Cloudy with a Chance of APT

Novel Microsoft 365 Attacks in the Wild

Doug Bienstock

Josh Madeley

Doug Bienstock
@doughsec

- Incident Response Manager – 7 years @ Mandiant
- Incident Response and Red Team lead
- Author of adfsdump/spoof, pwnauth
- Lifelong Green Bay Packers fan

Josh Madeley
@MadeleyJosh

- Manager of professional services – ~6 years @ Mandiant
- Incident Response lead
- Not an author of public tools
- Canadian Ex-Pat that has adopted the Patriots as my team of choice

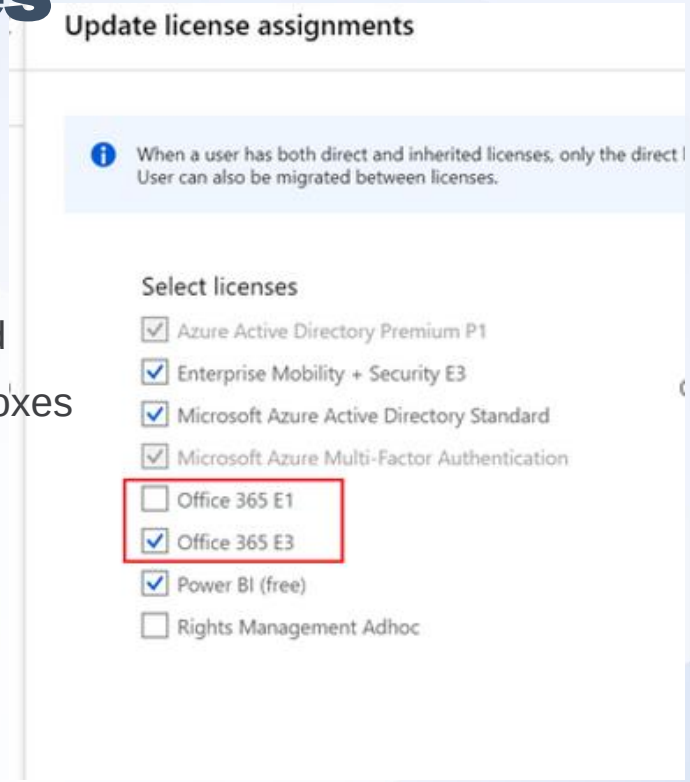
What's Going On?

- Last year demonstrated that Apex threat actors have become all stars at abusing Microsoft 365 to achieve their goals
- Large scale espionage campaigns targeted data stored within Microsoft 365
- Novel techniques used to:
  - Evade detection
  - Automate data theft
  - Persistent access beyond credential theft

Avoiding Detection

Disabling Security Features

- Bypass mailbox audit logging
  - **Set-MailboxAuditBypassAssociation**
  - The following scenarios are not logged
    - Mailbox Owner actions by specified users are not logged
    - Delegate actions performed by the users on other mailboxes
    - Admin Actions
- Downgrade licenses to E3
  - Save the target organization some money
  - Disables MailItemsAccessed logging



Mailbox Folder Permission Abuse

If it aint broke, don't fix it.

Mailbox Folder Permissions

- Alternative to Mailbox Delegation
- Mailbox owner, administrator, or an account with full access permissions can grant granular access to specific folders within a mailbox
- Part of Exchange Web Services (EWS)
- Many legitimate use cases will be seen in most environments
  - Sharing calendars
  - “Team” mailboxes
  - Assistants
- First mentioned in red team context by Black Hills in 2017 post

https://www.blackhillsinfosec.com/abusing-exchange-mailbox-permissions-mailsniper

Common Permissions

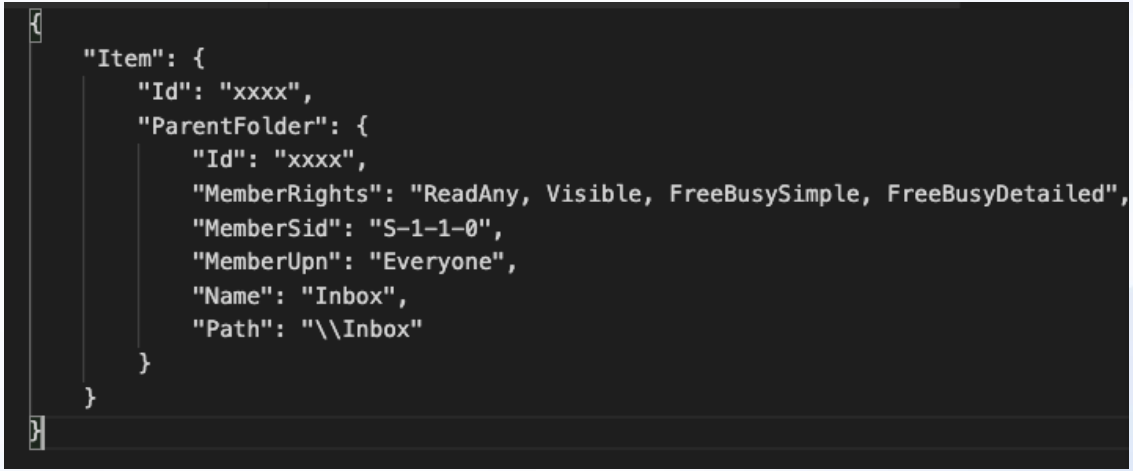
- Permissions can be assigned as individual permissions or roles
- `ReadItems` grants access to read mail items in a specific folder
- Roles that have the `ReadItems` permission
  - Author
  - Editor
  - NonEditingAuthor
  - Owner
  - PublishingEditor
  - PublishingAuthor
  - Reviewer*

Two Special Users

- Permissions can be assigned to individual users or mail-enabled security group
- Anonymous
  - Any external, unauthenticated users
- Default (aka “Everyone” in certain logs)
  - Any internal, authenticated users
- By default, the access for both special users is set to None.

Abuse

- Neat: Assign the “Default” user “Reviewer” role to allow any authenticated user access to the mailbox folder
  - Permissions do not cascade down from child to parent for existing folders, but newly created folders do inherit
  - `Set-MailboxFolderPermission` cmdlet OR EWS Managed API calls using a tool like EWSEditor



Detection

- Sign-Ins use EWS to access the modified folders and view email
  - Coded as “non-interactive” sign-ins
  - Non-existent in the Unified Audit Log and must be specifically enabled to forward to SIEM from other MSFT sources
- Unified Audit Log records `Set-MailboxPermission` events
  - There will be noise from legitimate admin and background EXO activity
- If Mail Items Accessed auditing is enabled look here
  - Throttling concerns
- Enumerate Mailbox Folder Permissions with PowerShell
  - Can be slow and should be targeted towards high value accounts

Hijacking Enterprise Applications and App Registrations

Types of Applications

- Two types of Applications
  - **App Registrations**
    - Initial instance of an application, lives in the tenant that created the app
    - Serves as a "blueprint" to create a service principal in any tenant that uses the application
  - **Enterprise Applications**
    - AKA Service Principals
    - A ”copy” of the app registration that lives in the consuming tenant
- Everything in Microsoft 365 uses this model, Microsoft Services like EXO are “first-party” Service Principals
- The term "application" is used to refer to both Enterprise Applications and App Registrations

Application Permissions

- Two types of permissions can be assigned:
  - Delegated Permissions: Enable apps to perform API operations on behalf of a user – limited to access data that user has access to. Users consent to the permissions at runtime. The application *acts as* that user.
  - Application Permissions: Enable apps to perform API operations without a signed in user and access tenant wide data. Requires Admin Consent. The application *acts as* itself
- Both App Registrations and Enterprise Applications can be assigned permissions

Secrets and Certificates

- Applications can have secrets or certificates associated with them to allow authentication *as the identity of the app*
  - Roughly analogous to API Keys
  - Applications can have multiple secrets or certificates associated with them
- Once created, they cannot be extracted from Azure AD
- Both App Registrations and Enterprise Apps can have secrets assigned to them
  - Enterprise Apps can only have secrets assigned via PowerShell

Enterprise Application Hijacking

- Attackers have modified two key components of existing applications
  - Adding new MS Graph Application Permissions, specifically `file.read` and `mail.read`
  - Adding new credentials (both secrets and certificates)
- Access tenant data remotely using the Graph API
  - Conditional Access Policies DO NOT APPLY when authenticating using app secrets
  - Service Principal sign-in logs were not available until mid-2020 and they don't show in the UAL
- There are dozens of Graph permissions to choose from
  - `Domain.ReadWrite.All` – Add a rogue IdP
  - `Directory.ReadWrite.All`

Abuse of App Registrations

- Apps can be created as multi-tenant – customers can “add an app” to their tenant
  - The App Registration is the “master copy” of the app and is linked to all Enterprise Apps in customer tenants
- If we compromise the App Registration we can access data stored in *any* tenant that has the Enterprise App copy
  - All we need is the friendly name (e.g. Microsoft.com) of the tenant we want to access
  - Good luck auditing activities that occur in someone else’s tenant
- Caveats
  - Permissions in each individual tenant may be different

Basic info | Location

App Reg Tenant

Date	7/21/2021, 1:34:28 PM
Request ID	fffe5a53-f02d-4970-a214-60a50f70ac01
Correlation ID	e6b74edd-d4cb-47ae-b1ae-f8f8eb207537
Status	Success
Application	
Application ID	6a7d585c-c340-45a6-b72e-96fc7425ba64
Resource	Microsoft Graph
Resource ID	00000003-0000-0000-c000-000000000000
Resource tenant ID	
Home tenant ID	
Service principal ID	9ddf2b4b-f989-4068-b98d-3399ca83517a
Service principal name	DoughTest

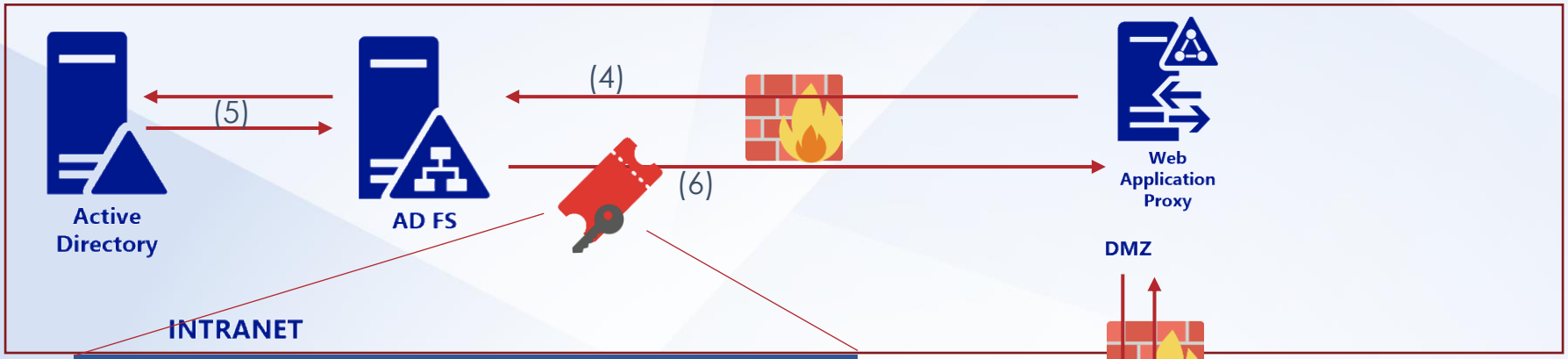
Basic info | Location

Target Tenant

Date	7/21/2021, 1:34:28 PM
Request ID	fffe5a53-f02d-4970-a214-60a50f70ac01
Correlation ID	e6b74edd-d4cb-47ae-b1ae-f8f8eb207537
Status	Success
Application	
Application ID	6a7d585c-c340-45a6-b72e-96fc7425ba64
Resource	Microsoft Graph
Resource ID	00000003-0000-0000-c000-000000000000
Resource tenant ID	
Home tenant ID	
Service principal ID	9ddf2b4b-f989-4068-b98d-3399ca83517a
Service principal name	DoughTest

MANDIANT®

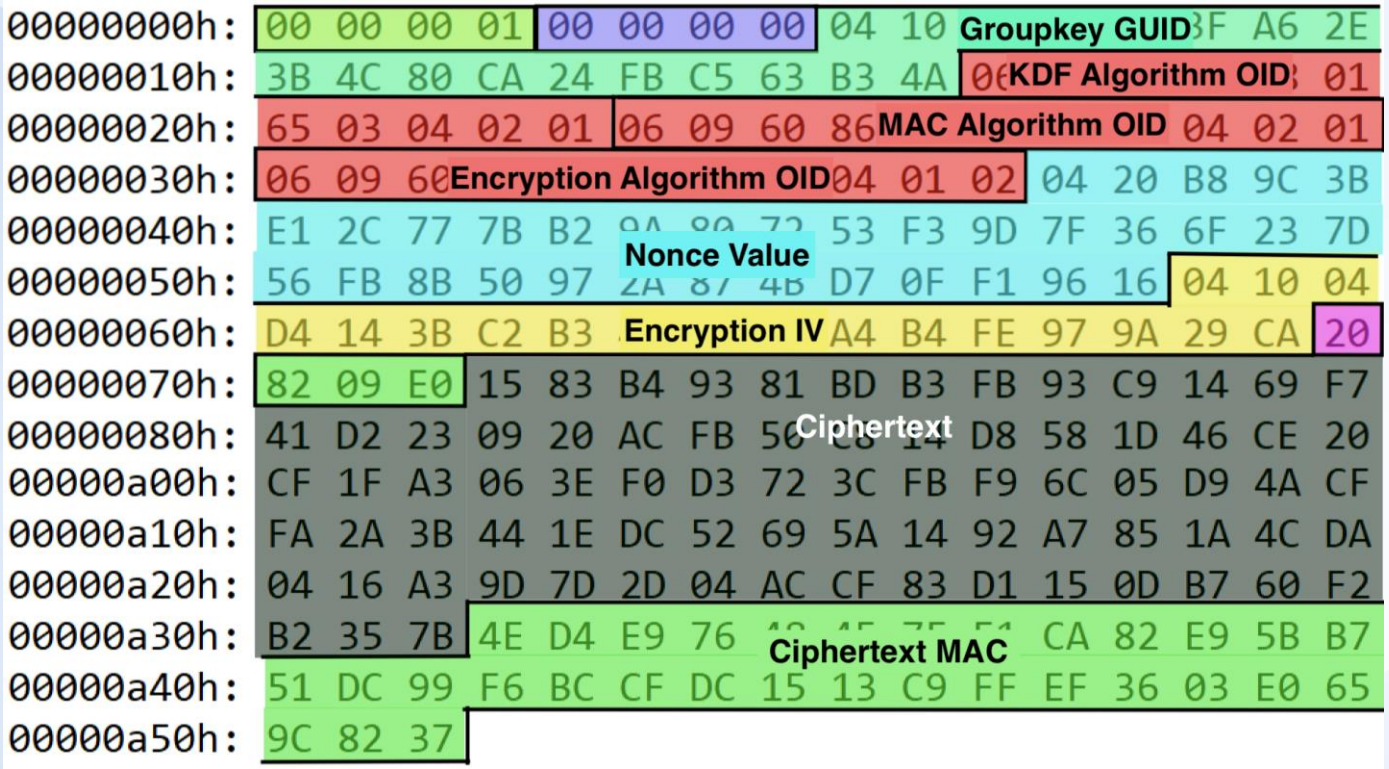
Golden SAML



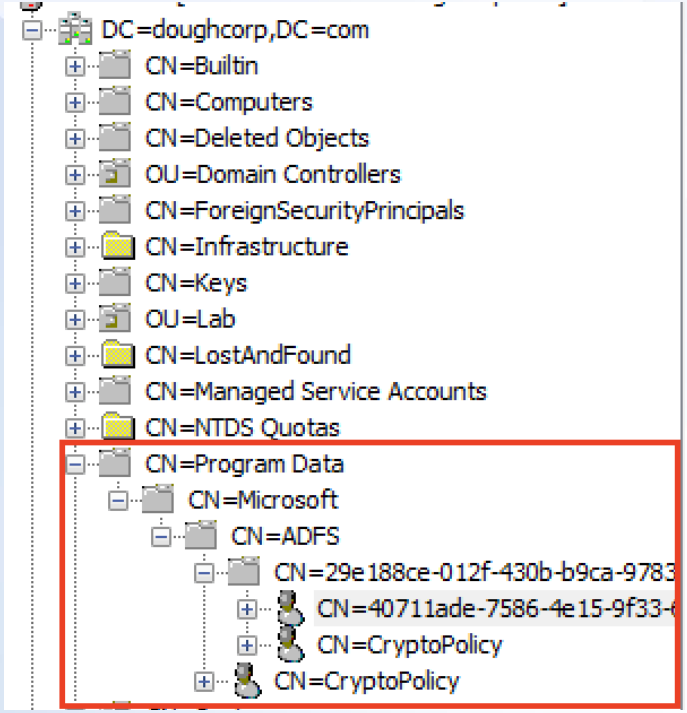

```
<t:RequestSecurityTokenResponse
xmlns:t="http://schemas.xmlsoap.org/ws/2005/02
/trust">
<saml:Assertion
xmlns:saml="urn:oasis:names:tc:SAML:1.0:assertio
n">
<saml:Attribute AttributeName="UPN"
AttributeNamespace="http://schemas.xmlsoap.
org/claims">
<saml:AttributeValue>
robin@doughcorp.co</saml:AttributeValue>
</saml:Attribute>
```

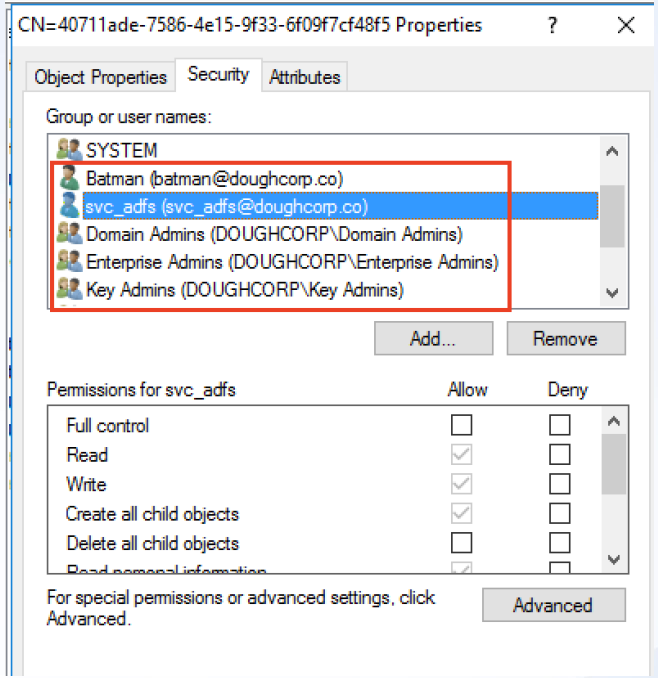
Decrypting the SigningToken

```
authEncrypt = this.DecodeProtectedBlob(cipherText);
```



DKM





Key Derivation

```
public static byte[] DeriveKeySP800_108(HMAC prf, byte[] label, byte[] context, int numberOfBytesToGenerate)
```

- DKM key is not used itself to decrypt Signing Certificate
- Used as initial input for HMAC-SHA256 Key Derivation (NIST SP 800-108)
  - Mostly, but not exactly, follows the standard (because standards are hard ;)
- Context is the Nonce decoded from blob
- Label is the OIDs of the encryption algorithms decoded from blob
- Outputs keys to use for AES encryption as well as SHA256 HMAC for verification of ciphertext

Are we there yet?

- Claims issuance rules
  - Determines the claims that will be included in the issued SAML token
  - Order of rules matters
  - Defenders **cannot** see the claims that are put in the token BUT
    - MSFT can, to a degree
    - May be monitoring for tokens that have abnormal or unneeded claims

```
@RuleName = "Issue UPN"
c:[Type ==
"http://schemas.microsoft.com/ws/2008/06/identity/claims/windowsaccountname"]
 => issue(store = "Active Directory", types =
("http://schemas.xmlsoap.org/claims/UPN"), query =
"samAccountName={0};userPrincipalName;{1}", param = regexreplace(c.Value,
"(?<domain>[^\\]+)\\(?<user>.+)", "${user}"), param = c.Value);

@RuleName = "Query objectguid and msdsconsistencyguid for custom ImmutableId
claim"
c:[Type ==
"http://schemas.microsoft.com/ws/2008/06/identity/claims/windowsaccountname"]
 => add(store = "Active Directory", types =
("http://schemas.microsoft.com/ws/2016/02/identity/claims/objectguid",
"http://schemas.microsoft.com/ws/2016/02/identity/claims/msdsconsistencyguid"),
query = "samAccountName={0};objectGUID,mS-DS-ConsistencyGuid;{1}", param =
regexreplace(c.Value, "(?<domain>[^\\]+)\\(?<user>.+)", "${user}"), param =
c.Value);

@RuleName = "Check for the existence of msdsconsistencyguid"
NOT EXISTS([Type ==
"http://schemas.microsoft.com/ws/2016/02/identity/claims/msdsconsistencyguid"])
 => add(Type = "urn:federation:tmp/idflag", Value = "useguid");

@RuleName = "Issue msdsconsistencyguid as Immutable ID if it exists"
c:[Type ==
"http://schemas.microsoft.com/ws/2016/02/identity/claims/msdsconsistencyguid"]
 => issue(Type =
"http://schemas.microsoft.com/LiveID/Federation/2008/05/ImmutableID", Value =
c.Value);
```

Are we there yet?

```
PS C:\Users\svc_adfs> Get-AdfsRelyingPartyTrust -Name "Microsoft Office 365 Identity Platform" | select TokenLifetime

TokenLifetime
-------------
            0
```

- Token Lifetime
  - Set per Relying Party Trust
  - Default value of 0 == 60 minutes
  - Defenders cannot see the Token Lifetime of submitted SAML tokens BUT
    - Microsoft can
    - May be monitoring for abnormal token lifetimes
  - Spoofed tokens could have a lifetime of years, but will not be valid once the ADFS signing token is rotated after normal 365-day lifespan

Bring your own signing cert

- Why dump the existing signing certificates when we can just use our own?
  - Access to the AD FS server not required
  - Similar to @DrAzureAD AAD Backdoor, but a little stealthier
- `Set-MsolDomainFederationSettings`
  - Global Admin and other privileged roles have access through MSOnline PowerShell
  - Nothing happens on the AD FS server

```
PS Cert:\CurrentUser\My\> Set-MsolDomainFederationSettings -DomainName doughcorp.co
 -NextSigningCertificate MIIDAzCCAeugAwIBAgIQHVxAdx5Ro6lD/Dq4v/A8ojANBgkqhkiG9w0BAQ
sFADArMSkwJwYDVQQDEyBBREZTIFNpZ25pbmcgLSBzdHMuZG91Z2hjb3JwLmNvbTAgFw0yMTA3MjAyMjA5N
DBaGA8yMDcxMDcyMDIyMTk0MFowKzEpMCcGA1UEAxMgQURGUyBTaWduaW5nIC0gc3RzLmRvdWdoY29ycC5j
```

```
TokenSigningCertificate          : [Subject]
                                     CN=ADFS Signing - sts.doughcorp.com

                                   [Issuer]
                                     CN=ADFS Signing - sts.doughcorp.com

                                   [Serial Number]
                                     61637941275E358D4C39C92E4F074181

                                   [Not Before]
                                     11/26/2020 11:14:09 PM

                                   [Not After]
                                     11/26/2021 11:14:09 PM

                                   [Thumbprint]
                                     64361D702218AC2BA058F51F7803D8CE070D871E

NextTokenSigningCertificate      : [Subject]
                                     CN=ADFS Signing - sts.doughcorp.com

                                   [Issuer]
                                     CN=ADFS Signing - sts.doughcorp.com

                                   [Serial Number]
                                     1D5C40771E51A3A943FC3AB8BFF03CA2

                                   [Not Before]
                                     7/20/2021 6:09:40 PM

                                   [Not After]
                                     7/20/2071 6:19:40 PM

                                   [Thumbprint]
                                     E193D383F3160D20635B1BC2BA40C2
```

Subject	Issuer	Effective Date	Expiration
Service communications			
CN=sts.doughcorp.com	CN=sts.doughcorp.com	11/26/2020	11/26/20
Token-decrypting			
CN=ADFS Encryption - sts....	CN=ADFS Encryption - sts...	11/26/2020	11/26/20
Token-signing			
CN=ADFS Signing - sts.dou...	CN=ADFS Signing - sts.do...	11/26/2020	11/26/20

Bring your own signing cert

- Nothing to see here, totally normal, nothing was modified
- No IP Address recorded

ADFS Replication

Farmville

- For larger orgs, AD FS servers can exist in a farm configuration
- By default, all farm nodes use the same configuration and secrets
- Nodes are kept in sync by a replication service that runs on the primary AD FS server (the first server that the AD FS role was installed on)
  - It actually runs on all farm nodes, useful for attackers

Replicating

- Replication service uses Windows Communication Framework (WCF)
  - Framework to easily build client server applications
  - Developer can build on top of preset channels (HTTP) and security (WS-Security, Kerberos)
- Endpoint is available at http://sts.acme.com:80/policystoretransfer
  - Kerberos based authentication using WS-TRUST SPNEGO
  - Data payloads are encrypted using shared secret derived from the Kerberos session key

Replicating

```
<PolicyStore>
    <AuthorizationPolicy>@RuleName = &quot;Permit Service Account&quot;
        exists([Type == &quot;http://schemas.microsoft.com/ws/2008/06/
        identity/claims/primarysid&quot;, Value == &quot;
        S-1-5-21-3508695881-2242692613-376241919-1107&quot;])
         =&gt; issue(Type = &quot;http://schemas.microsoft.com/
         authorization/claims/permit&quot;, Value = &quot;true&quot;);
        @RuleName = &quot;Permit Local Administrators&quot;
        exists([Type == &quot;http://schemas.microsoft.com/ws/2008/06/
        identity/claims/groupsid&quot;, Value == &quot;S-1-5-32-544&
        quot;])
         =&gt; issue(Type = &quot;http://schemas.microsoft.com/
         authorization/claims/permit&quot;, Value = &quot;true&quot;);
    </AuthorizationPolicy>
```

Replicating

- Quick and dirty WCF client to interact with the replication service
- ~150 lines of code, most of it boilerplate WCF initialization

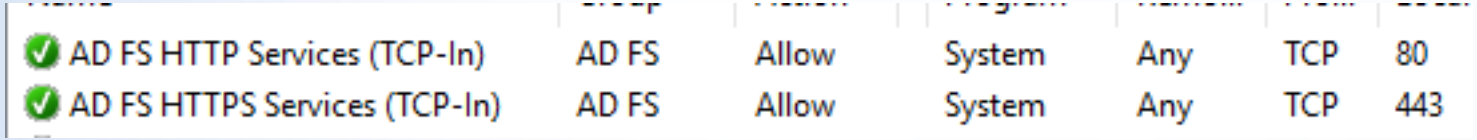
```
using System;
using System.ServiceModel;
using System.Xml;

[ServiceContract(Name="IPolicyStoreReadOnlyTransfer",
  Namespace = "http://schemas.microsoft.com/ws/2009/12/
  identityserver/protocols/policystore")]
3 references
public interface ServiceSettingsSync
{

    [OperationContract]
    4 references
    XmlElement GetState(string serviceObjectType, string
      mask, string filter, int clientVersionNumber);
}
```

Escalate, persistently

- Edit the ObjectACL for the DKM key to allow domain users read access
- Insert a new Authorization Policy into the AD FS database to permit access for the domain users GroupSID
- Any domain user can obtain the AD FS signing key from anywhere on the internal network

Why?

- AD FS servers expose port 80 to all systems by default
  - The AD FS role creates default firewall rules for us
- Stealth is built in for us ☺
  - Replication events are not logged at all
  - Editing the AD FS configuration database is not logged either
  - Auditing editing domain object ACLs (SACLs) is not often enabled in environments



AD FS HTTP Services (TCP-In)	AD FS	Allow	System	Any	TCP	80
AD FS HTTPS Services (TCP-In)	AD FS	Allow	System	Any	TCP	443

The End