2019

NT KONFERENCA

21. - 23. MAJ 2019

#ntk19

Lessons from the Field:
Vulnerabilities in Credentials & How to Fix Them

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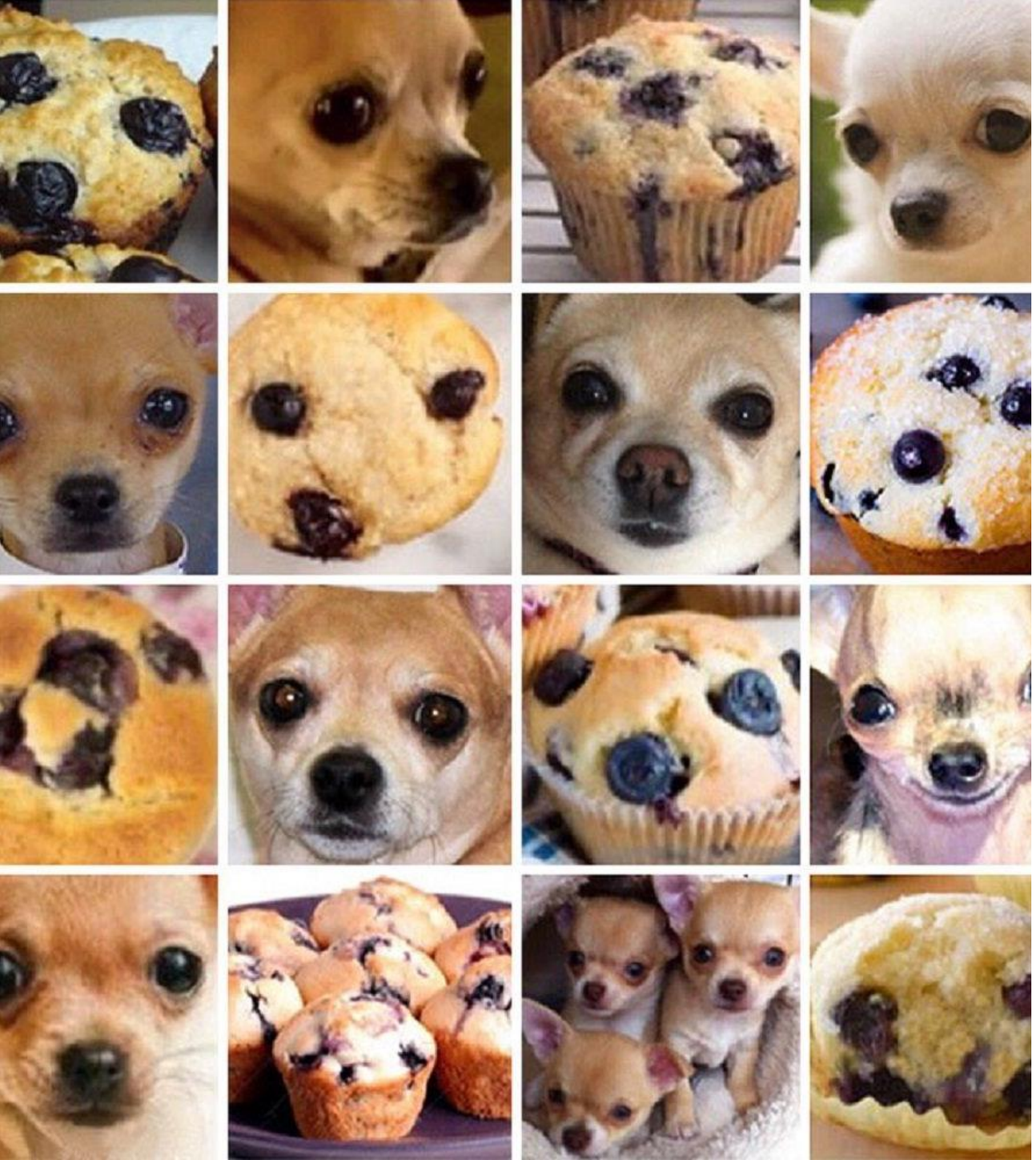

Definition of credentials

Set of data

that allows other party

to believe me

when I tell who I am

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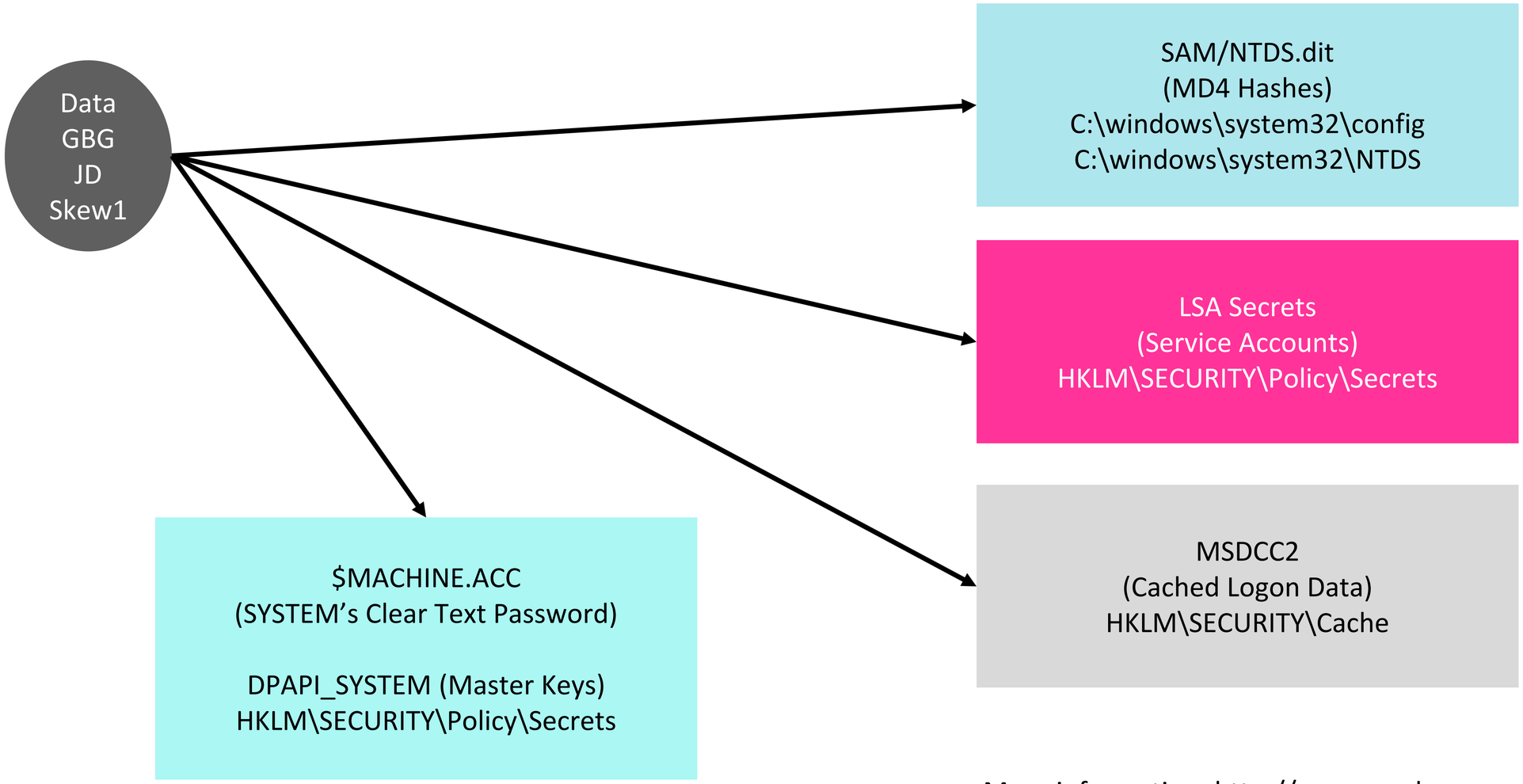
Credentials

Where are those?

- Configuration files
- Memory
- Registry
- Databases
- Network traffic
- Active Directory

Bootkey:

Class names for keys from HKLM\SYSTEM\CCS\Control\Lsa



More information: http://cqureacademy.com/blog

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Demo - Config files

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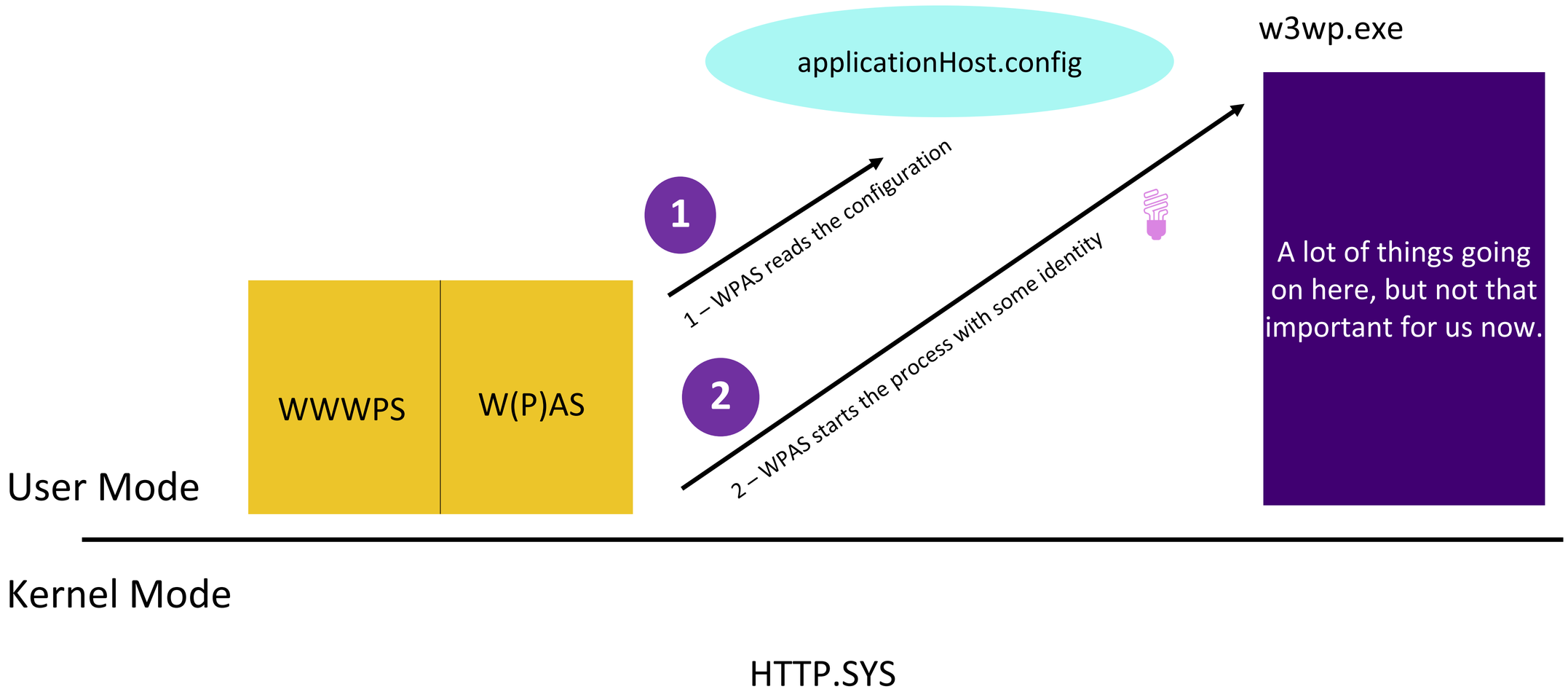
IIS Structure



Application Pools

- **Used to group one or more Web Applications**

  Purpose: Assign resources, serve as a security sandbox

- **Use Worker Processes (w3wp.exe)**

  Their identity is defined in Application Pool settings
  Process requests to the applications

- **Passwords for AppPool identity can be 'decrypted' even offline**

  They are stored in the encrypted form in applicationHost.config

Conclusion: IIS relies its security on Machine Keys (Local System)

Demo-
IIS

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Services

- **Store configuration in the registry**

  Always need some identity to run the executable!

- **Local Security Authority (LSA) Secrets**

  Must be stored locally, especially when domain credentials are used
  Can be accessed when we impersonate to Local System

- **Their accounts should be monitored**

  If you cannot use gMSA, MSA, use subscription for svc_ accounts (naming convention)

Conclusion: Think twice before using an Administrative account, use gMSA

Demo-Services

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Chasing the obvious: NTDS.DIT, SAM

To perform an analysis on NTDS.DIT you need to steal from the domain controller:

- ✓ NTDS.DIT
- ✓ Registry hives (at least the SYSTEM hive)

SAM, ntds.dit are stored locally on the server's drive

They do not contain Passwords

They use MD4 as a way of storing them

They are encrypted

The above means: **To read the clear text password you need to struggle!**

Demo-
SAM/NTDS.dit

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Are ‘cached credentials’ safe?

Cached Credentials

Encrypted Cached Credentials

DK = PBKDF2(PRF, Password, Salt, c, dkLen)

Microsoft’s implementation: MSDCC2=

PBKDF2(HMAC-SHA1, DCC1, username, 10240, 16)

0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	0123456789ABCDEF
10	00	0A	00	10	00	1C	00	00	00	00	00	00	00	00	00	.....
8B	04	00	00	01	02	00	00	02	00	00	00	0A	00	18	00	‹.....
26	C7	A8	43	88	7F	D0	01	04	00	01	00	01	00	00	00	&Ç¨Cˆ.Ð.....
01	00	0A	00	10	00	00	00	10	00	00	00	12	00	24	00	.....$.
4A	4F	26	05	63	9B	C3	22	9F	97	77	E6	B0	CD	52	BA	JO&.c›Ã"Ÿ—wæ°ÍR°
C0	76	14	67	D6	68	37	04	87	72	95	DC	19	6D	26	90	Àv.gÖh7.‡r•Ü.m&.
15	5C	25	C7	A8	17	05	7B	A3	D0	5C	6F	3C	A7	82	4A	.\%Ç¨..{£Ð\o<§,J
52	72	D1	B6	1F	91	6B	B7	9C	D2	20	9A	1B	25	ED	A0	RrÑ¶.‘k·œÒ š.%í
68	E5	4D	3E	42	F6	C4	BA	68	A1	BD	CB	5A	73	4A	89	håM>BöÄºh¡½ËZsJ‰
07	C7	E2	C5	50	20	4E	D6	CD	02	BA	BB	E6	E9	CA	F0	.ÇâÅP NÖÍ.º»æéÊð
8C	17	4E	CF	60	F7	90	D3	37	FB	30	4B	C3	95	B7	02	Œ.NÏ`÷.Ó7û0KÃ•·.
D6	38	75	63	D2	0F	15	AD	3A	C4	32	53	D5	8B	66	7D	Ö8ucÒ..-:Ä2SÕ‹f}
9D	FB	5D	AA	30	7E	B7	A5	F5	9B	57	32	D9	47	EE	EE	.û]ª0~·¥õ›W2ÙGîî
5C	07	6C	3B	64	78	A7	B1	78	C2	EA	F5	98	A8	CB	B1	\.l;dx§±xÂêõ˜¨Ë±
DD	34	92	00	93	9F	65	9D	38	E7	7B	F9	69	53	97	50	Ý4’.“Ÿe.8ç{ùiS—P
CB	82	49	38	CF	B4	CA	F9	4B	EB	D8	8E	4C	D4	6D	CE	Ë‚I8Ï´ÊùKëØŽLÔmÎ
09	7E	6F	F6	65	49	C6	9F	61	8D	4A	16	24	3A	40	CB	.~oöeIÆŸa.J.$:@Ë
CC	3C	D8	FD	FC	91	6B	E5	84	5E	68	9C	69	D7	B4	FD	Ì<Øýü‘kå„^hœi×´ý
62	44	8D	23	E8	0A	1E	BE	BB	34	EB	81	23	FE	E3	0E	bD.#è..¾»4ë.#þã.
76	55	9E	63	9E	DE	57	DC	0C	60	BE	A8	53	AF	BD	AA	vUžcžÞWÜ.`¾¨S¯½ª
AB	3F	ED	7A	EE	B4	62	50	EC	E1	B8	B1	8F	9E	A6	2B	«?ízî´bPìá¸±.ž¦+
9B	85	71	63	D9	6C	66	09	C2	70	DC	63	E6	22	E8	08	›…qcÙlf.ÂpÜcæ"è.
A4	55	5F	36	C2	64	1E	2B	B8	80	6A	A5	AC	17	92	41	¤U_6Âd.+¸€j¥¬.’A
3C	21	2E	DF	CC	EA	75	9E	99	31	C4	D6	8C	AF	C7	04	<!.ßÌêuž™1ÄÖŒ¯Ç.

Encrypted Cached Credentials: Legend

Name	Value	Start	Size	Color	Co
struct Header h		0h	96	Fg: Bg:	
ushort uname_len	16	0h	2	Fg: Bg:	
ushort domain_len	10	2h	2	Fg: Bg:	
ushort mail_nick_len	16	4h	2	Fg: Bg:	
ushort cn_len	28	6h	2	Fg: Bg:	
ushort u1	0	8h	2	Fg: Bg:	
ushort logon_script_len	0	Ah	2	Fg: Bg:	
ushort profile_path_len	0	Ch	2	Fg: Bg:	
ushort home_dir_len	0	Eh	2	Fg: Bg:	
uint user_sid	1163	10h	4	Fg: Bg:	
uint primary_group_id	513	14h	4	Fg: Bg:	
uint u2	2	18h	4	Fg: Bg:	
ushort group_sids_len	10	1Ch	2	Fg: Bg:	
ushort domain_netbios_name...	24	1Eh	2	Fg: Bg:	
FILETIME last_local_logon	04/25/2015 18:47:22	20h	8	Fg: Bg:	
ushort u3	4	28h	2	Fg: Bg:	
ushort u4	1	2Ah	2	Fg: Bg:	
uint u5	1	2Ch	4	Fg: Bg:	
ushort u6	1	30h	2	Fg: Bg:	
ushort u7	10	32h	2	Fg: Bg:	
uint u8	16	34h	4	Fg: Bg:	
uint u9	16	38h	4	Fg: Bg:	
ushort domain_name_len	18	3Ch	2	Fg: Bg:	
ushort email_len	36	3Eh	2	Fg: Bg:	
▷ byte iv[16]	JO&|c›Ã"Ÿ—wæ°ÍR°	40h	16	Fg: Bg:	
▷ byte cksum[16]	Àv¶gÖh7‡r•Ü.m&□	50h	16	Fg: Bg:	

Cached Logons: It used to be like that...

Windows 2003 / XP

The encryption algorithm is RC4.
The hash is used to verify authentication is calculated as follows:

```
DCC1 = MD4(MD4(Unicode(password)) .
LowerUnicode(username))
is
DCC1 = MD4(hashNTLM . LowerUnicode(username))
```

Usage in attacks

Before the attacks facilitated by pass-the-hash, we can only rejoice the "salting" by the username.

There are a number pre-computed tables for users as Administrator facilitating attacks on these hashes.

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Cached Logons: Now it is like this!

Windows Vista / 2008+

The encryption algorithm is AES128.

The hash is used to verify authentication is calculated as follows:

```
MSDCC2 = PBKDF2(HMAC-SHA1, Iterations, DCC1,
LowerUnicode(username))
```

with DCC 1 calculated in the same way as for 2003 / XP.

Usage in attacks

There is actually not much of a difference with XP / 2003!
No additional salting.

PBKDF2 introduced a new variable: the number of iterations SHA1 with the same salt as before (username).

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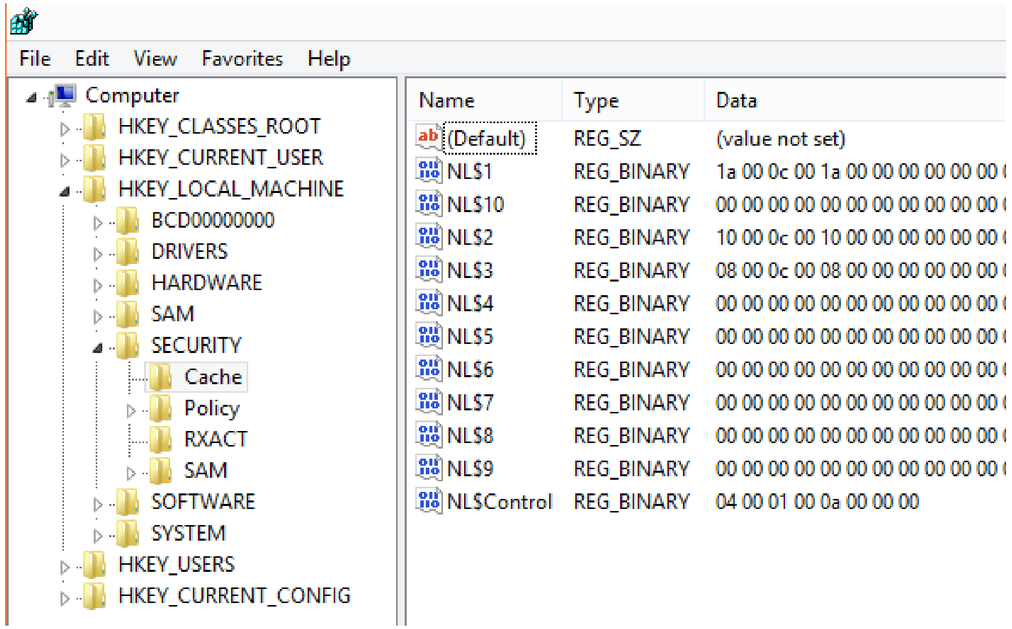
Cached Logons: Iterations

The number of iterations in PBKDF2, it is configurable through the registry:

```
HKEY_LOCAL_MACHINE\SECURITY\Cache
DWORD (32) NL$IterationCount
```

If the number is less than 10240, it is multiplied by 1024 (20 therefore gives 20480 iterations)

If the number is greater than 10240, it is the number of iterations (rounded to 1024)



Demo - Cached Creds

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Classic Data Protection API

Based on the following components:

Password, data blob, entropy

Is not prone to password resets!

Protects from outsiders when being in offline access

Effectively protects users data

Stores the password history

You need to be able to get access to some of your passwords from the past

Conclusion: **OS greatly helps us to protect secrets**

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Demo - DPAPI

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Demo - DPAPI - NG

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Ask users politely?

Credentials Security Takeways

Offline access

Cryptography that relies on keys stored in the registry is as safe as your offline access.

Domain Admins

We all know that they should log on to the Domain Controllers only.
Who are they? Can we trust them?

Mechanisms are safe

...when extracted. In practice they are as safe as your approach.

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