



CRACK ME IF YOU CAN 2021

TEAM WRITE-UP

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Team Members

The following team members (20) were actively involved in CMIYC 2021:

alotdv	atom	blandyuk	Chick3nman	dropdead
EvilMog	kontrast23	kryczek	matrix	m3g9tr0n
N GHT5	philsmd	rurapenthe	The_Mechanic	T0XIC
TychoTithonus	unix-ninja	Xanadrel	xmisery	_NSAKEY

Background

Crack Me If You Can is a password-cracking contest held by KoreLogic every year at DEF CON in Las Vegas (and in uncommon cases, at DerbyCon instead of DEF CON). The contest involves various tasks related to cracking passwords that have been obtained from many different (artificial) sources. These passwords are hashed using industry-standard algorithms of various difficulty and may or may not include salts.

Team Hashcat competed in this year's CMIYC under its common name of Team Hashcat.

Team Information & Planning

The competition ran from 10 AM Las Vegas Time 6th August 2021 until 6 AM Las Vegas Time 8th August 2021. The competition was sponsored by KoreLogic as per previous years. Team Hashcat, being distributed in various geographic regions, used our consolidated platform for managing hashes, completed jobs and team communication.

Certain team members were on-site in LAS, while others operated from their respective locations. Contrary to previous years, we decided to switch communication primarily to Slack.



Software Stack

The following software was used in the competition by the Team:

Name	Version	Link
hashcat	6.2.3	https://hashcat.net/hashcat/
Hashtopolis	0.12.0	https://github.com/s3inlc/hashtopolis
hashcat-utils	1.9	https://github.com/hashcat/hashcat-utils
MDXfind	1.112	https://hashes.org/mdxfind.php
princeprocessor	0.22	https://github.com/hashcat/princeprocessor
maskprocessor	0.73	https://github.com/hashcat/maskprocessor
hashcat-legacy	2.0.0	https://github.com/hashcat/hashcat-legacy
impacket/secretsdump	0.9.23	https://github.com/SecureAuthCorp/impacket
DSInternals	4.4	https://github.com/MichaelGrafnetter/DSInternals
Mimikatz	2.2.0-20210729	https://github.com/gentilkiwi/mimikatz
stuff made by us during the contest	-	https://github.com/hashcat/team-hashcat/tree/main/CMIYC2021
qemu	1.4.2	https://github.com/qemu/qemu
vbox	6.1	https://www.virtualbox.org/
autopsy	4.19.0	https://github.com/sleuthkit/autopsy
LC	-	
Google Sheets	-	

Team Hashcat

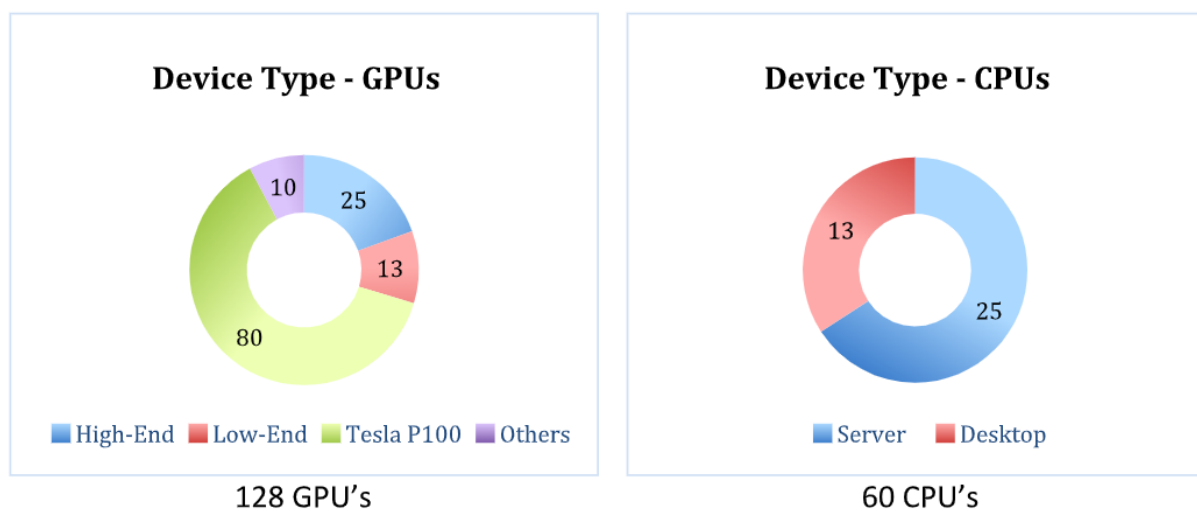
Please direct any questions or comments to hashcat discord



Hardware Stack

Keep in mind that in general all of our team members used just their normal hardware since this particular contest made it really hard to keep the hardware actually busy. So don't get discouraged by this quite modest list, **everybody can do it**.

The following hardware was used in the competition by the Team:



The Competition

The start of the competition

Korelogic decided to throw a curveball this year by not providing hashlists directly, but instead providing an OVA image containing a Windows Server 2019 VM enabled as an Active Directory domain controller.

To make working with the VM hard, Korelogic decided to booby trap it with various things like automatic shutdowns, calling back to KL (if networking was enabled), replacing various menu entries with garbage, etc.

From our side, extract hashes were easy; after import the OVA into VMware we mount the vmdk disk.

DEFCON

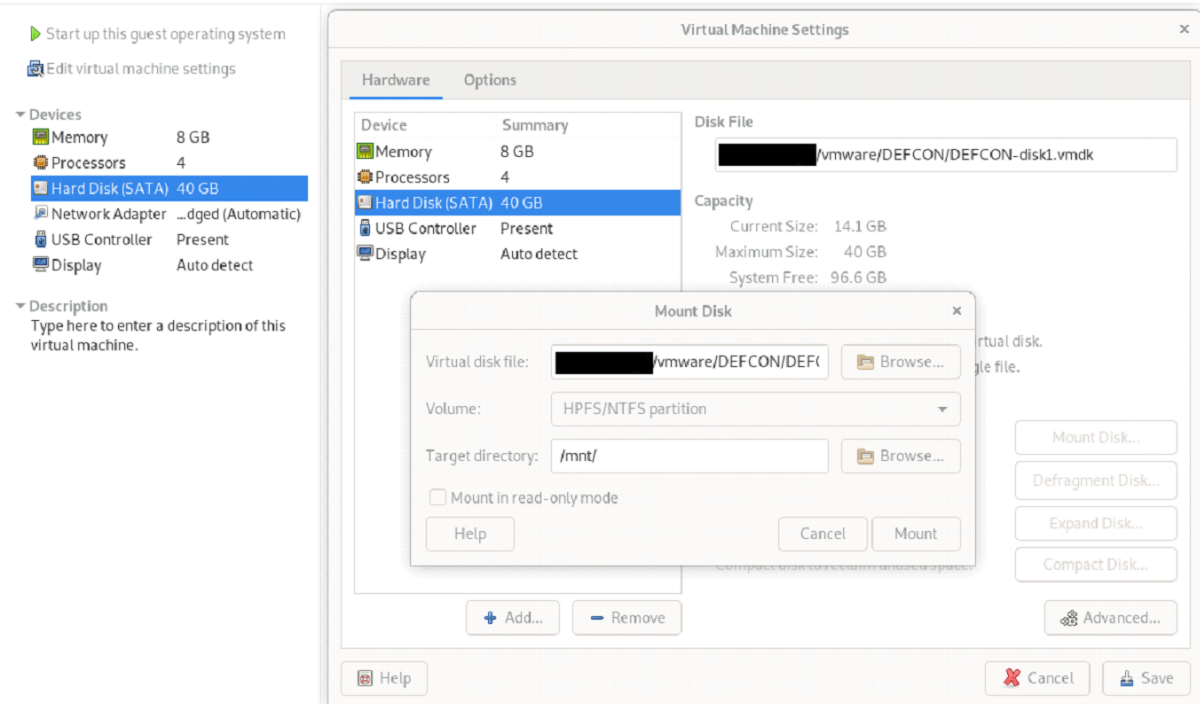


Figure 1 - vmdk mount

Next we make a copy of SAM, SECURITY, SYSTEM and NTDS.dit files and then we use secretdump from Impacket to perform extractions of local and domain hashes.

```
$ cp -avf /mnt/Windows/System32/config/{SAM,SECURITY,SYSTEM} /tmp/  
'/mnt/Windows/System32/config/SAM' -> '/tmp/SAM'  
'/mnt/Windows/System32/config/SECURITY' -> '/tmp/SECURITY'  
'/mnt/Windows/System32/config/SYSTEM' -> '/tmp/SYSTEM'  
$ cp -avf /mnt/Windows/NTDS/ntds.dit /tmp/  
'/mnt/Windows/NTDS/ntds.dit' -> '/tmp/ntds.dit'
```

Figure 2 - extract SAM, SECURITY, SYSTEM and NTDS.dit from vmdk



```
$ secretsdump.py -sam /tmp/SAM -security /tmp/SECURITY -system /tmp/SYSTEM local
Impacket v0.9.23 - Copyright 2021 SecureAuth Corporation

[*] Target system bootKey: 0x6b24968ebc57b36af26458acf985c664
[*] Dumping local SAM hashes (uid:rid:lmhash:nthash)
Administrator:500:aad3b435b51404eeaad3b435b51404ee:3d76c152728d6cbb3e1ac6fa7928c898:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
DefaultAccount:503:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
[-] SAM hashes extraction for user WDAGUtilityAccount failed. The account doesn't have hash information.
[*] Dumping cached domain logon information (domain/username:hash)
[*] Dumping LSA Secrets
[*] $MACHINE.ACC
$MACHINE.ACC:plain_password_hex:de64f631d5d4d15a37f5cb2c9b956fadb477fc3a423e73c5d89a13d69e1161938ed4dca7ff
ca3bc585095a51decbf76fb4d47cc72d7413ce049fc7c0e4f4f11c3c78eea4ed0c6d9303bf1bc08cabbac7c45b392752c93f7b564a
00f9c067c6ac3b3d9359b3b2ecc8c0b3c5faf6a471bb73f3e40250ec9e07a8a1219e66664ed7505fface802b95f23d7ef610a7b1fc
ba8453672cbc1943f3cc37858c7a84b2dbd63d431d9db40c9bf6d93bb7c0fa287bc730cd2c9a8d7363d4aac5b03b2bf2fefec1e8c71
cad0b7dfaacc8d17860eed60a4289001e17293c955f70d17e15394c8e31658e8a3aa514fd1a01efea4b55947e
$MACHINE.ACC: aad3b435b51404eeaad3b435b51404ee:9a052586970c691ed184388c8375dbb4
[*] DPAPI SYSTEM
dpapi_machinekey:0xabbbde825e2df8720a770be831eea1482b7f74c93
dpapi_userkey:0x485662536ea32fd2842a2a821a532f1110785dbf
[*] NL$KM
0000 1D 79 27 44 50 DD BA A9 B1 BF C4 7B C5 7F 70 78 .y'DP.....{..px
0010 C9 C6 37 DE B8 15 DA 00 DE 93 2D 2E 89 9C B6 D8 ..7.....
0020 DD E3 17 68 7C 46 58 C8 A3 58 5E D3 D6 75 06 2E ...h|FX..X^..u..
0030 E8 39 FC C2 67 40 B2 56 80 D9 86 67 CE DF 4F E8 .9..g@.V...g..0.
NL$KM:1d79274450ddbba9b1bfc47bc57f7078c9c637deb815da00de932d2e899cb6d8dde317687c4658c8a3585ed3d675062ee839
fcc26740b25680d98667cedf4fe8
[*] Cleaning up...
```

Figure 3 - retrieve local hashes with impacket/secretsdump

```
$ secretsdump.py -ntds /tmp/ntds.dit -system /tmp/SYSTEM -hashes lmhash:nthash -history -outputfile /tmp/c
miyc-2021-domain-hashes local
Impacket v0.9.23 - Copyright 2021 SecureAuth Corporation

[*] Target system bootKey: 0x6b24968ebc57b36af26458acf985c664
[*] Dumping Domain Credentials (domain\uid:rid:lmhash:nthash)
[*] Searching for pekList, be patient
[*] PEK # 0 found and decrypted: 7e1bb9c7e3ade3ab1fa459ac0557aac
[*] Reading and decrypting hashes from /tmp/ntds.dit
Administrator:500:aad3b435b51404eeaad3b435b51404ee:d07380d54e3ba6dfc61521fc7e8556b8:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
WIN-LF82DBTHTRA$:1000:aad3b435b51404eeaad3b435b51404ee:9a052586970c691ed184388c8375dbb4:::
krbtgt:502:aad3b435b51404eeaad3b435b51404ee:42a0648655a9037a87bc0562e96b958a:::
krbtgt_history0:502:aad3b435b51404eeaad3b435b51404ee:b5ca59b606a13445af2043409d2c0086:::
CLIENT01$:1102:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
1109671212$:1103:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
305544428$:1104:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
1328328851$:1105:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
96417225$:1106:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
dpapi_machinekey:0xabbbde825e2df8720a770be831eea1482b7f74c93
dpapi_userkey:0x485662536ea32fd2842a2a821a532f1110785dbf
```

Figure 4 - retrieve domain hashes with impacket/secretsdump

During the full extraction of domain hashes, we successfully cracking the local admin password and then the domain one. With these passwords we are able to login to Windows, and found the “plaintexts” :)

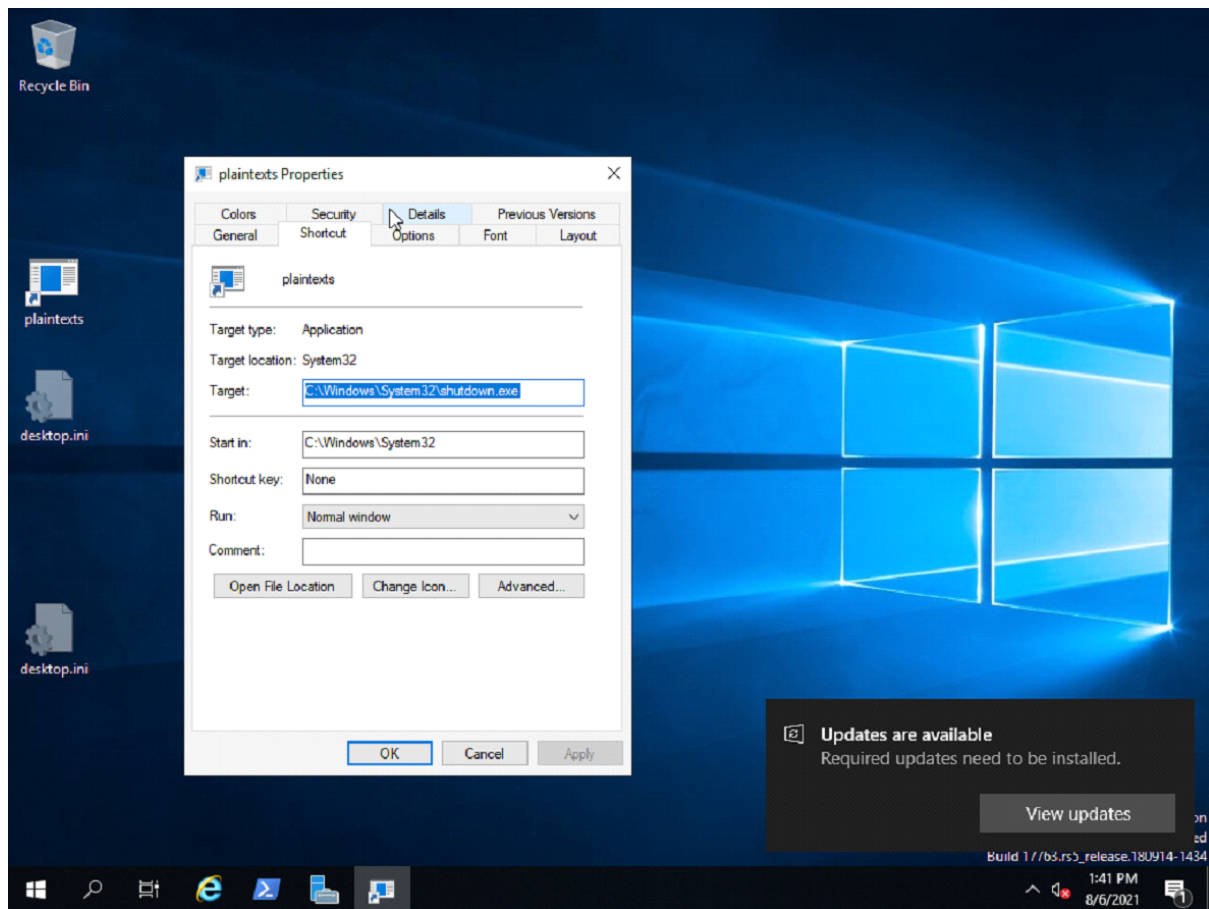


Figure 5 - plaintexts Properties

We proceed first by remove Windows Defender using Server Manager (from Manage/Remove Roles and Features) to disable Antivirus real-time protection. (Optionally just disable the protection.)

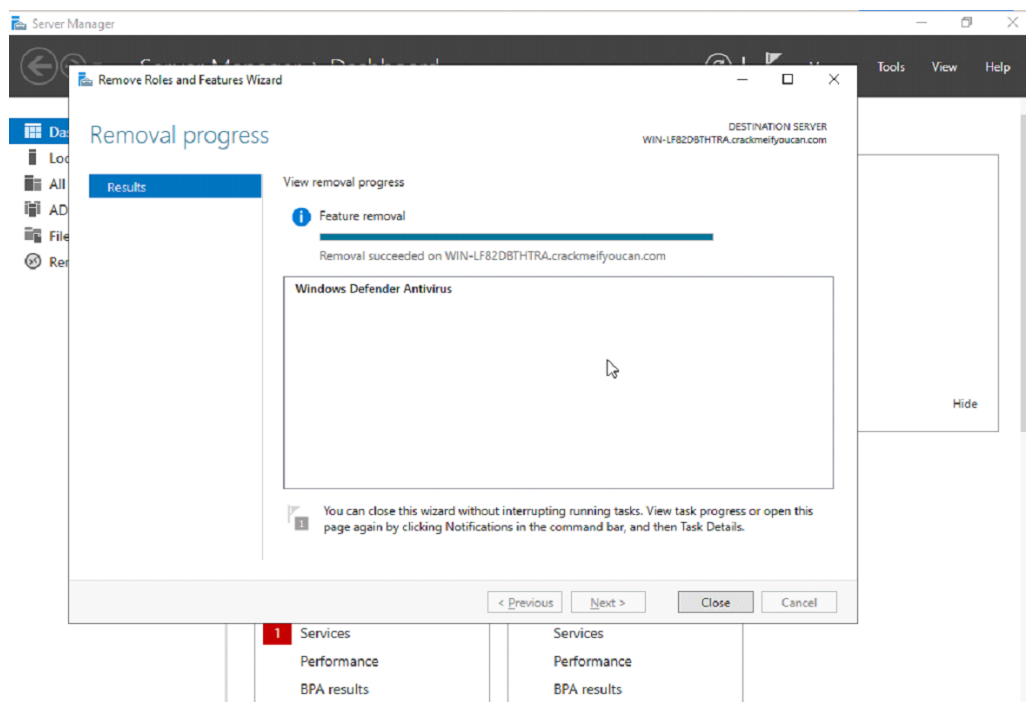


Figure 6 - remove Windows Defender Antivirus

Then we connect a USB drive to VM and we are able to run mimikatz. In that way we are able to extract some others/related info useful to perform future analysis/attacks.

```
Administrator: C:\Windows\System32\cmd.exe

D:\mimikatz_trunk\x64>mimikatz.exe

#####  mimikatz 2.2.0 (x64) #19041 Jul 29 2021 11:16:51
## ^ ##.  "A La Vie, A L'Amour" - (oe.eo)
## / \ ##  /** Benjamin DELPY `gentilkiwi` ( benjamin@gentilkiwi.com )
## \ / ##   > https://blog.gentilkiwi.com/mimikatz
'## v ##'   Vincent LE TOUX ( vincent.letoux@gmail.com )
'#####'   > https://pingcastle.com / https://mysmartlogon.com **/

mimikatz # log cmiyc-2021-mimikatz.log
Using 'cmiyc-2021-mimikatz.log' for logfile : OK

mimikatz # privilege::debug
Privilege '20' OK

mimikatz # lsadump::lsa /inject
Domain : CRACKMEIFYOUCAN / S-1-5-21-2081535704-4210724908-3814002959

RID : 000001f4 (500)
User : Administrator

* Primary
  NTLM : d07380d54e3ba6dfc61521fc7e8556b8
  LM :
  Hash NTLM: d07380d54e3ba6dfc61521fc7e8556b8

* Kerberos
  Default Salt : WIN-LF82DBTHTRAAdministrator
  Credentials
    des_cbc_md5 : 9e5eedf646b616d

* Kerberos-Newer-Keys
  Default Salt : WIN-LF82DBTHTRAAdministrator
  Default Iterations : 4096
  Credentials
    aes256_hmac (4096) : 6850f7b8d50a1e01204cc7e0c2d82c174437a924c2554fe4d7d9934c2890cccd
    aes128_hmac (4096) : c486f6eac45c37a754530d696226dc2d
    des_cbc_md5 (4096) : 9e5eedf646b616d

* NTLM-Strong-NTOWF
  Random Value : c2de42502a3103b50aa50b6eee551c5a
```




Figure 7 - retrieve credentials using lsadump with mimikatz

Notes:

- to use a USB drive we had to set "USB Compatibility" to "USB 3.1" in the VM settings on VMware
- Windows server shutdown every hour due to license expired. We fix this using Powershell: "slmgr -dlv" and "slmgr -rearm"

To make sure about all hashes was extracted, we use DSInternals Get-ADDBAccount powershell script to dump again the NTDS.dit, after repairing it using "esentutil".

```
Administrator: Command Prompt - powershell
Created:
Modified:

Reading accounts from AD database
184701+ accounts

Guid: e8d03056-15c0-4d66-8986-47d799fa37ee
SamAccountName: User_99486313
SamAccountType: User
UserPrincipalName:
PrimaryGroupId: 513
SidHistory:
Enabled: True
UserAccountControl: NormalAccount
AdminCount: False
Deleted: False
LastLogonDate:
DisplayName:
GivenName:
Surname:
Description:
ServicePrincipalName:
SecurityDescriptor: DiscretionaryAclPresent, SystemAclPresent, DiscretionaryAclAutoInherited, SystemAclAutoInherited, SelfRelative
Owner: S-1-5-21-2081535704-4210724908-3814002959-512
Secrets
NTHash: d93cdd92c2e9d60fc0288605c032800c
LMHash:
NTHashHistory:
Hash 01: d93cdd92c2e9d60fc0288605c032800c
Hash 02: bc7375ab6b5153cf9d65aaf75fac8ded
Hash 03: 89f417d2e08672f42d12fc272c763bac
Hash 04: 0073314ea795716982068ed9add52d36
Hash 05: 3c0a81fcf12aaf127827f31075360b2
Hash 06: 9f84519f659df89c71eb37d77a9633b2
Hash 07: 1f973171f59094a313d936fcb451b800
LMHashHistory:
Hash 01: 8c60dab93bd6f64ce560b4aea89c6306
Hash 02: ec7aa971b203a8f2ed57cb85e4ce657f
Hash 03: 344d1d4deebfb3bc32d8e69f1d1970d
Hash 04: 5c3d92b72ea9ce4b63aad0f214a901c8
Hash 05: 970639891ec71c30dc3e87e2bc31b739
Hash 06: 932f890e35a11f55030b6940009bf177
```

Figure 8 - dump accounts with secret attributes from AD using DSInternals Get-ADDBAccount

We are using filter to retrieve only have the user objects (remove the computer objects). This helped to also get the "Description" field with passwords in clear text.



```
1090558 DistinguishedName: CN=Training-1972,CN=Users,DC=crackmeifyoucan,DC=com
1090559 Sid: S-1-5-21-2081535704-4210724908-3814002959-771072
1090560 Guid: bbl9af8d-8323-4e82-ad85-70ca61858f1b
1090561 SamAccountName: Training-1972
1090562 SamAccountType: User
1090563 UserPrincipalName:
1090564 PrimaryGroupId: 513
1090565 SidHistory:
1090566 Enabled: True
1090567 UserAccountControl: NormalAccount
1090568 AdminCount: False
1090569 Deleted: False
1090570 LastLogonDate: 8/3/2021 9:44:40 PM
1090571 DisplayName:
1090572 GivenName:
1090573 Surname:
1090574 Description: Password_is_cruEGsgdlhWX
1090575 ServicePrincipalName:
1090576 SecurityDescriptor: DiscretionaryAclPresent, SystemAclPresent, DiscretionaryAclAutoInherited, SystemAclAutoInherited,
1090577 SelfRelative
1090578 Owner: S-1-5-21-2081535704-4210724908-3814002959-512
1090579 Secrets
1090580 NTHash: 4afad6e9d4b58980e1d980b34f530a8b
1090581 LMHash:
1090582 NTHashHistory:
1090583 Hash 01: 4afad6e9d4b58980e1d980b34f530a8b
1090584 LMHashHistory:
1090585 Hash 01: fd92acd84cb8257e57007adf6e8e14c4
```

Figure 9 - extract Training's user password from DSInternals / Get-ADDBAccount dump

These passwords have been extracted also using strings from linux, as shown below.

```
$ strings -el /tmp/ntds.dit | grep -i password | tac
Password_is_HXMV0YzeKfth
Password_is_N6HRGpBjChGk
Password_is_8Cp4YHQhaGdI
Password_is_3fvqv4guq3UG
Password_is_DhD4TAXb8Gcp
Password_is_jMmLfildtTZG
Password_is_9gzLI7LZDRrK
Password_is_DMFehgi46eiR
Password_is_ZEDnB4sCQ09a
```

Figure 10 – extracting Training's user password from ntds.dit with strings

Hashes

This year, the number of hashes in the competition were relatively small compared to previous years – but not any easier. The hashes were spread out as follows:

- NTLM hashes at ~70 000 hashes

However, during the whole contest we were not sure if these 70k were actually all of them due to Korelogic's mindfuckery

All hashes came out of the active directory with username and correlated history, with “history0” being the user’s current password, through “history6” as the oldest. This is also how Korelogic awarded points - value of the hash increasing with the complexity:.

Team Hashcat

Please direct any questions or comments to hashcat discord



history0 - 64 points
history1 - 32 points
history2 - 16 points
history3 - 8 points
history4 - 4 points
history5 - 2 points
history6 - 1 point

This led to an interesting dynamic, since the oldest (and lowest scoring) hashes needed to be cracked first to extract the information necessary to progress to the newer ones.

Unsurprisingly, History6 list did not give us any trouble. We basically managed to crack almost all of them instantly with standard attacks like rockyou+rules. The same goes for History5.

As a side note, the initial few hours were especially chaotic due to Korelogic releasing the lists for history6 and history5 in the first couple of hours, which forced us to double-check whether our lists were correct. So good job on introducing another layer of chaos, @KL :P

At the same time, History4 was slowly being cracked - by iterating over the founds from history6 and history5, using additional rules and hybrid attacks as patterns emerged.

History3 was the first layer that began to give us more of a challenge. At this point in the contest, it was clear that the same process demonstrated in the test hashes (released prior to the contest) was used on the contest hashes as well and that every “newer” layer (history 2, 1 and 0) were based on further manipulations of previous founds, either directly (additional rules applied to the preceding found) or indirectly (general thematic trends per user).

At this point, we began a Google spreadsheet tab to correlate the cracks we have against the users from where they came.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	
	User	Type	ID	Jeafrec	Current.found	H5.found	H5.found	H5.found	H5.found	H5.found	H5.found	H5.found	H5.found	Cracks	Value	Source?
265	User_11617936	User	11617936	8												
266	User_11617936	User	11617936	8	1533 did wily right in	these led way right in	wisdom i have	THL STAR47	Untraced2	MCOnPdy2	Neathir			4	0	gamez
267	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	bbia
268	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
269	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
270	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
271	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
272	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
273	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
274	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
275	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
276	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
277	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
278	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
279	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
280	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
281	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
282	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
283	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
284	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
285	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
286	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
287	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
288	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
289	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
290	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
291	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
292	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
293	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
294	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
295	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
296	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
297	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
298	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
299	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
300	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
301	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
302	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
303	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
304	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
305	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
306	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
307	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
308	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
309	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
310	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
311	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
312	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
313	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
314	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
315	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
316	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
317	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
318	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
319	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
320	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
321	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
322	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
323	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
324	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
325	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
326	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
327	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
328	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
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331	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
332	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
333	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
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342	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
343	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
344	User_11617936	User	11617936	8	06338mE3E38	39mO6v3m385	way of wisdom	Faj06**	i-djast	eyuorova	analo			6	0	borjot
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From that initial correlation tab, we began to identify different groups (or themes) that the plains were based on. As the groups became clear and new cracks became available, we began to iteratively repopulate the spreadsheet for central reference. Using a perl script that we wrote on the fly on Saturday, we analyzed each user on a per-crack basis, and applied a heuristic to make a cumulative “best guess” as to which password group that user belonged to. For example, if three passwords for a given user contained number words like “billion” and “sixty”, then that user received a “numberword” score of 3. The largest score was then used to “vote” for the “best” category for that user. There were some false positives due to certain substrings being used at first (with “two” being one of the more problematic, so it was eventually omitted), but the heuristic, while simple, was generally pretty reliable - and got increasingly more reliable as more cracks arrived and with some additional tuning. The resulting labels allowed any member who wanted to attack or study a specific group to filter on just that group, reducing the noise of unrelated cracks and allowing natural pattern recognition “by sight” to be much more efficient.

The identified groups were initially tagged as follows (though some of them ended up being slightly inaccurate, they were still useful for filtering the target hashes):

bible	bonjovi	ferengi	games	song	numberword
contest	latinloc	password	h2stem	training	website

We are going to refer to these groups from here on out.

KJV Bible

This group identified itself by having a history6 and history5 crack to a name plus a number which turned out to be psalms of the bible. To move up a step to history4, we needed first to crack using a couple of standard methods. Once we had a couple of examples, we could correlate the psalms and identify that the plain is a word from the psalm. So far, so good - but what about history3 and above? There it started to get a bit tricky. For a while nothing worked, but with some endurance, we managed to crack a couple of the history3 to find that those turned out to be 3 words from the psalm. Once identified, extracting those 3-word phrases from a sourced KJV bible could be done with a simple script. (1250 total cracks) From here, going to history2 was another layer of complexity which proved to be challenging at first. Finding the first cracks took quite a while, but by random chance we found a few that turned out to be similar words but different. After further analysis and tests the revelation was that those crack to 3-5 words from the psalm, seamlng random in order but we knew at this point where this was heading. At this point, we had an idea but feared that the potential keyspace (if you permuted every combination of words from every psalm for a particular user) was quite high - and labor intensive. The solution was to automate - first parts of it, then everything.



The first iteration was a perl script that converted a psalm into a hashcat-legacy table attack. By adding some additional modifiers to hashcat, it also gave us the first cracks of history0 - which turned out to be exactly the same text as history1 but with leetspeak.

its closing time -> 1+5 c!051ng +1m3

Knowing this we started another iteration of the attack.

The second iteration was to exchange hashcat-legacy with the freshly created tool "simple-table" that atom prepared before the contest (because of the test hashes) which looked like this:

```
cat rawphrase.txt | tr ' ' '\n' | sort -u | sed -e 's/^/1\t/' | sort -u > table;
cat table.add >> table;
perl simple_table.pl template table | hashcat -m 1000 all.left -r base.rule -r
leetspeak.rule --username -o current.out
```

Additionally we created a base.rule which contained overall modifiers that we found could be used - like removing the character "j" and leetspeak.rule which contained the identified leetspeak-conversions.

leetspeak.rule

```
sa@sc<se3si1so0ss$sh5sv^sl!st+
sa4sc<se3si1so0ss$sh5sv^sl!st+
sa@sc<se3si1so0ss5sv^sl!st+
sa4sc<se3si1so0ss5sv^sl!st+
sh5 so0 se3 sa@
sh5 so0 se3
sh5 so0
sh5
so0 se3 sa@
se3 sa@
sa@
so0 se3
sh5 so0 sa@
sh5 se3 sa@
sh5 sa@
st+
sh5 so0 se3 sa@ st+ sv^
sh5 so0 se3 st+
sh5 so0 st+
sh5 st+
so0 se3 sa@ st+
se3 sa@ st+
sa@ st+
so0 se3 st+
sh5 so0 sa@ st+
sh5 se3l sa@ st+
```



Continuing the attack with the second iteration was working, but still not very efficient - due to the effort required in precisely identifying the psalm. And depending on the word count in the psalm, the very large keyspace that the attack need to go through to find both plains for history1 and history0.

Further iterations:

permute3.c	Tool version 3 for applying permutation attacks like permute.c from hashcat-utils, but not for individual letters of passwords, but for words
splitter.pl	Extract 5/N random words for a Bible psalm The speed of word generation is around 22 MW/s per thread \$ time ./permute < 100.txt head -1000000000 > /dev/null real 0m45.005s The speed drops to 1.5 MH / s due to parsing, expanding, compressing and finally hashing The total key space of all 5 word permutations from all KJV psalms (with our reference database and without uniqueness) is 1,617,781,809,660 Then 1617781809660/1500000 = 1078521 seconds = 300 hours = too much
minintlm3.c	As a solution to this, we had to improve the I/O time so that we could achieve 22 MH/s instead of 1.5 MH/s. The result is a standalone NTLM cracker, threadless, only CPU, but very light, so it can execute N many instances. Why not use Hashcat? The splitter.pl script was too slow to generate enough candidate passwords quickly enough while running on a single instance. Hence, we need to run multiple instances of it. But multiple instances of Hashcat put a heavy load on the system. So why not use jtr/mdxfind? Both do not support NTLM with password candidates > length 27, which was very often the case with the KJV challenge. The three tools are chained as follows: \$ splitter.pl kjv_all.txt ./permute3 ./minintlm history0_hashes.txt
history0.c	A tool developed after we had some success with the above chains, but works more efficiently. It combines permute3 and minintlm and also does a unique sorting of the words per psalm to further reduce the number of combinations. It now contains essentially all of the relevant code to write a simple password cracker. We've added some comments so that anyone interested in how a password cracker is built can easily learn from it. Of course, this doesn't include deep tweaks, threading, or writing crypto-primitives as the goal was to keep it simple
bla2.sh	Simple script that is run N times history0 to make full use of all CPU resources. It divides the workload among the threads by using the hashcat-utils' gate.bin utility. For example, my computer has 16 CPU listed in /proc/cpu, so I use "gate.bin 16 0" for the first thread, "gate.bin 16 1" for the second, and so on. The same could be done in history0, but it's a good



	opportunity to show how gate.bin can help parallelize programs that don't natively support multiple threads.
--	--

Tools can be found here: <https://github.com/hashcat/team-hashcat/tree/main/CMIYC2021>

When things cleared up, we had a total of 605 cracks from history0/1.

If you are wondering how we got a good source to programmatically use as a basis for these attacks, we pulled it from the Gutenberg Project and processed it a bit. Due to copyright issues, we can not do more than linking to the source:

<https://www.gutenberg.org/files/10/10-0.txt>

You cannot use this source 1:1 due to formatting issues like word wrapping. We used some regex-magic to untangle it.

Bonjovi

BON JOVI :D and variants on the word 'Obsessiveness'

Ferengi

Ferengi Rules of Acquisition (Deep Space 9), reordered, then with rules.

This group was fairly straight forward to crack. Once we had enough cracks, it was just a matter of doing a Google search with the exact number and format of how it's written to find the actual source.

History5	Number.	239.
History4	Rule #Number.	Rule #239.
History3	Word + ?d?s	mislabel1
History2	3-5 words from the rule in right order + ?d	afraid to mislabel1
History1	3-5 words from the rule random order	mislabel a product.1
History0	we didn't crack anything here	afraid be a mislabel to

(For anybody interested, after the contest was finished, we figured out the actual replace-rules to crack history0 by running the plains from history1 against a table attack with leet-table. One by one we opened them and extracted the rules: seE sl1 si: so. st% ssS sa@ sx* sg&)



Games

This group went kind meh, so here are just the notes that survived the chaos:

Games - board games, video games, card games - may even be separate subgroups	https://nintendo.fandom.com/wiki/List_of_Nintendo_games and others
APPLY SOME RULES WITH HASHCAT CPU, THEN PIPE TO GPU w/MORE RULES	lots of "game"-related ones available. download correlation tab and filter on 'game' surrounded by underscores
	strip spaces and trim at length 8

Song

Should have been divided between song lyrics and author quotes, but in practice this was very difficult to automate. In the debriefing, it was clear that KoreLogic generated these as a single group of hashes on purpose.

Cracking History5-2 was not that difficult, and mostly done by standard methods. History1 and 0 was again quite hard to get cracks but after the first few we saw a similar pattern appear as for the bible.

History6	name + \$d	Arnold1
History5	full name + \$d	Tim Arnold1
History4	word that relates to the name + \$d	would1
History3	words that relate to the name + \$d	what love would1
History2	2-3 words that relate to the name mixed with ?d?s	would want1
History1	3-5 random words that relate to the name	love want would what Ask
History0	3-5 random words that relate to the name + leetspeak	!0v3 w4n+ w0u!d wh4+ A5k

Due to the fact that we didn't manage to get a hold of a good source for either author quotes or songs to crack a lot of those, we were not able to really elaborate on the exact pattern.



Numberword

These were all based on the written forms of some different numbers, including “two”, “billion”, “sixty”, and others. Proceeding from the oldest to newest was straightforward, appending numbers, extending length, and applying rules.

contest

DEF CON, Vegas, Ballys, etc etc etc

Latinloc

These were locations in Latin America, including estados in Mexico, departments in Bolivia, and others.

Password

Passwords regularly based on the word ‘password’, but also a mashup of general password strategies. May be based on RockYou or some other corpus. This group is probably what the KL outbriefing referred to as the “intern-generated” hashes.

h2stem

h2 column has the stem word - always [word]2020 or 2021, with optional single special

Training

The plains found within the VM.

powershell: repair with “esentutil” dump with dsinternals (directory services internals) + filter to only have the user objects (remove the computer objets) + convert from UTF-16 to UTF-8. The easiest way to extract the passwords was using “strings -e l” and then grep “PASSWORD_IS” on the output.

Website

Did not crack any - this puzzle totally escaped us. The information required had to be pulled from other metadata associated with specific users.

After the end of the contest, we successfully extract the website’s user passwords from ntds.dit using strings :)



```
$ strings -e /tmp/ntds.dit | grep https
https://6477:3C0Zu8GkMPTVLukL@www.crackmeifyoucan.com/
https://3956:o2xSjyFAB2lJCtYe@www.crackmeifyoucan.com/
https://5272:s3fGhLQTr1LFR3bV@www.crackmeifyoucan.com/
https://3438:ty7RfMQEI4MWPTr@www.crackmeifyoucan.com/
https://20415:ZDhFzJw4CsbE35IS@www.crackmeifyoucan.com/
https://12981:ActVsIZudw83Zo8L@www.crackmeifyoucan.com/
https://18475:8jmD3o612mDRdaTy@www.crackmeifyoucan.com/
https://25033:2kA7PyyjzK2eLaVA@www.crackmeifyoucan.com/
https://3688:YwZPzPMx1GcbuQsA@www.crackmeifyoucan.com/
https://27944:UW0iz1ndixlyIfn7@www.crackmeifyoucan.com/
https://19265:c0vYKLfZ6n7CCsbU@www.crackmeifyoucan.com/
https://5499:UJ8vnB8NDWE0YXME@www.crackmeifyoucan.com/
https://747:AomfELydvMDFkB6r@www.crackmeifyoucan.com/
https://13232:ynk2VWMeUZTPq8J4@www.crackmeifyoucan.com/
https://7874:rFhzaPEL8E0NHgva@www.crackmeifyoucan.com/
https://30853:rXWt5kzB43i24rS3@www.crackmeifyoucan.com/
https://16343:XA6exIX75knm8YSG@www.crackmeifyoucan.com/
https://27425:XtGxzF0Ih22sIM00@www.crackmeifyoucan.com/
https://27463:iekNjSah0aPsAWMa@www.crackmeifyoucan.com/
https://13837:PxWGhX7KcoRyf15M@www.crackmeifyoucan.com/
https://20931:Pjt8vXb1UuULHpK0@www.crackmeifyoucan.com/
https://519:5dNcCGnf4rnpfGp3@www.crackmeifyoucan.com/
https://30073:avKUfV42VeEW91XH@www.crackmeifyoucan.com/
https://13910:WU32jTQOLzIrFCkM@www.crackmeifyoucan.com/
https://103:QbjSjeT8tJu0V2fN@www.crackmeifyoucan.com/
```

Figure 12 - extracting Website's user passwords from ntds.dit using strings

111 plaintexts useful to crack 1:1 history0 hashes, so 7104 missing points here :|

Other stuff we did

Autocrack for sleep time:

[autocrack.sh](#)

```
#!/bin/sh
while true; do
shuf -n 10 /root/dd/dict_all.dict.txt | /root/dd/smartquote.pl | sort -u | sed -e 's/^/1\t/'
> /root/dd/table
shuf -n 2 /root/dd/template.seed > /root/dd/template
```

Team Hashcat

Please direct any questions or comments to hashcat discord



```
perl /root/dd/simple_table.pl /root/dd/template /root/dd/table |  
/root/git/hashcat/hashcat -m 1000 /root/dd/all.left -g 100000 -o /root/dd/current.out  
--remove --generate-rules-func-max=30  
/root/git/hashcat/hashcat -m 1000 /root/dd/all.left /root/dd/dict_all.dict.txt -g  
100000000 -O -w3 -o /root/dd/current.out --remove --generate-rules-func-max=30  
done;
```

template.seed

```
11  
111  
1111  
11111  
1 1  
1 1 1  
1 1 1 1  
1 1 1 1 1
```

“Blind” non pattern attacks based on all cracks:

-----START-----quick and stupid sh-----

```
cat dict.txt > 1.txt  
sort dict.txt | tr -d [:punct:] | tr -d [:digit:] | uniq -ic | sort -rn | cut -b9- >> 1.txt  
sort dict.txt | tr -d [:punct:] | tr -d [:digit:] | tr [:upper:] [:lower:] | uniq -ic | sort -rn |  
cut -b9- >> 1.txt  
cat dict.txt | tr [:alpha:] "\n" >> 1.txt  
cat dict.txt | tr [:digit:] "\n" >> 1.txt  
cat dict.txt | tr [:punct:] "\n" >> 1.txt  
cat dict.txt | tr [:punct:] "\n" | tr [:digit:] "\n" >> 1.txt  
cat dict.txt | tr [:punct:] "\n" | tr [:digit:] "\n" >> 1.txt  
cat dict.txt | tr [:upper:] "\n" >> 1.txt  
cat dict.txt | tr [:lower:] "\n" >> 1.txt  
cat test.wordlist >> 1.txt  
cat anothertest.wordlist >> 1.txt  
cat 1.txt | sort | uniq -ic | sort -rn | cut -b9- > 2.txt  
cat 2.txt > 3.txt  
cat 2.txt | cut -b -3 >> 3.txt  
cat 2.txt | cut -b -4 >> 3.txt  
cat 2.txt | cut -b -5 >> 3.txt  
cat 2.txt | cut -b -6 >> 3.txt  
cat 2.txt | cut -b -7 >> 3.txt  
cat 2.txt | cut -b -8 >> 3.txt  
cat 2.txt | cut -b -9 >> 3.txt  
cat 2.txt | cut -b -10 >> 3.txt  
cat 2.txt | cut -b -11 >> 3.txt  
cat 2.txt | cut -b -12 >> 3.txt
```



```
cat 2.txt | cut -b -13 >> 3.txt
cat 2.txt | cut -b -14 >> 3.txt
cat 2.txt | cut -b -15 >> 3.txt
cat 2.txt | cut -b -16 >> 3.txt
cat 2.txt | cut -b -17 >> 3.txt
cat 2.txt | cut -b -18 >> 3.txt
cat 2.txt | cut -b -19 >> 3.txt
cat 2.txt | cut -b -20 >> 3.txt
cat 2.txt | cut -b -21 >> 3.txt
cat 2.txt | cut -b -22 >> 3.txt
cat 2.txt | cut -b -23 >> 3.txt
cat 2.txt | cut -b -24 >> 3.txt
cat 2.txt | cut -b -25 >> 3.txt
cat 2.txt | cut -b -26 >> 3.txt
cat 2.txt | cut -b -27 >> 3.txt
cat 2.txt | cut -b -28 >> 3.txt
cat 2.txt | cut -b -29 >> 3.txt
cat 2.txt | cut -b -30 >> 3.txt
sort 3.txt | uniq -ic | sort -rn | cut -b9- > 4.txt
cat 4.txt > 5.txt
cat 4.txt | tr [:upper:] [:lower:] >> 5.txt
sort 5.txt | uniq -ic | sort -rn | cut -b9- > 6.txt
cat 1p.txt >> 6.txt
sort 6.txt | uniq -ic | sort -rn | cut -b9- > wordlist.txt
-----END-----quick and stupid sh-----
```

Then run :

- -a 6 -a 7 attacks with mask like ?a?a?a?a
- -a 1 attacks | stdin with debugged rules from previous cracks
- combined rules attacks -r toggle -r debugged
- -a 1 attacks with phrases (2,3,4,5 words) and -j \$[space]



Conclusion

Team	Points	Last Change (UTC)	history0	history1	history2	history3	history4	history5	history6	Class
Hashcat	978,070	2021-08-08 16:58:51	7,497	7,538	7,913	8,687	8,722	8,710	8,634	Pro
Cynosure Prime	949,848	2021-08-08 16:57:07	6,963	7,691	8,060	8,598	8,606	8,654	8,628	Pro
HashMob.net users	831,122	2021-08-08 16:59:16	5,860	6,506	7,436	8,539	8,663	8,667	8,616	Pro
john-users	800,430	2021-08-08 16:59:50	5,849	5,926	6,882	8,400	8,332	8,600	8,622	Pro
trontastic	778,391	2021-08-08 16:59:02	5,405	6,081	6,976	8,313	8,571	8,492	8,491	Pro
1IHsxRAM7GzoM	630,694	2021-08-08 16:49:37	4,101	4,878	5,756	7,802	8,052	8,414	8,586	Pro

Figure 13 – Final Scores

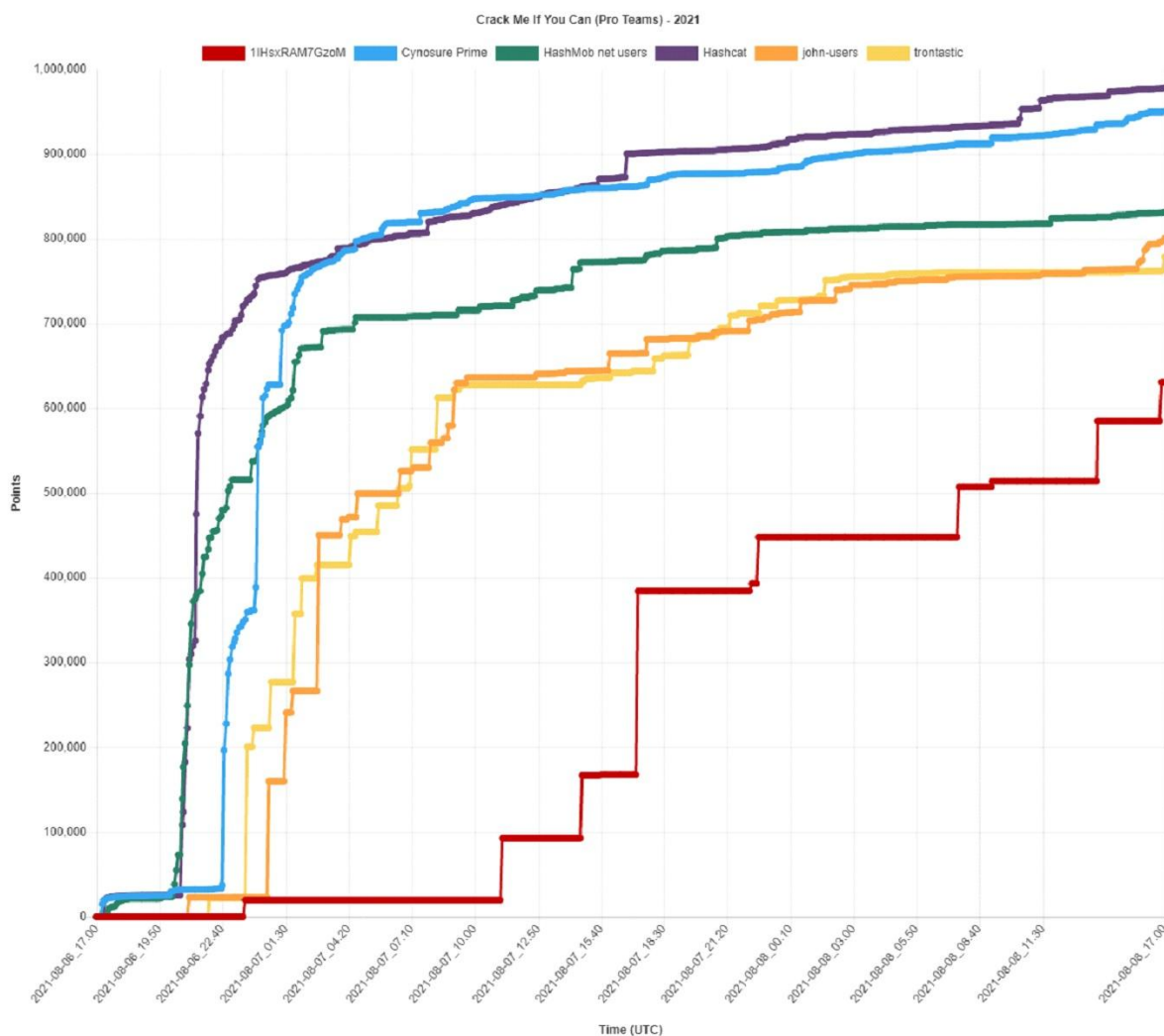


Figure 14 – Final Stats

1/10, would not bang... Besides that pretty cool 48 hours, thanks KL!



Here are some unfiltered thoughts of our team members:

evilmog: The contest was chaotic, while I liked the fact that it was only NTLM it was extremely hard to get into my groove. Most likely I'm out of practice, but my frustrations for the most part are to do with me fighting with LC and us having no clean way of exploiting our massive pile of hardware. Next year I'm just not using htp and will have to code something custom to send manual attacks out. It seems every year Minga screws with the pro teams and it's kind of lots of fun. The Pro contest take so much time to get into the groove that you miss out on the rest of defcon

matrix: I enjoyed it a lot, especially because of the VM challenge, for which some skills related to the world of security were needed.

Xanadrel: Spent first hours monitoring & fixing shit, didn't even play with the VM, didn't do much cracking, this felt like the most dull contest I ever did.

_NSAKEY: The AD stuff turned me off but I get why it was done, and a Category 4 Doom Storm at work pulled me away during the last 3 hours.

Kontrast23: interesting contest, partly over-engineered, constant impression "there must be more" but wasn't, enjoyed the hunt and development

unix-ninja: there was a lot of dissonance; communication wasn't great and there as a bit of overlapping work.

atom: The KJV challenge has been my personal favorite challenge. I had to write several small tools to get there, but for the short time it was, it wasn't too difficult. And the reward was good enough to spend most of the time on. Still, I wonder if I could do better if I took advantage of the RNG involved. But without the possibility to analyze a source or binary it is very likely I am just wasting my time.

tychotithonus: I enjoyed the novelty of working with purely fast hashes, the variety of strategies used to generate the target plaintexts, and the challenge of correlation of user password history (which I didn't have much experience with).

blandyuk: Good contest but would have liked more algos like MSSQL and maybe some phpass on a Wordpress site. This could have easily been done via a second VM. The patterns per user which got harder as the history went down was great. More complex but still based on original password. Shows users do not go far from password.

RuraPenthe: I liked the real-world scenario of a damaged or lost domain controller image we had to recover to get the hayes that Minga mixed with his usual evil ways to make us suffer.

dropdead: Loved the balance between "too hard" and "super easy" in combination with sheer willpower to break through those histories.