filter by. Default is ALL.
Available brands are:
  ALL AMEX MASTERCARD VISA MAESTRO DISCOVER UATP CHINAUNIONPAY UNKNOWN INTERPAYMENT CARDGUARD DINERSCLUB BANKCARD

Your choice(s) (Press Enter to skip this filter): AMEX
(CDPO): query ALLTHEFILES
You can filter on Expiration date. Here are your options:
   (G)reater than OR equal to YYMM
   (L)ess than OR equal to YYMM
   (E)qual to YYMM
   (B)etween AND including YYMM and YYMM
   (N)o Expiration date filter [default]

Your Choice: G
   What year must all Expiration Dates be greater than OR equal to? YYMM: 1706

Please choose brands (separated by space) that you would like to filter by. Default is ALL.
   Available brands are:
      ALL AMEX MASTERCARD VISA MAESTRO DISCOVER UATP CHINAUNIONPAY UNKNOWN INTERPAYMENT CARDGUARD DINERSCLUB

Your choice(s) (Press Enter to skip this filter): AMEX

Please choose the track you would like to filter by. Available choices are:

   (A) track 1 OR both tracks
   (B) track 1 ONLY
   (C) track 2 OR both tracks
   (D) track 2 ONLY
   (E) Only Both Tracks
   (N) Skip [default]

You're choice: E
Please choose brands (separated by space) that you would like to filter by. Default is ALL.
   Available brands are:
      ALL AMEX MASTERCARD VISA MAESTRO DISCOVER UATP CHINAUNIONPAY UNKNOWN INTERPAYMENT CARDGUARD DINERSCLUB

B BANKCARD

Your choice(s) (Press Enter to skip this filter): AMEX

Please choose the track you would like to filter by. Available choices are:
   (A) track 1 OR both tracks
   (B) track 1 ONLY
   (C) track 2 OR both tracks
   (D) track 2 ONLY
   (E) Only Both Tracks
   (N) Skip [default]

You're choice: e
Your query returned 21693 unique pan-exp combinations.

Would you like to add the query results to a collection? (Y/N): y
What would you like the name of your new Query to be? AMEX_report
Writing AMEX_report to the database. Patience you must have.
AMEX_report added to the database in 0 seconds. Calculating stats now...
21693 unique pan+exp combinations added to AMEX_report in 0 seconds!

(CDPO): file AMEX report
(CDPO): csvstats
<table>
<thead>
<tr>
<th>Collection Name</th>
<th>Unique PANs</th>
<th>Unique pan+exp Dates</th>
<th>Track 1 Only</th>
<th>Track 2 Only</th>
<th>Track 1 and 2</th>
<th>Expiration date (JSON)</th>
</tr>
</thead>
<tbody>
<tr>
<td>system3_decoded</td>
<td>217002</td>
<td>217739</td>
<td>833</td>
<td>6263</td>
<td>210643</td>
<td>{u'1304': 1, u'1305': 1, u'0'}</td>
</tr>
<tr>
<td>system4_decoded</td>
<td>218598</td>
<td>219342</td>
<td>1218</td>
<td>6391</td>
<td>211733</td>
<td>{u'1304': 1, u'1305': 1, u'1'}</td>
</tr>
<tr>
<td>system2_decoded</td>
<td>223692</td>
<td>224256</td>
<td>204</td>
<td>6094</td>
<td>217958</td>
<td>{u'9201': 2, u'1302': 1, u'1'}</td>
</tr>
<tr>
<td>patient0_decoded</td>
<td>855</td>
<td>855</td>
<td>417</td>
<td>340</td>
<td>98</td>
<td>{u'1605': 22, u'1608': 18, 1'}</td>
</tr>
<tr>
<td>AMEX_report</td>
<td>21672</td>
<td>21693</td>
<td>0</td>
<td>0</td>
<td>21693</td>
<td>{u'2003': 2, u'1908': 12, u'1'}</td>
</tr>
<tr>
<td>ALLTHEFILES</td>
<td>619557</td>
<td>622291</td>
<td>2038</td>
<td>17319</td>
<td>602934</td>
<td>{u'1304': 2, u'1305': 2, u'}</td>
</tr>
</tbody>
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<th>DISCOVER</th>
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Statistics for: AMEX_report

Unique PANs: 21672
Unique pan+exp Dates: 21693
  pan+exp >= 1706: 21693
  pan+exp < 1706: 0

track Counts:
  track 1 Only: 0
  track 2 Only: 0
  Both Tracks: 21693

Brands:
  AMEX: 21693

Expiration date Counts:
2017: 12207
2018: 8975
2019: 828
  01:21 02:18 03:19 04:15 05:375 06:345 07:20 08:12 09:1 12:2
2020: 58
  01:1 02:4 03:2 04:3 05:11 06:11 07:4 08:7 09:3 10:4 11:3 12:5
2021: 125
  02:3 03:7 04:2 05:26 06:2 07:8 08:6 09:20 10:21 11:12 12:18
2022: 360
  01:31 02:46 03:32 04:45 05:58 06:45 07:34 08:17 09:12 10:10 11:16 12:14
2023: 40
  01:9 02:9 03:15 04:6 05:1

Query Parameters:
Query: SELECT * FROM ALLTHEFILES WHERE (exp >= 1706) AND (brand = "AMEX") AND (track = 12)
(CDPO): quit

Oh my goodness! Shut me down. Machines counting track data. How perverse.

Thanks for using CDPO!

You Are The Best!
Download CDPO

• [https://github.com/davidpany/CDPO](https://github.com/davidpany/CDPO)
Future

• More controls over loaded collections (drop, merge?)
• Tab completion
• Combination speed improvements
• Stronger encryption
• Binlist brand postprocessing
WATCH OUT!

• Format preserving encryption?
• Store cards or gift cards?
• Chip and PIN/signature?
Shoutouts

• Encryption functionality implemented by Patrick Charbonneau
• Struggled through old ways with Jay Taylor
• New improved combination SQL statement coming from Brandan Schondorfer for moar speedz
Summary

• Standardized
• Fast
• Features!
• Expandable – send (feature|merge) requests to @DavidPany
• Not infallible – send bug reports to @DavidPany or use GitHub
  • Pretty great, but use at your own risk
  • Consult with lawyers and card brands to confirm results
Thanks!

• Questions?

• @davidpany