An Introduction to SMB for Network Security Analysts

Nate Marx

401 TRG

Of all the common protocols a new analyst encounters, perhaps none is quite as impenetrable as Server Message Block (SMB). Its enormous size, sparse documentation, and wide variety of uses can make it one of the most intimidating protocols for junior analysts to learn. But SMB is vitally important: lateral movement in Windows Active Directory environments can be the difference between a minor and a catastrophic breach, and almost all publicly available techniques for this movement involve SMB in some way. While there are numerous guides to certain aspects of SMB available, I found a dearth of material that was accessible, thorough, and targeted towards network analysis. The goal of this guide is to explain this confusing protocol in a way that helps new analysts immediately start threat hunting with it in their networks, ignoring the irrelevant minutiae that seem to form the core of most SMB primers and focusing instead on the kinds of threats an analyst is most likely to see. This guide necessarily sacrifices completeness for accessibility: further in-depth reading is provided in footnotes. There are numerous simplifications throughout to make the basic operation of the protocol more clear; the fact that they are simplifications will not always be highlighted. Lastly, since this guide is an attempt to explain the SMB protocol from a network perspective, the discussion of host based information (windows logs, for example) has been omitted.

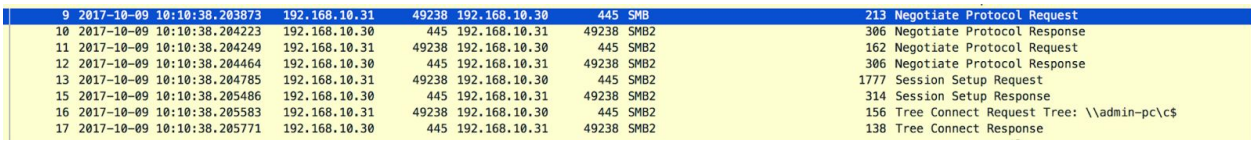
The Basics

At its most basic, SMB is a protocol to allow devices to perform a number of functions on each other over a (usually local) network. SMB has been around for so long and maintains so much backwards compatibility that it contains an almost absurd amount of vestigial functionality, but its modern core use is simpler than it seems. For the most part, today SMB is used to map network drives, send data to printers, read and write remote files, perform remote administration, and access services on remote machines.

SMB runs directly over TCP (port 445) or over NetBIOS (usually port 139, rarely port 137 or 138). To begin an SMB session, the two participants agree on a dialect, authentication is performed, and the initiator connects to a ‘tree.’ For most intents and purposes, the tree can be thought of as a network share.[1] The PCAP below, shown in Wireshark, demonstrates a simple session setup and tree connect. In this case, the machine 192.168.10.31 is

[1] A network share is some sort of shared resource on the network. Think of a drive or folder accessible over the network.

connecting to the “c$” share (equivalent to the C:\ drive) on the 192.168.10.30 machine, which is called “admin-pc.”[2]

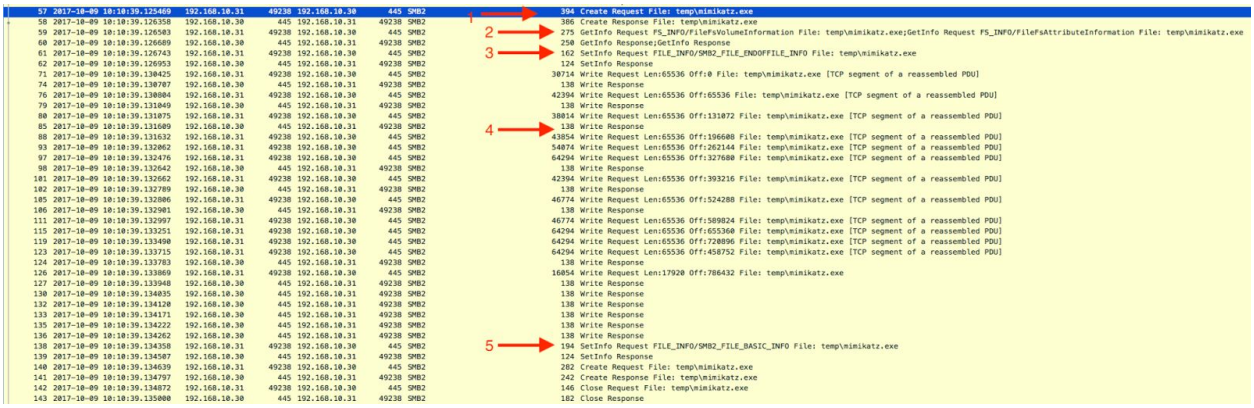


9	2017-10-09 10:10:38.203873	192.168.10.31	49238	192.168.10.30	445	SMB	213 Negotiate Protocol Request
10	2017-10-09 10:10:38.204223	192.168.10.30	445	192.168.10.31	49238	SMB2	306 Negotiate Protocol Response
11	2017-10-09 10:10:38.204249	192.168.10.31	49238	192.168.10.30	445	SMB2	162 Negotiate Protocol Request
12	2017-10-09 10:10:38.204464	192.168.10.30	445	192.168.10.31	49238	SMB2	306 Negotiate Protocol Response
13	2017-10-09 10:10:38.204785	192.168.10.31	49238	192.168.10.30	445	SMB2	1777 Session Setup Request
15	2017-10-09 10:10:38.205486	192.168.10.30	445	192.168.10.31	49238	SMB2	314 Session Setup Response
16	2017-10-09 10:10:38.205583	192.168.10.31	49238	192.168.10.30	445	SMB2	156 Tree Connect Request Tree: \\admin-pc\c$
17	2017-10-09 10:10:38.205771	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Tree Connect Response

If you open this PCAP in wireshark and look at the packet details, you will find a lot of information, and it can sometimes be difficult to tell what is relevant. Fortunately, as analysts we are mostly unconcerned with the details of these setup packets (with the exception of those relevant to authentication, which is discussed below). For the most part it is sufficient to make note of the machine and share being accessed and move on.

There are two special shares that you will see referenced often: the IPC$ and ADMIN$ shares. The ADMIN$ share can basically be thought of as a symbolic link to the path C:\Windows.[3] The IPC$ share is a little different. It does not map to the file system directly, instead providing an interface through which remote procedure calls (RPC) can be performed, as discussed below.[4]

To get a better idea of how basic actions are performed with SMB, we’ll first take a look at a simplified version of a file copy. It looks like this:[5]



57	2017-10-09 10:10:39.125469	192.168.10.31	49238	192.168.10.30	445	SMB2	394 Create Request File: temp\mimikatz.exe
58	2017-10-09 10:10:39.126358	192.168.10.30	445	192.168.10.31	49238	SMB2	386 Create Response File: temp\mimikatz.exe
59	2017-10-09 10:10:39.126503	192.168.10.31	49238	192.168.10.30	445	SMB2	275 GetInfo Request FS_INFO/FileFsVolumeInformation File: temp\mimikatz.exe;GetInfo Request FS_INFO/FileFsAttributeInformation File: temp\mimikatz.exe
60	2017-10-09 10:10:39.126689	192.168.10.30	445	192.168.10.31	49238	SMB2	250 GetInfo Response;GetInfo Response
61	2017-10-09 10:10:39.126743	192.168.10.31	49238	192.168.10.30	445	SMB2	162 SetInfo Request FILE_INFO/SMB2_FILE_ENDOFFILE_INFO File: temp\mimikatz.exe
62	2017-10-09 10:10:39.126953	192.168.10.30	445	192.168.10.31	49238	SMB2	124 SetInfo Response
71	2017-10-09 10:10:39.130425	192.168.10.31	49238	192.168.10.30	445	SMB2	30714 Write Request Len:65536 Off:0 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
74	2017-10-09 10:10:39.130707	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
76	2017-10-09 10:10:39.130804	192.168.10.31	49238	192.168.10.30	445	SMB2	42394 Write Request Len:65536 Off:65536 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
79	2017-10-09 10:10:39.131049	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
80	2017-10-09 10:10:39.131075	192.168.10.31	49238	192.168.10.30	445	SMB2	30814 Write Request Len:65536 Off:131072 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
85	2017-10-09 10:10:39.131609	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
88	2017-10-09 10:10:39.131632	192.168.10.31	49238	192.168.10.30	445	SMB2	43854 Write Request Len:65536 Off:196608 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
93	2017-10-09 10:10:39.132062	192.168.10.31	49238	192.168.10.30	445	SMB2	54074 Write Request Len:65536 Off:262144 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
97	2017-10-09 10:10:39.132476	192.168.10.31	49238	192.168.10.30	445	SMB2	64294 Write Request Len:65536 Off:327680 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
98	2017-10-09 10:10:39.132642	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
101	2017-10-09 10:10:39.132662	192.168.10.31	49238	192.168.10.30	445	SMB2	42394 Write Request Len:65536 Off:393216 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
102	2017-10-09 10:10:39.132789	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
105	2017-10-09 10:10:39.132806	192.168.10.31	49238	192.168.10.30	445	SMB2	46774 Write Request Len:65536 Off:524288 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
106	2017-10-09 10:10:39.132901	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
111	2017-10-09 10:10:39.132997	192.168.10.31	49238	192.168.10.30	445	SMB2	46774 Write Request Len:65536 Off:589824 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
115	2017-10-09 10:10:39.133251	192.168.10.31	49238	192.168.10.30	445	SMB2	64294 Write Request Len:65536 Off:655360 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
119	2017-10-09 10:10:39.133490	192.168.10.31	49238	192.168.10.30	445	SMB2	64294 Write Request Len:65536 Off:720896 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
123	2017-10-09 10:10:39.133715	192.168.10.31	49238	192.168.10.30	445	SMB2	64294 Write Request Len:65536 Off:458752 File: temp\mimikatz.exe [TCP segment of a reassembled PDU]
124	2017-10-09 10:10:39.133783	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
126	2017-10-09 10:10:39.133869	192.168.10.31	49238	192.168.10.30	445	SMB2	16054 Write Request Len:17920 Off:786432 File: temp\mimikatz.exe
127	2017-10-09 10:10:39.133948	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
130	2017-10-09 10:10:39.134035	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
132	2017-10-09 10:10:39.134120	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
133	2017-10-09 10:10:39.134171	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
135	2017-10-09 10:10:39.134222	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
136	2017-10-09 10:10:39.134262	192.168.10.30	445	192.168.10.31	49238	SMB2	138 Write Response
138	2017-10-09 10:10:39.134358	192.168.10.31	49238	192.168.10.30	445	SMB2	194 SetInfo Request FILE_INFO/SMB2_FILE_BASIC_INFO File: temp\mimikatz.exe
139	2017-10-09 10:10:39.134507	192.168.10.30	445	192.168.10.31	49238	SMB2	124 SetInfo Response
140	2017-10-09 10:10:39.134639	192.168.10.31	49238	192.168.10.30	445	SMB2	282 Create Request File: temp\mimikatz.exe
141	2017-10-09 10:10:39.134797	192.168.10.30	445	192.168.10.31	49238	SMB2	242 Create Response File: temp\mimikatz.exe
142	2017-10-09 10:10:39.134872	192.168.10.31	49238	192.168.10.30	445	SMB2	146 Close Request File: temp\mimikatz.exe
143	2017-10-09 10:10:39.135000	192.168.10.30	445	192.168.10.31	49238	SMB2	182 Close Response

---

[2] This network setup may look familiar to you. This and all the PCAPs referenced in this document are loosely based on the lab setup in the fantastic Microsoft Advanced Threat Analytics Attack Simulation Playbook here: https://gallery.technet.microsoft.com/ATA-Playbook-ef0a8e38 . This is a great resource whether you use ATA in your environment or not.

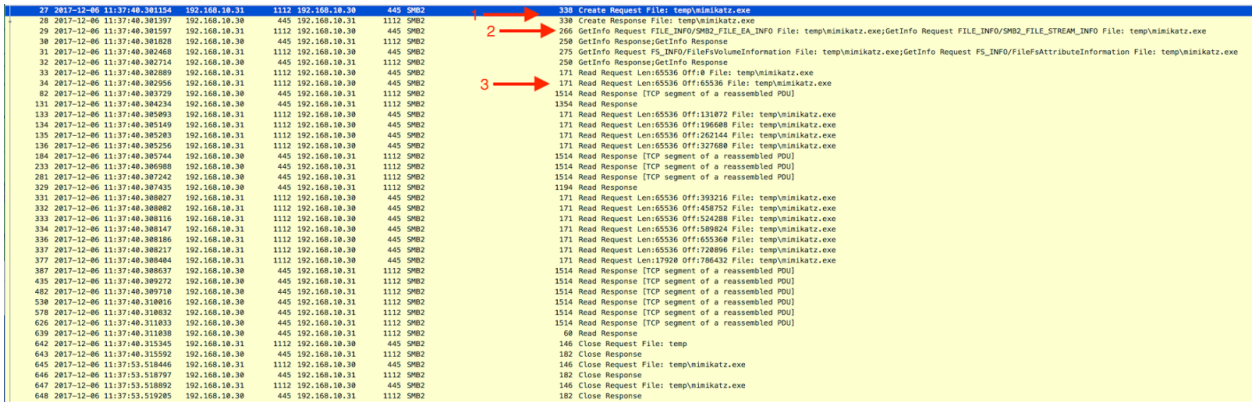
[3] For further reading, see here: http://www.intelliadmin.com/index.php/2007/10/the-admin-share-explained/

[4] For further info, see here: http://smallvoid.com/article/winnt-ipc-share.html and here: https://support.microsoft.com/en-us/help/3034016/ipc-share-and-null-session-behavior-in-windows

[5] The added complexity in the full PCAP comes from two things: creating and setting the appropriate metadata of the C:\temp folder, and adding metadata to the received mimikatz file and \tmp directory.

The first action we see is parsed by wireshark as “Create Request File.” In this instance, this tells 192.168.10.30 that 192.168.10.31 would like to create the file mimikatz.exe[6] (1). It is important to note that this is the same command used to access a file, so seeing a “Create Request” doesn’t always mean that a file is being created. 192.168.10.31 retrieves some information about the filesystem it’s writing to with GetInfo (2), and then transmits some length information with SetInfo (3). Next 192.168.10.31 requests a number of writes to send the actual file bytes over (4). We append some metadata (including timestamps) to the complete remote file (5) and close it. Our file transfer is now complete.

Reads work similarly; the following PCAP shows the write operation exactly reversed. Host 192.168.10.31 is downloading mimikatz from host 192.168.10.30.



We begin by “creating” the request file again (1), though in this case it is an extant file that we are requesting a handle to. We use GetInfo to get a number of pieces of metadata from the file (2), and then make read requests for the actual file bytes (3).

There are a large number of other SMB commands, but many of them are either rare or relatively self explanatory, and we won’t go into detail about them here.[7] You may encounter AndX commands,[8] which can be confusing at first. These simply allow two commands to be packaged as one, with one SMB header. For most purposes, you can treat them as two separate commands.

[6] The phenomenal mimikatz tool, by Benjamin Delpy, is an essential part of every security researcher’s toolbox. It can be found here: https://github.com/gentilkiwi/mimikatz. Precompiled versions are available here: https://github.com/gentilkiwi/mimikatz/releases

[7] For more information, see here: https://msdn.microsoft.com/en-us/library/ee441741.aspx.

[8] https://msdn.microsoft.com/en-us/library/ee442210.aspx

Authentication

As security analysts, one of the details we are most interested in from SMB traffic is user/machine pairing. An unusual login on a device can be a thread that unravels an entire lateral movement attempt. In Windows Active Directory environments, there are two main ways that hosts authenticate to servers and each other: NTLM and Kerberos. NTLM, the older of the two, has been in use since the release of Windows NT in 1993 but remains supported in the latest versions of Windows.[9] It uses a user's password hash to encrypt a challenge it is sent by the device it is authenticating to. It is thus extremely vulnerable to pass-the-hash type attacks,[10] and Kerberos is the recommended authentication protocol for Active Directory environments. NTLM continues to be used in Workgroup environments (Windows environments without domain controllers) and some older systems.[11]

Kerberos, introduced to Active Directory in Windows 2000, is a more modern and robust authentication protocol, but requires a Ticket Granting Server (TGS) to operate, usually on an Active Directory Domain Controller. A full explanation of Kerberos is beyond the scope of this paper,[12] so we will instead focus on the two aspects of the protocol that are important for our discussion here. One, Kerberos authentication happens separately from SMB, and involves interaction with a TGS and the service you are attempting to authenticate to. Two, Kerberos tickets, used to access services on remote machines, do not contain user information that is useful to us in cleartext.

Pass-the-hash attacks on NTLM and pass-the-ticket attacks on Kerberos[13] can both be very difficult to detect at a network level, since the traffic often looks the same as legitimate use. It is key for network defenders to have an understanding of what users should be logged into which machines, as well as to maintain good discipline about which accounts are used to access which resources. SMB traffic analysis can sometimes help us with this. NTLM authentication, shown below, includes the user attempting to authenticate in cleartext.[14]

Depending on how you capture network traffic, it may or may not be possible to follow a Kerberos session. While the username is not included in the cleartext SMB authentication,

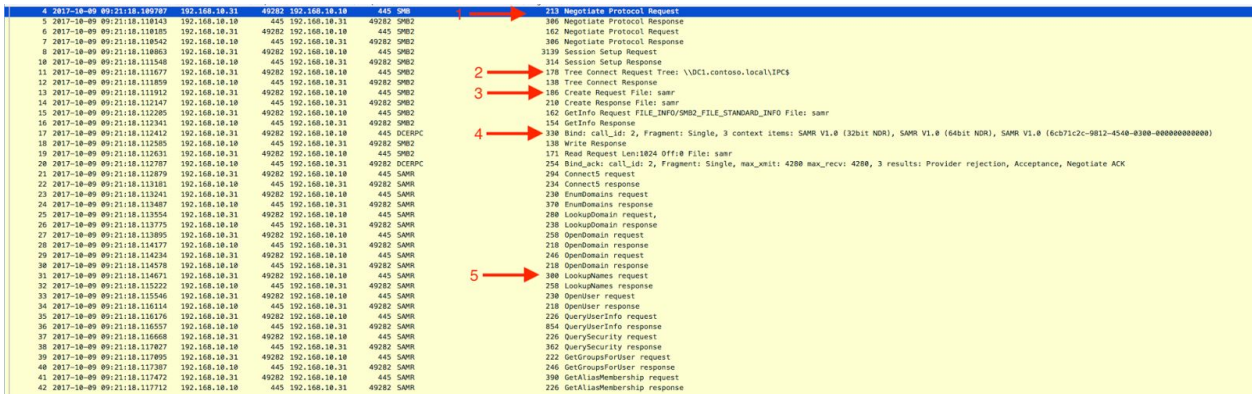
---

[9] https://docs.microsoft.com/en-us/windows-server/security/kerberos/ntlm-overview
[10] See http://www.harmj0y.net/blog/redteaming/pass-the-hash-is-dead-long-live-localaccounttokenfilterpolicy/ for more details.
[11] See https://blogs.msdn.microsoft.com/chiranth/2013/09/20/ntlm-want-to-know-how-it-works/ for further details.
[12] See here for more details: http://www.roguelynn.com/words/explain-like-im-5-kerberos/
[13] See here for more information: https://technet.microsoft.com/en-us/dn785092.aspx
[14] This PCAP is taken from the wireshark website, it is "smb-on-windows-10.PCAPng"

you may be able to follow the initial authentication with the TGS and see the returned ticket being used in an SMB session. See here for more details.

RPC

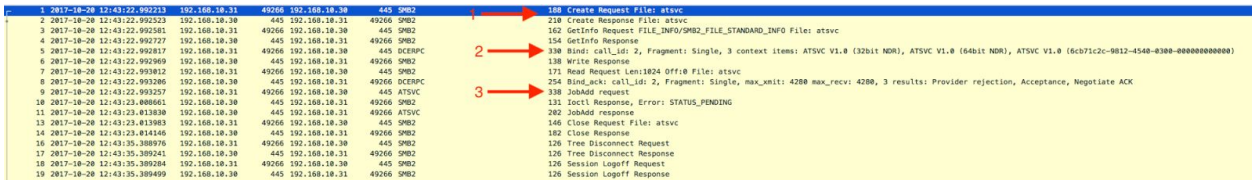
One common use case for SMB is to make remote procedure calls (RPC) to another machine on a local network. This functionality can be used for a number of things, but we are especially interested in how it is used for things like user and group enumeration, which can be signs of attempted lateral movement. It's important to note that RPCs can be made over raw TCP as well as over SMB, so absence of SMB traffic doesn't mean absence of RPC. We'll start by looking at a simple example of RPC over SMB which we might see if someone is attempting to enumerate all the users in our domain using the net command.[15]



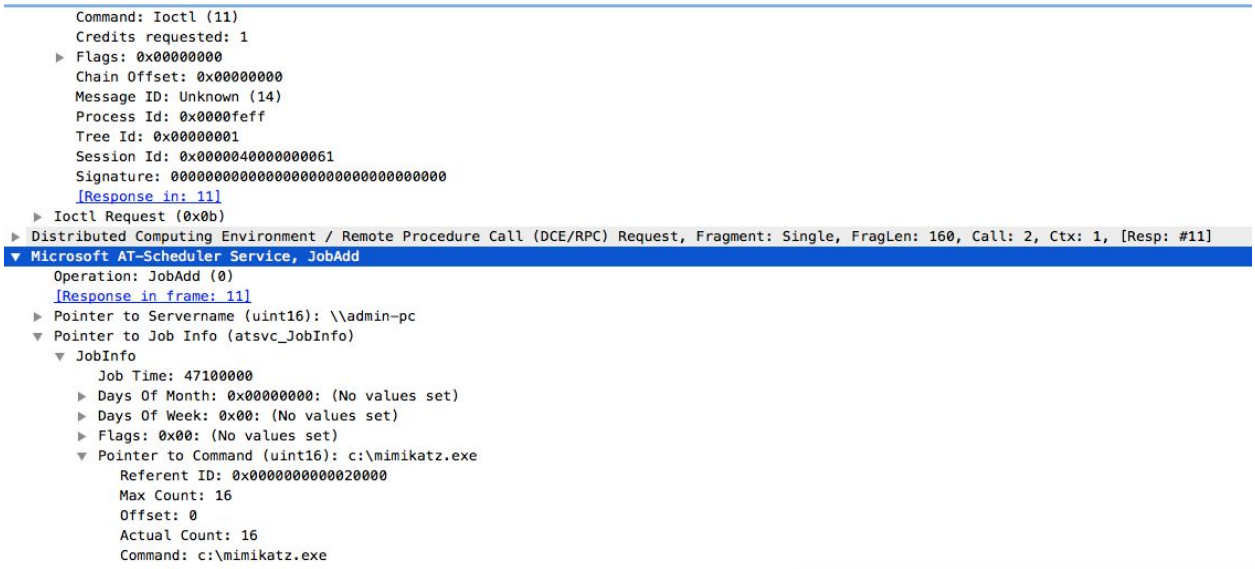
This PCAP starts similarly to the others we've seen, with a protocol negotiation and session setup (1). Note that we are connecting to the IPC$ share (2): this will be the tree we connect to for all RPC. Next, we "Create Request File," (3) where the filename is the name of the service we are connecting to (in this case, the Security Accounts Manager (SAMR)). It is important to note that while Wireshark parses the SAMR protocol for us, in the case of a service it doesn't recognize this filename would be very useful to us in identifying what we were querying. Next, we call an RPC bind and then formally connect to the service (4). Now that we're connected to the service, Wireshark parses the individual commands sent to SAMR. We can see that 192.168.10.31 is attempting to enumerate the users in the domain through this service (5).

[15] The exact command being run in this PCAP is "net user /domain". The entire PCAP is not included in this screenshot, see here (INCLUDE PCAP!!)

We'll look at one other simple example of RPC over SMB: using the **at** command to schedule a task on a remote computer.[16] We'll look at only part of the PCAP, from after the session has been set up and we have connected to the IPC$ share.



From a high level, this PCAP looks similar to the SAMR calls above. We create a request file with the name of the service (1) (atsvc, as we can see from the SMB Create Request File command), call an RPC bind (2), and then send a JobAdd request to the at service (3). There are a couple of things to note: one, since RPC runs on SMB in this case, each RPC command must have an SMB command associated with it. In this instance, RPC bind is on top of an SMB write, while the communication with the service happens over ioctl/fsctl commands.[17] This can be a little confusing, so it can sometimes be best to think of it as three independent layers: the SMB, the RPC, and the service (in this case, ATSVC). Many RPC commands will ride on top of an SMB ioctl command, as we can see below. Assuming you are not tearing packets apart byte-by-byte, the SMB command is not hugely important: instead, focus on the RPC call or (if Wireshark can parse it) the service running on RPC.[18]



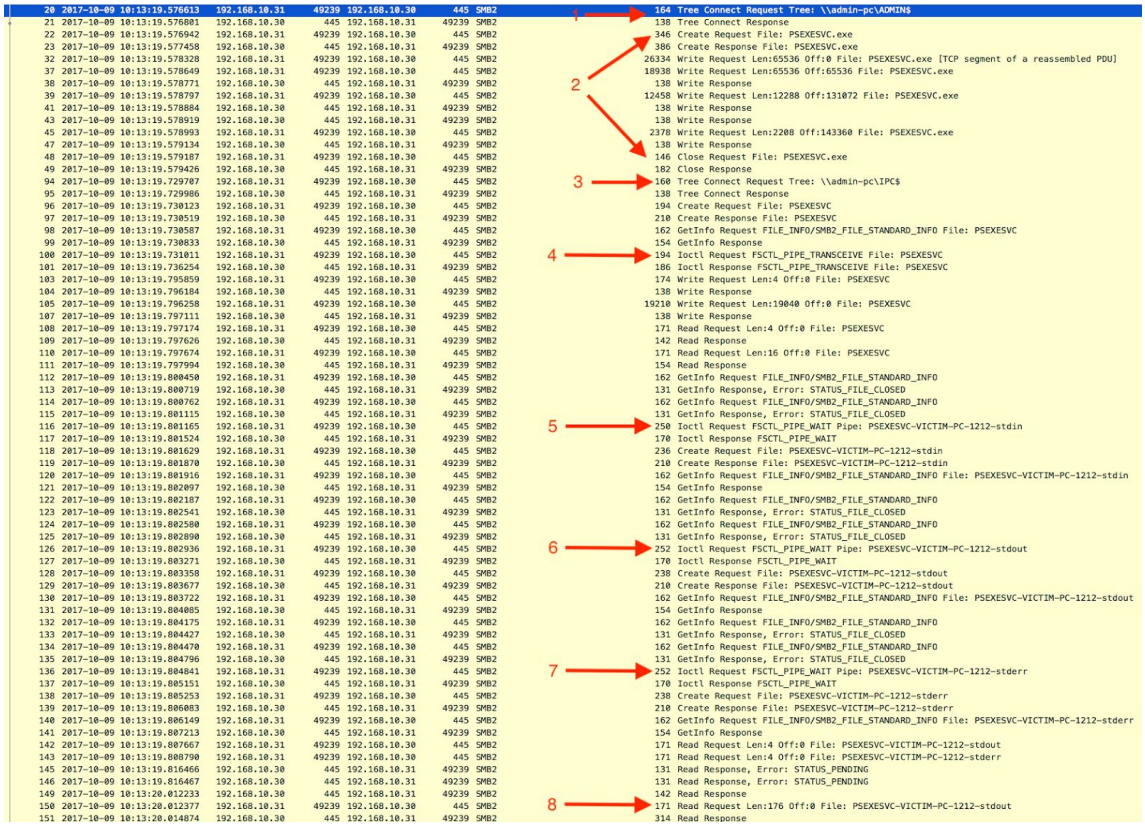
[16] https://support.microsoft.com/en-us/help/313565/how-to-use-the-at-command-to-schedule-tasks
[17] https://msdn.microsoft.com/en-us/library/cc246545.aspx
[18] This is a significant simplification. The SMB command does ultimately matter and has implications for how the data is passed to the RPC call and the service at a low level. Fully discussing this is beyond the scope of this guide, but I encourage every reader to carefully inspect the RPC calls in each PCAP to see how the SMB, RPC, and service commands relate.

Wireshark parses the at scheduler service command for us, and we can see that the user is attempting to schedule mimikatz to run.

PSExec

PsExec, a windows remote administration tool, has long been an attacker favorite for lateral movement in Active Directory environments. PsExec's own website describes it as "a light-weight telnet-replacement that lets you execute processes on other systems, complete with full interactivity for console applications, without having to manually install client software. PsExec's most powerful uses include launching interactive command-prompts on remote systems and remote-enabling tools like IpConfig that otherwise do not have the ability to show information about remote systems."[19] While it is still commonly used for legitimate administration tasks, its extensive functionality makes it useful to attackers. It is worthwhile to keep an eye on all uses of it in your network, if it is deployed at all.

PsExec can be fairly complicated on the wire, so we will begin by looking at two examples with some simplification. The first shows PsExec being used to extract a file from a target machine.[20]

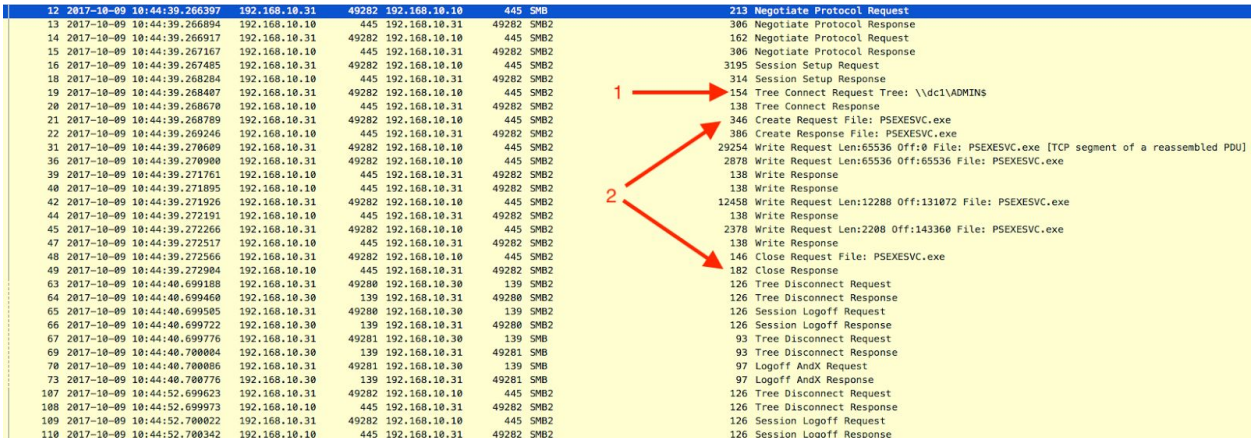


[19] https://docs.microsoft.com/en-us/sysinternals/downloads/psexec

[20] The exact command being run is: psexec.exe \\admin-pc -accepteula cmd /c (cd c:\temp ^& mimikatz.exe "privilege::debug" "sekurlsa::tickets /export" "exit") (see the ATA playbook above)

We first connect to the ADMIN$ share (1) (which points to C:\Windows), and copy over the PSEXESVC.exe file (2). This is an executable which will eventually be run on the target machine as a temporary service. We then connect to the IPC$ share (3) (note that we don't need to do another session setup for this to happen). Since Wireshark can't parse the PSEXESVC (like it could ATSVC and SAMR) at time of writing, we see the raw ioctl request (4), FSCTL_PIPE_TRANSCEIVE, instead of it being decoded into service specific commands. We then open (or more accurately, FSCTL_PIPE_WAIT on[21]) the service's stdin (5), stdout (6), and stderr (7), and then start reading the actual file from stdout (8). As of version 2.1, PsExec encrypts all communication between the local and remote machines, so we can't glean much more insight from this PCAP.

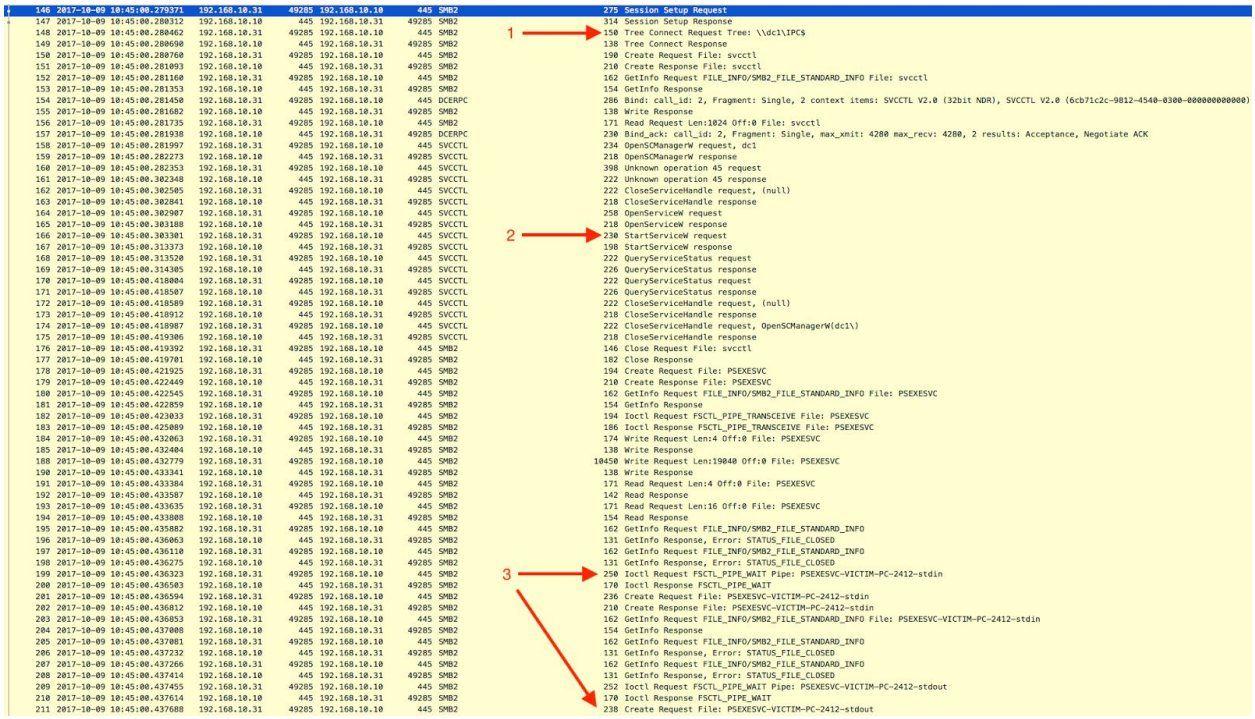
The next example we'll look at is using PsExec to add a user to a remote machine, and looks fairly different. The initial setup is similar, we connect to the ADMIN$ share (1) and copy over the PSEXESVC.exe file (2), though in this case we then completely disconnect.



12	2017-10-09 10:44:39.266397	192.168.10.31	49282	192.168.10.10	445	SMB	213 Negotiate Protocol Request
13	2017-10-09 10:44:39.266894	192.168.10.10	445	192.168.10.31	49282	SMB2	306 Negotiate Protocol Response
14	2017-10-09 10:44:39.266917	192.168.10.31	49282	192.168.10.10	445	SMB2	162 Negotiate Protocol Request
15	2017-10-09 10:44:39.267167	192.168.10.10	445	192.168.10.31	49282	SMB2	306 Negotiate Protocol Response
16	2017-10-09 10:44:39.267485	192.168.10.31	49282	192.168.10.10	445	SMB2	3195 Session Setup Request
18	2017-10-09 10:44:39.268284	192.168.10.10	445	192.168.10.31	49282	SMB2	314 Session Setup Response
19	2017-10-09 10:44:39.268407	192.168.10.31	49282	192.168.10.10	445	SMB2	154 Tree Connect Request Tree: \\dc1\ADMIN$
20	2017-10-09 10:44:39.268670	192.168.10.10	445	192.168.10.31	49282	SMB2	138 Tree Connect Response
21	2017-10-09 10:44:39.268789	192.168.10.31	49282	192.168.10.10	445	SMB2	346 Create Request File: PSEXESVC.exe
22	2017-10-09 10:44:39.269246	192.168.10.10	445	192.168.10.31	49282	SMB2	386 Create Response File: PSEXESVC.exe
31	2017-10-09 10:44:39.270609	192.168.10.31	49282	192.168.10.10	445	SMB2	29254 Write Request Len:65536 Off:0 File: PSEXESVC.exe [TCP segment of a reassembled PDU]
36	2017-10-09 10:44:39.270980	192.168.10.31	49282	192.168.10.10	445	SMB2	2878 Write Request Len:65536 Off:65536 File: PSEXESVC.exe
39	2017-10-09 10:44:39.271761	192.168.10.10	445	192.168.10.31	49282	SMB2	138 Write Response
40	2017-10-09 10:44:39.271895	192.168.10.10	445	192.168.10.31	49282	SMB2	138 Write Response
42	2017-10-09 10:44:39.271926	192.168.10.31	49282	192.168.10.10	445	SMB2	12458 Write Request Len:12288 Off:131072 File: PSEXESVC.exe
44	2017-10-09 10:44:39.272191	192.168.10.10	445	192.168.10.31	49282	SMB2	138 Write Response
45	2017-10-09 10:44:39.272266	192.168.10.31	49282	192.168.10.10	445	SMB2	2378 Write Request Len:2208 Off:143360 File: PSEXESVC.exe
47	2017-10-09 10:44:39.272517	192.168.10.10	445	192.168.10.31	49282	SMB2	138 Write Response
48	2017-10-09 10:44:39.272566	192.168.10.31	49282	192.168.10.10	445	SMB2	146 Close Request File: PSEXESVC.exe
49	2017-10-09 10:44:39.272984	192.168.10.10	445	192.168.10.31	49282	SMB2	182 Close Response
63	2017-10-09 10:44:40.699188	192.168.10.31	49280	192.168.10.30	139	SMB2	126 Tree Disconnect Request
64	2017-10-09 10:44:40.699460	192.168.10.30	139	192.168.10.31	49280	SMB2	126 Tree Disconnect Response
65	2017-10-09 10:44:40.699505	192.168.10.31	49280	192.168.10.30	139	SMB2	126 Session Logoff Request
66	2017-10-09 10:44:40.699722	192.168.10.30	139	192.168.10.31	49280	SMB2	126 Session Logoff Response
67	2017-10-09 10:44:40.699776	192.168.10.31	49281	192.168.10.30	139	SMB	93 Tree Disconnect Request
69	2017-10-09 10:44:40.700004	192.168.10.30	139	192.168.10.31	49281	SMB	93 Tree Disconnect Response
70	2017-10-09 10:44:40.700086	192.168.10.31	49281	192.168.10.30	139	SMB	97 Logoff AndX Request
73	2017-10-09 10:44:40.700776	192.168.10.30	139	192.168.10.31	49281	SMB	97 Logoff AndX Response
107	2017-10-09 10:44:52.699623	192.168.10.31	49282	192.168.10.10	445	SMB2	126 Tree Disconnect Request
108	2017-10-09 10:44:52.699973	192.168.10.10	445	192.168.10.31	49282	SMB2	126 Tree Disconnect Response
109	2017-10-09 10:44:52.700022	192.168.10.31	49282	192.168.10.10	445	SMB2	126 Session Logoff Request
110	2017-10-09 10:44:52.700342	192.168.10.10	445	192.168.10.31	49282	SMB2	126 Session Logoff Response

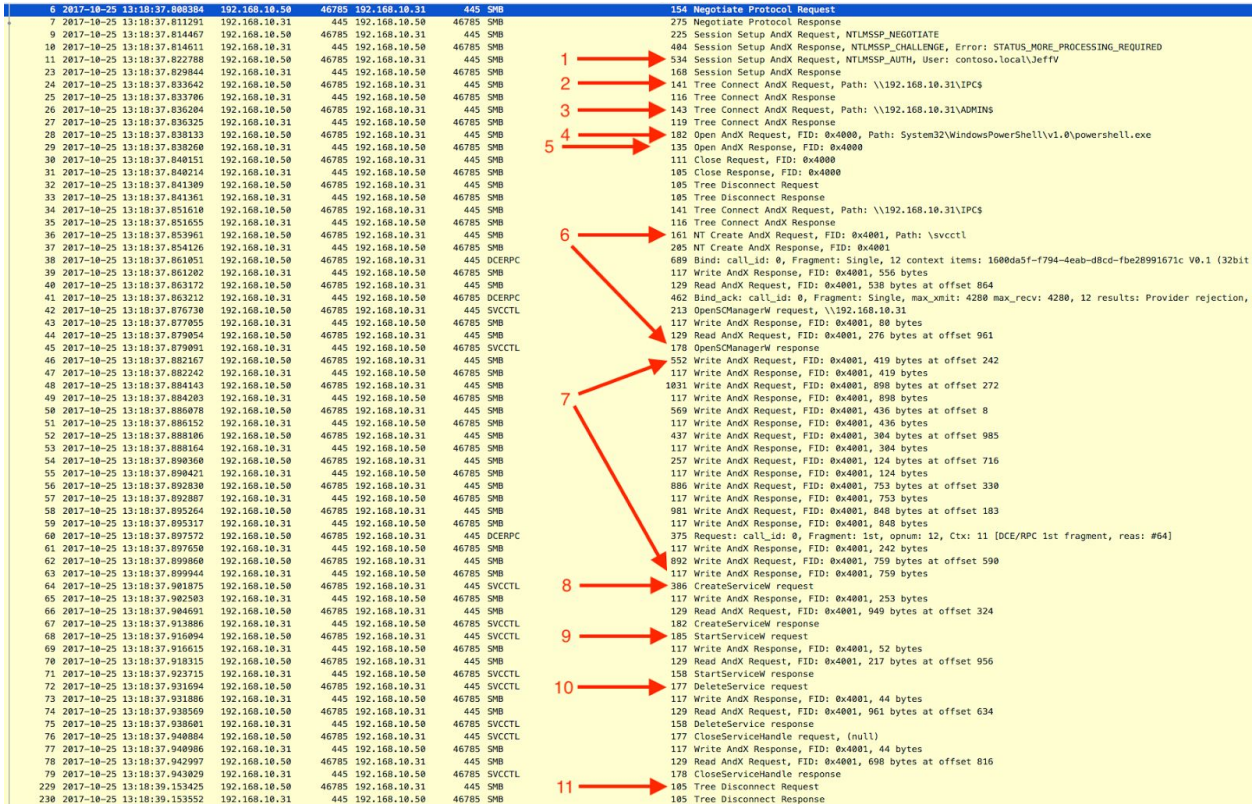
[21] https://msdn.microsoft.com/en-us/library/cc232126.aspx

However, when we reconnect to the IPC$ share (1), we launch PsExec via an RPC call to the SVCCTL service (as opposed to sending an ioctl to the PSEXESVC pipe, as we did above) (2) and then connect to the stdin, stdout and stderr as before (3).



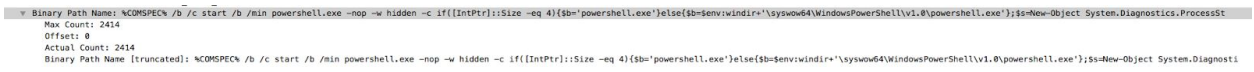
The metasploit framework (https://www.metasploit.com/) also contains its own version of PsExec which works a little differently under the hood.[22] In this PCAP, we're using it to pass some NTLM credentials we stole across SMB and then download meterpreter to a target machine.

[22] https://www.offensive-security.com/metasploit-unleashed/psexec-pass-hash/



This is the unabridged PCAP and it shows just how efficient this module is at transmitting a payload. You'll notice it makes extensive use of AndX commands. On further inspection, however, you'll see that all of the AndX commands are "No further commands," meaning we're only sending one command. It is possible that the AndXs are used for evasion.

We perform a normal NTLM authentication (1) and then connect to the IPC$ (2) and ADMIN$ (3) shares (note that in this case we are connecting to them both simultaneously, unlike the previous two examples). We then attempt to open the PowerShell executable on the remote machine (4). This is metasploit checking for the presence of PowerShell so it doesn't have to send over the PSEXESVC executable, which some solutions may detect as malicious. It successfully finds it (5), connects to the SVCCTL service (6), and then transfers a file over (7). It creates (8) and starts a service (9) , then cleans up (10) and disconnects (11). If we inspect the service creation, we can actually see the PowerShell command that spawns a meterpreter loader.



Though the command is truncated in wireshark, in the raw packet bytes we can see it is meant to decode and execute shellcode.

Lateral Movement Techniques

So far we've looked at a number of individual examples of potentially malicious behavior over SMB, but we have not looked at any big picture techniques of how attackers might actually traverse a network. There are of course quite a number of potential strategies to this, but one relatively common technique I'd like to focus on is both easy to perform and relatively difficult to detect. Since Windows stores some credentials (either Kerberos tickets or NTLM hashes) in memory for logged on users, an attacker can sometimes gain more valuable credentials by gaining local Admin on a box, dumping the Kerberos tickets or NTLM hashes from memory, and then impersonating that user to move to another machine that they have access to. That process can then potentially be repeated on another machine. This requires only mimikatz and legitimate Windows tools, and so defender knowledge of appropriate machine/user pairings and proper access controls are essential. SMB analysis can also help us in a couple ways. First, inspecting SMB for unusual authentication can give us a hint when something isn't right. If our network uses Kerberos, but we see an NTLM authentication between two machines, something is definitely up. Secondly, a technique like the one above often involves a lot of reconnaissance, because it is essential for attackers to know which users have what permissions and who is logged into what machines. Attackers can sometimes create enumeration noise while trying to figure this out (though enumeration tools do have a number of legitimate uses), and seeing unusual RPC calls related to user permissions, group memberships, or active sessions can sometimes indicate compromise.[23]

A good attacker can move almost silently through your network, and even when you are armed with knowledge of SMB, they can sometimes evade detection. Windows Management Instrumentation (WMI) and PowerShell remoting are two techniques that can avoid using SMB altogether and perform some of the same functionality we've discussed.[24] No one indicator we've seen in this post indicates malicious behavior on its own, but as with any protocol, a good knowledge of what normal SMB traffic looks like in your network is critical for finding anomalous behavior that might be attacker related. I hope this guide has been a useful introduction and you can use some of the tools you've learned here to begin hunting in your network.[25]

---

[23] See https://www.sixdub.net/?p=591 for an excellent discussion of a similar lateral movement technique.

[24] WMI can use RPC over TCP, and powershell remoting can be run over Windows Remote Management (WinRM), which is HTTP based. See https://technet.microsoft.com/en-us/library/ff700227.aspx for more details on powershell remoting.

[25] http://www.harmj0y.net/blog/ is a fantastic resource to begin expanding your knowledge of Active Directory attack techniques. http://adsecurity.org/ is another excellent source.

About 401TRG

401TRG (Threat Research Group) is the Threat Research & Analysis Team at ProtectWise. Using our experience and background in incident response and network forensics in both the public and private sectors, we study ProtectWise's extensive network-oriented datasets. This work is focused around network traffic analysis, reverse engineering malware, building behavioral detections, and much more. Now we are sharing our knowledge and intelligence discoveries with fellow network defenders and information security professionals to strengthen the community as a whole.