MIRcon 2014

Analysis of Malicious Security Support Provider DLLs

Matt Graeber
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Introduction

- Matt Graeber
  - FireEye Labs Advanced Reverse Engineering (FLARE) Team
    - Malware Analyst
    - Instructor
  - Past
    - Researcher
    - US Army Red Team
    - 中文翻译
  - Reformed certification hoarder
  - For fun
    - PowerShell!
      - PowerSploit
  - Twitter - @mattifestation

Goals

- What are security support providers (SSP)
- Local security authority (LSA)/SSP architecture
- SSPs from an attacker's perspective
- Legitimate SSPs
- SSP internals
- Installation
- Detection
- Mitigation
- Obligatory IDA screenshot
- Obligatory PowerShell screenshot

Background

- A malicious security support provider (SSP) DLL was found recently during a recent IR engagement.
- Searching for 'SpLsaModeInitialize' – a required SSP DLL export, yielded only two unique hits in our internal malware database.
- The uniqueness of this type of malware warranted additional investigation…

Definitions

- A security support provider (SSP) – a.k.a security package:
  - A user-mode security extension used to perform authentication during a client/server exchange.
  - e.g. schannel (SSL)
- An authentication package (AP)
  - Used to extend interactive logon authentication
  - e.g. Enable RSA token authentication
- SSP/AP
  - Can serve the tasks of SSPs and APs. Loaded in lsass.
  - e.g. kerberos and msv1_0 (NTLM)

LSA Extensible Architecture

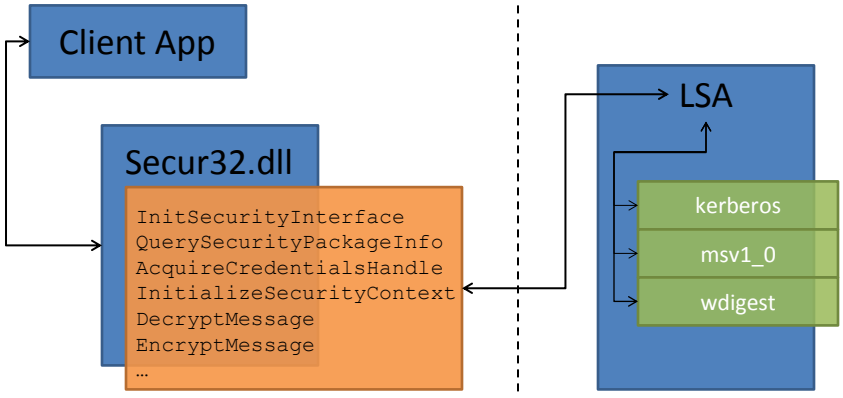
The Local Security Authority (LSA) is responsible for nearly all aspects of local security on a system

- Authenticate and log on users
- Manage credentials – SAM/NTDS/etc.
- Built-in support for message privacy and integrity

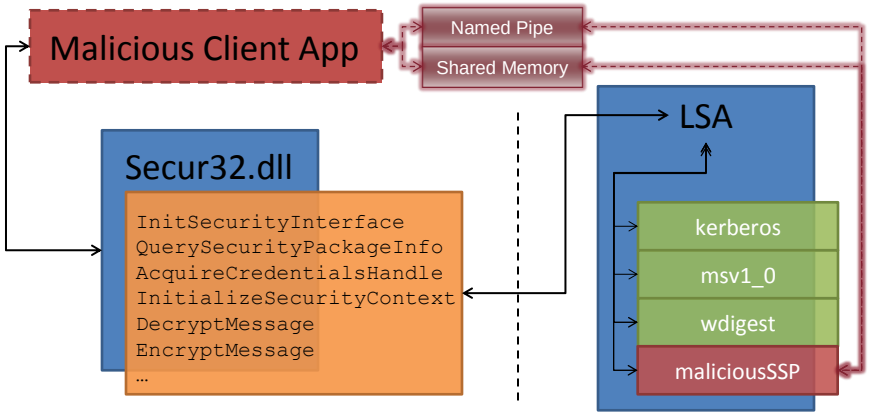
LSA is extensible

- SSP/APs are loaded into LSA (lsass.exe) at boot
- Custom SSP/APs can either replace or proxy existing providers.

SSPI Architecture - Legitimate



SSPI Architecture - Malicious



SSP Benefits from an Attacker's Perspective

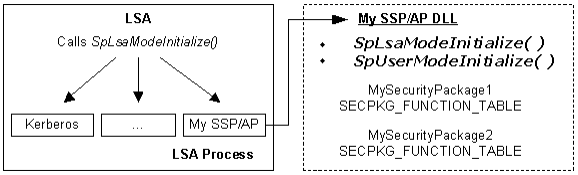
- Once installed, your DLL is loaded into lsass.exe!
  - i.e. no need to inject into lsass.exe
- Not a well-known persistence mechanism
- Once loaded into lsass, you are handed an officially supported "credential capture API".
- i.e. officially supported, Mimikatz-like functionality without needing Mimikatz

Common Legitimate SSPs

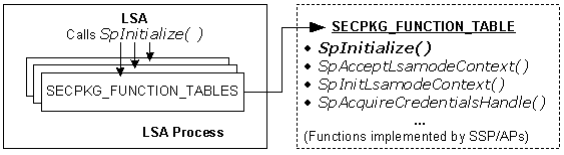
- Microsoft
  - msv1_0.dll
  - kerberos.dll
  - negoexts.dll
  - wsauth.dll
  - schannel.dll
  - TSpkg.dll
  - msoidssp.dll
  - pku2u.dll
  - etc.
- 3rd Party
  - wsauth.dll – VMWare Horizon View
  - CTXAUTH.dll – Citrix
  - phonefactorlsa.dll – PhoneFactor

LSA SSP Initialization Procedure

1. Inform LSA of SSP implemented functions

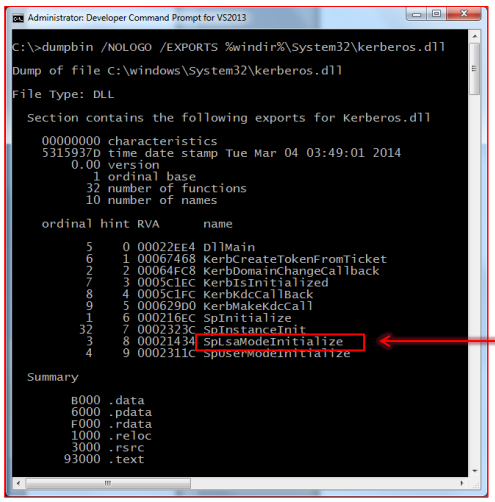


2. Inform SSP of available LSA support functions



http://msdn.microsoft.com/library/windows/desktop/aa378339.aspx

SSP Development - Requirements



Minimum required functions*

1. SpInitialize
2. SpShutDown
3. SpGetInfo

Required Export

SSP Development - Implementation

```
NTSTATUS NTAPI SpLsaModeInitialize(
  _In_   ULONG LsaVersion,
  _Out_  PULONG PackageVersion,
  _Out_  PSECPKG_FUNCTION_TABLE *ppTables,
  _Out_  PULONG pcTables
);
```

- Called by LSA when your SSP DLL is loaded.
- Only required export function
- Informs LSA of the functions your SSP DLL implements via PSECPKG_FUNCTION_TABLE
- LSA expects at a minimum, the following in PSECPKG_FUNCTION_TABLE:
  - SpInitialize
  - SpShutDown
  - SpGetInfo

```
typedef struct SECPKG_FUNCTION_TABLE {
  ...
  SpInitializeFn                *Initialize;
  SpShutdownFn                  *Shutdown;
  SpGetInfoFn                   *GetInfo;
  SpAcceptCredentialsFn         *AcceptCredentials;
  SpGetCredentialsFn            *GetCredentials;
  SpGetUserInfoFn               *GetUserInfo;
  SpAddCredentialsFn            *AddCredentials;
  SpSetExtendedInformationFn    *SpChangeAccountPasswordFn;
  ...
} SECPKG_FUNCTION_TABLE, *PSECPKG_FUNCTION_TABLE;
```


SSP Development - Implementation

```
NTSTATUS SpInitialize(
  _In_  ULONG_PTR PackageId,
  _In_  PSECPKG_PARAMETERS Parameters,
  _In_  PLSA_SECPKG_FUNCTION_TABLE
FunctionTable
);
```

- Called by LSA after SpLsaInitialize
- Informs your SSP DLL the available LSA functions via PLSA_SECPKG_FUNCTION_TABLE

```
typedef struct _LSA_SECPKG_FUNCTION_TABLE {
  ...
  PLSA_GET_CREDENTIALS              GetCredentials;
  PLSA_OPEN_SAM_USER                OpenSamUser;
  PLSA_GET_USER_CREDENTIALS         GetUserCredentials;
  PLSA_GET_USER_AUTH_DATA           GetUserAuthData;
  PLSA_UPDATE_PRIMARY_CREDENTIALS   UpdateCredentials;
  PLSA_GET_AUTH_DATA_FOR_USER       GetAuthDataForUser;
  CredReadDomainCredentialsFn       *CrediReadDomainCredentials;
  PLSA_PROTECT_MEMORY               LsaProtectMemory;
  PLSA_PROTECT_MEMORY               LsaUnprotectMemory;
  PLSA_GET_SERVICE_ACCOUNT_PASSWORD GetServiceAccountPassword;
  ...
} LSA_SECPKG_FUNCTION_TABLE, *PLSA_SECPKG_FUNCTION_TABLE;
```

SSP Development - Implementation

```
NTSTATUS SpShutDown(void);
```

- Called at system shutdown
- Can simply return NULL
- lsass.exe will crash if this if not implemented

SSP Development - Implementation

```
NTSTATUS SpGetInfo(_Out_ PSecPkgInfo PackageInfo);
```

- Provides general information about a security package
- Can return the following info:
  - Name
  - Description
  - Capabilities
  - etc.
- Must be implemented but it doesn't need to do anything.

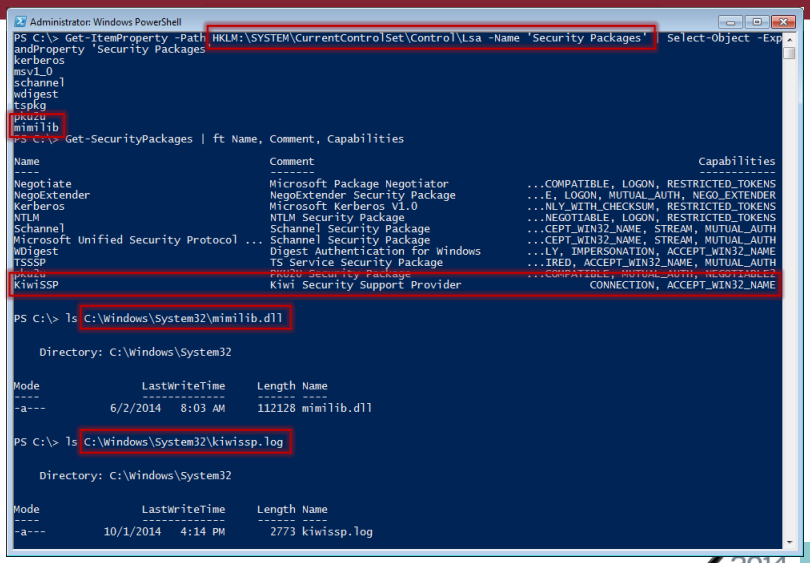
SSP Installation

1. Copy the SSP DLL to `%windir%\System32`
   - Note: Because the DLL is loaded into lsass, it must be compiled for the same architecture as lsass.exe
2. Add the file name (without extension) to:
   - `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\Security Packages`
   - `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\OSConfig\Security Packages`
3. Optional: Load it into lsass immediately by calling secur32!AddSecurityPackage
4. Reboot

Malicious SSP PoC – mimilib SSP

- Benjamin Delpy (@gentilkiwi) recently added SSP functionality to mimilib.dll. He has yet to document or heavily advertise this functionality.
- Once installed and loaded into lsass.exe, it captures passwords in plaintext.
- This is achieved with the SpAcceptCredential callback function.

Malicious SSP PoC – mimilib SSP



Malicious SSP PoC – mimilib SSP

%windir%\System32\kiwissp.log

```
[00000000:000003e7] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (SYSTEM)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
[00000000:000003e7] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (SYSTEM)
[00000000:000003e7] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (SYSTEM)
[00000000:000527ee] [00000002] WIN-LOI4CUIDKP1\anonymous (anonymous)  badpassword
[00000000:00052807] [00000002] WIN-LOI4CUIDKP1\anonymous (anonymous)  badpassword
[00000000:00065d64] [00000002] WIN-LOI4CUIDKP1\anonymous (anonymous)  badpassword
[00000000:00065d7a] [00000002] WIN-LOI4CUIDKP1\anonymous (anonymous)  badpassword
[00000000:000003e5] [00000005] \ (LOCAL SERVICE)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
[00000000:000003e5] [00000005] \ (LOCAL SERVICE)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
[00000000:000003e4] [00000005] WORKGROUP\WIN-LOI4CUIDKP1$ (NETWORK SERVICE)
```

Malicious SSP Mitigations

Prevention

- Windows 8.1/Server 2012 R2 running Secure Boot with UEFI:
  - `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\RunAsPPL (DWORD) = 1`
- Makes lsass a protected process. Forces SSP DLLs to be co-signed by Microsoft.
- With Secure Boot (w/ UEFI) enabled, `RunAsPPL` is set as a UEFI secure variable and cannot be deleted.

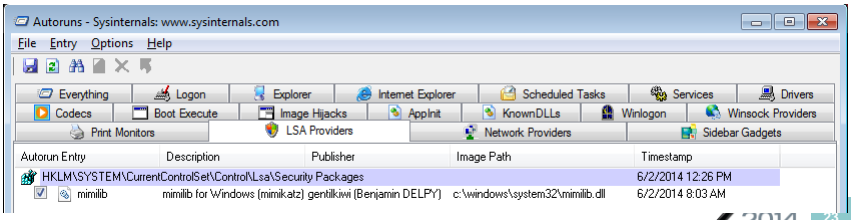
Malicious SSP Detection

- Windows 8.1/Server 2012 R2 only
- Generate event logs upon loading of an unsigned lsass module:
  - `HKLM\SOFTWARE\Microsoft\Windows NT\CurrentVersion\Image File Execution Options\LSASS.exe`
  - `AuditLevel = 8 (REG_DWORD)`
  - Reboot
- When an unsigned SSP is loaded, either of the following events will trigger:
  - 3033
  - 3066

Malicious SSP Detection

Detection

- Whitelist legitimate SSP DLLs.
- Alert when `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\Security Packages` or `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\OSConfig\Security Packages` is modified to contain an SSP not in the whitelist.
- Alert on any DLLs that export SpLsaModeInitialize that are not in the whitelist.
- MIGHT be present under 'LSA Providers' in Sysinternals Autoruns

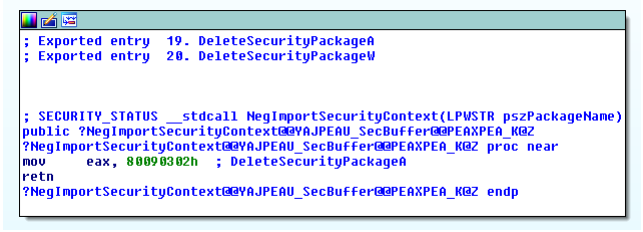


Malicious SSP Mitigations

Removal

- Remove the SSP from the following reg keys:
  - `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\Security Packages`
  - `HKLM\SYSTEM\CurrentControlSet\Control\Lsa\OSConfig\Security Packages`
- Delete the DLL from `%windir%\System32`
- Call `secur32!DeleteSecurityPackage`?
  - Oops! MS forgot to implement that function.
- Reboot ☹

Malicious SSP Mitigations



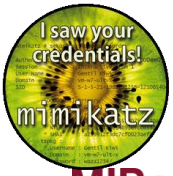
References

- Registering SSP/AP DLLs
- Configuring Additional LSA Protection
- LSA Mode Initialization
- Mimikatz PoC SSP

Merci!!!

Thank you Benjamin Delpy (@gentilkiwi) for the following:

1. Performing all the original research on malicious SSPs
2. Writing a PoC malicious SSP
3. Writing Mimikatz! <3
4. Patiently and enthusiastically answering all my dumb questions.



QUESTIONS?