TinyPOS:

An analysis of a Point-of-Sale malware ecosystem

Forcepoint

Report

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The Power of 4K

What is the very first thing that comes to mind when we see “4K”? For the casual, tech-savvy person it’s probably the ultra-high definition of recent years’ TV models. For anyone who has been using a computer since the dawn of the PC era, it might mean a ‘demo’ program: a small piece of low-level code that creates outstanding (for the system it runs on, at least) 3D visuals on screen. For the less tech savvy one, it might just mean good old cash. Curiously, both of these last two definitions can be applied to our latest investigation.

When we discovered UDPoS last year, we had mixed views on both it and recent Point-of-Sale (POS) malware in general. On one hand we didn’t really expect anything new in terms of POS malware, on the other, we could easily identify the underlying reasons why these threats are still popular.

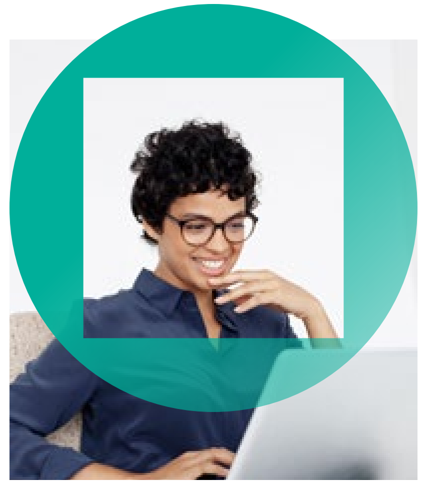
UDPoS was a warning sign that the POS portion of the threat landscape is still something to keep an eye on. Meanwhile, events such as Kroll Cyber Security revealing PinkKite – a new POS based threat, although with little to no tangible information available - and activities on the infamous Joker’s Stash site made us dig deeper.

Tiny + Loader

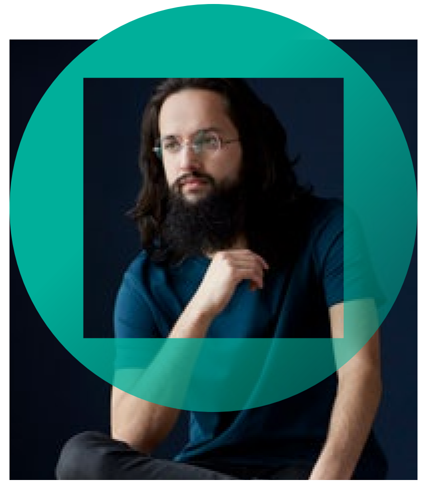
For more than a year we have been tracking a delivery mechanism built around very small components created purely in assembly. It’s not entirely uncommon to see malware code created in such a way, however trends of recent years have been towards the usage and adoption of high-level languages (C/C++/C#/Delphi/Java/GO etc) rather than low-level coding. Generally, with high bandwidth internet connections and powerful desktops there is little benefit in putting extra effort into hand crafting assembly: the difference in both delivery and execution time won’t generally be noticeable. Still, it was evident that someone still has a taste for more traditional methods of writing malware.

Delivery

During our investigation we haven’t come across samples being delivered as the primary payload (or email attachment) of an attack. Instead, they’ve been delivered as an additional payload alongside well-known banking trojan families such as Emotet or IcedID. Long term tracking provided us the opportunity to gather various samples and components of the Tiny ecosystem, as a result we have now analyzed over 2000 unique samples. These components fall into four main categories: ‘loaders’, ‘mappers’, ‘cleaners’ and ‘scrapers’, with loaders reflecting about 95% of the total population and all of the components falling into the 2-7kb range. We will elaborate more on the function of the different components later.



Forcepoint X-Labs has been collecting samples of Point-of-Sale (POS) malware that stood out for their hand crafted nature, were written in assembly code and were very small in size (2-7kB).



How it works

The loader

It all starts with the delivery of a small loader called TinyLoader, an obfuscated executable with simple – yet powerful – downloader functionality. Upon execution, it will first brute force its own decryption key (a 32- bit value, meaning this takes a fraction of second on modern PCs) before using this to decrypt the main program code.

The core functionality of the decrypted code is communication with a set of hardcoded C2 servers by IP and port. If the C2 is active, it will provide what is effectively a piece of shellcode, encrypted by another 32-bit constant. This shellcode is not 'fire and forget': it instead sees the loader establish a semi-interactive two-way communication with the C2.

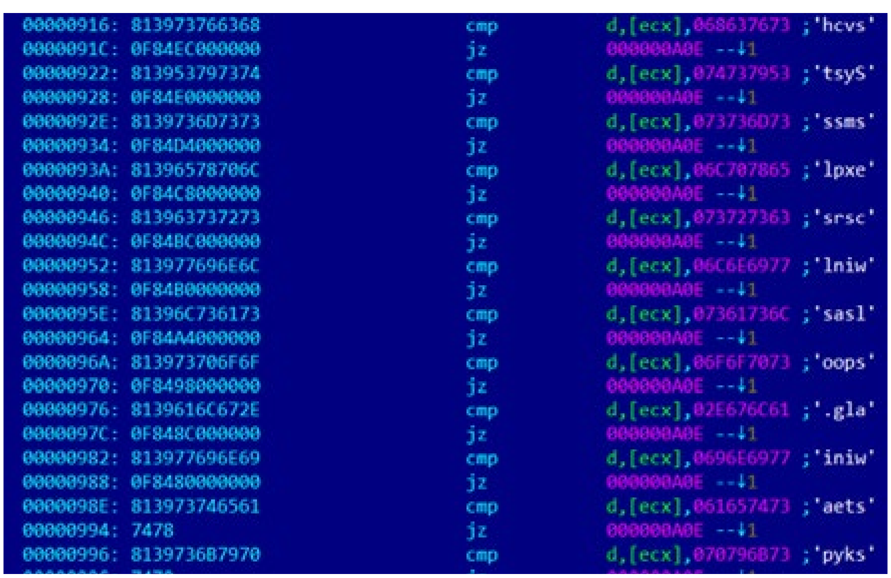
Note that the earliest traits and mentions of TinyLoader go back to as far as 2015.

The shellcode

The shellcode's first action is to download snippets of a longer piece of code into memory in multiple steps, concatenate them, and execute the resulting program once the code is complete.

The first payload built this way enumerates through the process list of the victim's PC, flagging every process which is not included in a hardcoded blacklist. This blacklist consists mainly of system process names stored in a shortened four-character long format. The list of processes is then sent back to the C2 and the loader begins building another piece of in-memory shellcode.

This second piece of code is an HTTP-based downloader that awaits further parameters that specify what to download, from where, and where to save it on the local system. Often the executable downloaded here is another TinyLoader pointing to yet another IP/port combination. This method seems to serve no specific purpose other than making the execution chain longer and potentially breaking dynamic analysis environments. If the victim's PC meets the desired criteria – for example it's a POS system – then another payload will be delivered and executed.



```
00000916: 813973766368    cmp    d,[ecx],068637673 ;'hcvs'
0000091C: 0F84EC000000    jz     000000A0E --↓1
00000922: 813953797374    cmp    d,[ecx],074737953 ;'tsyS'
00000928: 0F84E0000000    jz     000000A0E --↓1
0000092E: 8139736D7373    cmp    d,[ecx],073736D73 ;'ssms'
00000934: 0F84D4000000    jz     000000A0E --↓1
0000093A: 81396578706C    cmp    d,[ecx],06C707865 ;'lpxe'
00000940: 0F84C8000000    jz     000000A0E --↓1
00000946: 813963737273    cmp    d,[ecx],073727363 ;'srsc'
0000094C: 0F84BC000000    jz     000000A0E --↓1
00000952: 813977696E6C    cmp    d,[ecx],06C6E6977 ;'lniw'
00000958: 0F84B0000000    jz     000000A0E --↓1
0000095E: 81396C736173    cmp    d,[ecx],07361736C ;'sasl'
00000964: 0F84A4000000    jz     000000A0E --↓1
0000096A: 813973706F6F    cmp    d,[ecx],06F6F7073 ;'oops'
00000970: 0F8498000000    jz     000000A0E --↓1
00000976: 8139616C672E    cmp    d,[ecx],02E676C61 ;'.gla'
0000097C: 0F848C000000    jz     000000A0E --↓1
00000982: 813977696E69    cmp    d,[ecx],0696E6977 ;'iniw'
00000988: 0F8480000000    jz     000000A0E --↓1
0000098E: 813973746561    cmp    d,[ecx],061657473 ;'aets'
00000994: 7478            jz     000000A0E --↓1
00000996: 81397368 7970   cmp    d,[ecx],070796873 ;'pyks'
```

Figure 1: Example of the process blacklist embedded into shellcode

The POS payload - scrapers

Code-wise the POS component is very similar to the loader, except there is no additional encryption, as whenever it is delivered the operators are almost certain - due to the pre-filtering above - that a valuable target has been identified.
This component works like any other POS memory scraper: opening processes based on either a predefined black or whitelist of process names, creating a new thread for each matching one and scanning their full memory range for Track 1 and Track 2 credit card data. If such data is found, first it will be verified by the Luhn algorithm for integrity, then it will be encrypted by a pre-defined key (another 32 or 64-bit value stored in the POS binary itself) and either sent to yet another C2 identified, again, by IP/port combination or it will be saved locally.

Note the process name – the one data was stolen from - added at the end of the record.

Example of Track 1 data:
%B4XXXXXXXXXXXXXX2^DOE/JOHN^1305101000000001000000003000000?

Example of Track 2 data:
;5XXXXXXXXXXXXXX2=1103101000000300001?

Example of stolen Track 2 data before encryption:
4000000000000002=19011010000012300000 *test_pos.exe

The mappers

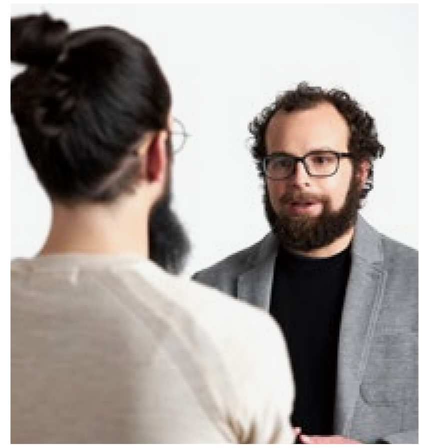
There is a special component type that we have chosen to call 'mappers'. Their main purpose is to gather information about the PC and the environment it was executed on. That's done by making a map of active processes (either all running processes or just those from a pre-defined black or whitelist, depending on the sample) and looking for local system (i.e. Autorun registry keys, Image path for active processes) and network related information. Processes are flagged differently depending on whether they could be opened or not.

For the network reconnaissance capability, the execution of the 'net view' command was implemented in a non-standard way by utilizing named pipes instead of simply executing a command shell. We believe 'mappers' help the operators gather extensive knowledge of different POS system layouts and also to deploy campaigns targeting only specific retailers.

```
"accupo","active","adres3","afr38.","afr8.e","agilpd","aldelo","alohae","alohat","atm.ex","atxexe","b2clic","back o"
"backof","barque","bbacku","bo.exe","boagen","boeft.","bopos.","bosrv.","bosrve","boutil","brain.","brstdv","cajare"
"campus","cardre","cardwo","ccprin","ccs.ex","ccv_se","centra","cicipo","client","cmacic","cmcage","concor","counte"
"cpsvcs","cre200","credit","dbstps","ddcdsr","drvcom","dscc.e","dsicar","dsicon","dsihea","dsimer","dsinas","dsipdc"
"dsipor","dsirap","dsirbs","dspos3","dvd ma","dwnam_","e7.exe","e8back","easipo","edc.ex","edcsvr","eft.ex","eftpos"
"eftsvr","egenui","epayad","epixpo","epos.e","eps_ca","eps_ge","epseng","erpm_p","esmart","esprun","expres","fastba"
"fbserv","fin.ex","focus.","focus_","fpos.e","freewa","frontb","gcomcl","generi","ghserv","gpdire","gtb.ex","gtb2.e"
"host2.","hyperc","iastor","iber.e","iberqs","icarz.","inetcc","infini","ingeni","intuit","invent","ipmgui","issdeb"
"isspos","java.e","javaw.","jpos.e","jregil","keypay","keystr","kpsvc.","liaiso","maximu","mdshtt","mdtran","menulo"
"mercsv","mercur","micro$","millen","mitels","msrwed","mxslip","mysqld","naviga","ncrloa","nextge","nmep_c","nthost"
"omnipo","opos.e","ops.ex","paladi","pccw.e","pccwin","pcvpos","pdv.ex","pdvnfc","pgterm","pixela","pixelp","plwins"
"pops.e","pos vi","pos.ex","pos210","pos5ma","posdps","posisy","posiw.","posrep","poster","postoo","poswin","powerp"
"prowin","ptoven","pxpp.e","qbcfmo","qbidps","qbmsgm","qbpos.","qbposd","qbw32p","refpos","regist","resdbs","rmaler"
"rmccwi","rmpos.","rpro8.","rpro9.","rs232m","rw5mai","sistem","sitcie","sitddt","sitdis","sitred","sitsaf","slsysm"
"smartp","soposu","spcwin","spgage","sqlser","stserv","sympho","syspdv","teckey","top_po","tpe_53","tpg_se","tpgser"
"trader","tripos","upos.o","utg2.e","utg2sv","uvsh.e","versic","versig","vitech","vmcli_","vmsrv.","vposte","w3wp.e"
"washse","wc_cor","webpos","winpos","winvqp","workst","wposip","wpro.e","xcharg","xchrgs","xtouch"
```

Figure 2: Example of the process blacklist embedded into shellcode

Some of the mapping samples contain no less than 200+ unique POS process names in their embedded whitelist. To put that into perspective, a merchant will typically buy one model of POS terminal to use across their business, with these solutions generally covering both hardware and software components. As there are no trial editions of POS software bundles freely available on the internet, gathering insights of the components is no easy job. Judging by the sheer numbers, it's safe to assume that many years of background research and information gathering is reflected in these whitelists.



The cleaners

As their name suggests, these components are responsible for cleaning up leftover content once the operation was finished. Such content can be running processes, Autorun registry keys, scheduled tasks and files in specific folders on the filesystem. Just like mappers, these modules are also customized for specific needs and won't always include every type of cleanup. Some would only kill a specific process and delete the corresponding executable while others might do all and also send the report of the successful – or failed - cleaning back to a C2.

Obfuscation and anti-analysis techniques

While the individual components of the Tiny ecosystem can hardly be considered challenging from an analysis standpoint, they still utilize some basic obfuscation and anti-debug tricks. Note that not all of the techniques are utilized by every component, the early stage downloaders were meant to be protected more. Some techniques which were identified are as follows:

- → Call / Push obfuscation
- → Fake API calls
- → Junk instructions
- → Imports by hash
- → Icon resource randomization
- → VS_VERSION_INFO randomization
- → Dynamic loading of all imported API functions
- → Simple encryption layer added after compilation

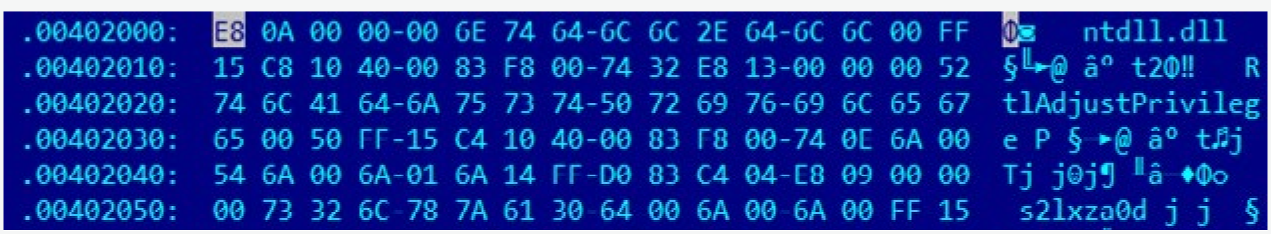


Figure 3: Example of Call / Push obfuscation

The infrastructure

There are more than a dozen IP addresses utilized by the operators, however most used in older campaigns are either out of service or have been recycled by now. Even though the ports used to change frequently (sometimes within a day) the IPs for ongoing campaigns are static. There are certain port numbers reserved for specific activities; for example port 17771 is always used by the memory scraper modules for data exfiltration. For a complete list of IPs and ports please refer to the IOC section.

IP	AS	AS NAME
5.8.18.222	202425	INT-NETWORK, SC
23.228.232.92	40676	Psychz Networks, US
31.184.234.108	44050	PIN-AS, RU
46.161.40.145	58271	VSERVER-AS, UA
62.210.36.112	12876	AS12876, FR
77.72.84.115	29073	StartUPG-NET, GB
85.93.20.42	57509	LL-INVESTMENT-LTD, BG
85.93.5.136	200998	EMGOLDEXNET-AS, DE
91.197.232.26	200363	BK-AS, IE
95.154.199.104	20860	IOMART-AS, GB
179.43.147.209	51852	PLI-AS, CH
185.174.102.20	8100	QUADRANET-GLOBAL, US
185.183.160.137	206766	INETTECH1-AS, RU
185.248.100.188	44812	IPSERVER-RU-NET Fiord, RU
188.126.77.137	42708	PORTLANE, SE
193.142.30.201	59580	BATTERFLYAIMEDIA-AS, RU
193.28.179.200	58146	SVOD-NET, CZ
194.165.16.165	48721	ADM-SERVICE-AS, RU
194.165.16.166	48721	ADM-SERVICE-AS, RU
194.165.16.199	48721	ADM-SERVICE-AS, RU
199.165.16.165	195	SDSC-AS, US

Note that some of the IP addresses overlap with IPs previously used by the Cerber ransomware. Due to the nature of how Cerber operates and the lack of additional evidence, we could not determine whether this was a coincidence or an actual link between the two different threats. The finite number of IPv4 addresses available can occasionally result in the coincidental recycling of addresses across unrelated campaigns and groups.

Why are we still facing POS-based fraud?

There are several issues that come together to make POS systems a soft (and tempting) target.

The software side

Firstly, the solutions are frequently based on old software technologies. Lots of POS applications are still based on POSReady 2009 (Windows XP based) or POSReady 7 (Windows 7 based) platforms, both of these are reaching their EOL in the upcoming months or years (see table below).

There is a new Windows 10 based POS platform called Windows IoT Enterprise, but migration and license costs can be challenging for many merchants.

PRODUCT	EXTENDED SUPPORT END DATE
Windows Embedded POSReady 2009	4/9/2019
Windows Embedded POSReady 7	10/12/2021
Windows 10 IoT Enterprise 2015 LTSB	10/14/2025
Windows 10 IoT Enterprise 2019 LTSC	1/9/2029

On top of that, POS systems often have some sort of remote access application installed for remote management and troubleshooting. This could enlarge the attack surface as lost, stolen or unchanged default credentials might provide access for the adversaries. In certain cases, if standard database engines are deployed and data is still stored without any encoding or encryption, it might also provide the ability for the memory scraper module to not only intercept current transactions but also historical ones. Several TinyPOS samples contains SQL and MySQL related names ("sqlser", "mysqld") in their process whitelist.

The hardware side

On the other side, hardware-based restrictions and outdated standards are an even greater concern. Magnetic strips (Track 1/2 type of data) are still being utilized due to the lack of EMV support world-wide. The EMV standard was originally written about 25 years ago, but adoption is much slower than expected.

The liability factor

There are numerous types of credit card fraud, with POS-based theft making up only one, shrinking piece of the whole. As total loss climbed up into the range of billions of dollars, banks were looking for a way to shift liability over to the merchants. In reality this means since 1 January 2005 (EU) and 1 October 2015 (U.S.) merchants are liable for all non EMV based transactions. As a result, adoption of EMV has increased momentum in the EU, but it is still lagging behind in other regions (mainly U.S. and Asia).

The human factor

An unfortunate side effect in the form of human (im)patience is also contributing to slower adoption of EMV. Swiping of a card is a quick and convenient way of making payments compared to entering at least four digits on a keypad. There are certain regions of the globe where people are reluctant to remember yet another PIN and don't wish to be slowed down by the process. For them, new and emerging contactless payment methods will be welcome. While some of these are still asking for a PIN for transactions over a certain limit such as PayPass (and that limit may vary per country), there are also semi-limitless options like Apple Pay.

The connectivity issue

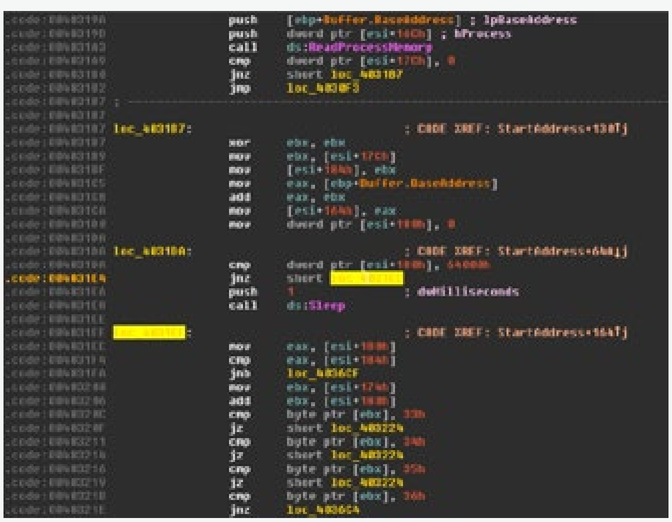
POS terminals can utilize different ways of communication for both in and outbound connections. Depending on the nature of the retailer, some might have strictly Ethernet cabling, but the likelihood of using Wi-Fi and 3/4G based communication is becoming more widespread. There are certain scenarios, i.e. taxis, where cabling is just not an option. Also, depending on the total number of terminals used and the network infrastructure, there might be servers dedicated to proxy requests towards the bank instead of every terminal having a direct connection. Whenever there is an unfiltered direct internet connection, there is a higher risk of data exfiltration going unnoticed.

All of the factors mentioned on the left, are in play when it comes to a merchant's ability – and willingness – to protect against POS based attacks.

Forks of a common codebase

One of the obvious questions is whether TinyPOS and PinkKite are really different malware families. The short answer is no, they are not different malware families. While it wouldn't take a significant amount of time for cybercriminals to recreate the assembly source code of the components by reversing existing samples, there are certain improvements to the codebase - especially to the memory scraper code – which can be found in both.

The main difference lies in the method of data exfiltration. TinyPOS variants aim for direct exfiltration over the internet, connecting to a pre-defined C2 and encrypting credit card data by a 32-bit key. The PinkKite approach is used in scenarios where direct exfiltration is not an option. Under such circumstances credit card data will be either stored on the local filesystem or the local network and encryption is done by a 64-bit key. The exfiltration process will be manual and will require persistence on the given system to access the previously saved data. As many PinkKite samples contain internal network addresses along with login credentials, it's safe to assume operators of the malware are gaining these by hacking into target systems after the initial reconnaissance stage.



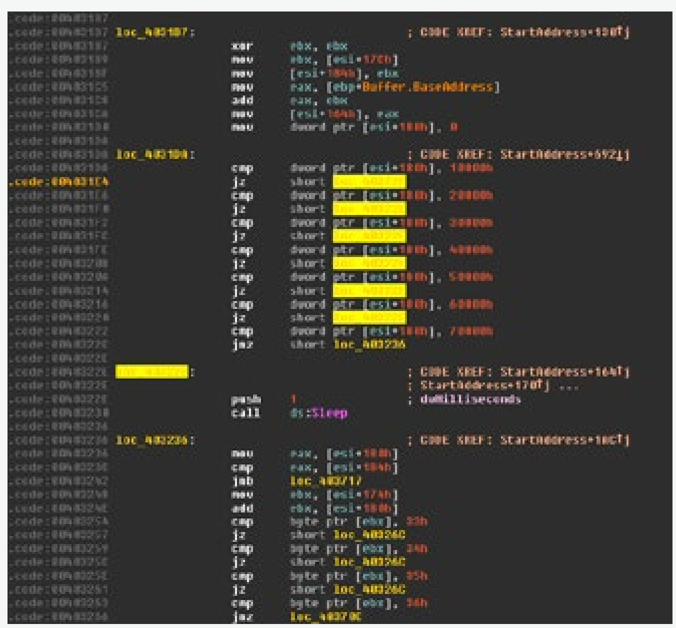


Figure 4: Example of code evolution in the memory scraper module

Protecting against POS fraud

Individuals

First of all, you should make sure that your credit or debit card is EMV compliant. If it's not then your only option is to use the magnetic strip and most of the time that also requires you to hand over your card to a 3rd party. Reaching out to the issuer of the card and negotiating a replacement – EMV-based, or one even supporting contactless payment - prior to the original expiration date is highly advised.

Merchants

The most important thing is to confirm the various connectivity options to and from the POS terminals prior to securing other aspects of the network. If the only option for terminals to reach out to the bank is through a proxy and no direct internet connection is provided, that can greatly reduce the chance of immediate data exfiltration. Also, in case maintaining and upgrading the terminals is handled by an external party, try to limit having open ports only for the duration of the scheduled sessions.

Conclusion

As we can see it doesn't take hundreds or thousands of kilobytes of code to steal valuable credit card data on a large scale. The Tiny ecosystem is built from simple yet effective components – each one being responsible for a dedicated task – written in a low-level programming language that only very few programmers (i.e. people working with embedded systems) consider their 'weapon of choice'.

While Swipe-and-Sign exists as an authentication option for card-present transactions, POS malware like TinyPOS will continue to be effective. We strongly recommend that retailers and banks aggressively pursue a faster move to EMV (at least Chip-and-Signature, preferably Chip-and-PIN).

It is also recommended that an audit be performed on any system storing and transmitting personal data in relation to how that data is managed and stored. The goal should be to make it harder for credit card data to be extracted from the retailer's systems. This includes while in transit.

Indicators of Compromise (IoC)

Mutexes

edcfix
srvrcard
carmahot
s2lxza0d
t0cnhig9
sqfinuk32
thmnhig9
hfDscs
ntcrash
xcm3264
fswinine
msoft
fswinisrchx
fswinisrchy
fswinisrch
fwnmsft
winfx1xf
joycml1
sqlsvr_0
l_smsq32
lsms_32

IPs and Ports

179.43.147.209:40071
185.174.102.20:17771
185.183.160.137:6317
185.183.160.137:8181
185.248.100.188:7454
188.126.77.137:4119
188.126.77.137:4357
188.126.77.137:4358
188.126.77.137:443
188.126.77.137:6317
188.126.77.137:8181
188.126.77.137:9090
193.142.30.201:1192
193.142.30.201:1193
193.142.30.201:17771
193.142.30.201:17799
193.142.30.201:9290
193.28.179.200:10012
193.28.179.200:27117
194.165.16.165:1444
194.165.16.165:1445
194.165.16.165:17771
194.165.16.165:19991
194.165.16.165:22143
194.165.16.165:22144
194.165.16.165:7450
194.165.16.165:7451
194.165.16.165:7453
194.165.16.165:8181
194.165.16.165:8289
194.165.16.165:9090
194.165.16.166:17771
194.165.16.166:443
194.165.16.166:444
194.165.16.199:17771
199.165.16.165:17799
23.228.232.92:1192
23.228.232.92:1195
23.228.232.92:1196
31.184.234.108:10011
31.184.234.108:10012
46.161.40.145:1192
46.161.40.145:1193
46.161.40.145:1195
46.161.40.145:1196
46.161.40.145:1393
46.161.40.145:17771
46.161.40.145:4356
46.161.40.145:4357
46.161.40.145:4358
46.161.40.145:4360
46.161.40.145:443
46.161.40.145:444
46.161.40.145:8181
46.161.40.145:9290
5.8.18.222:1191
5.8.18.222:1192
5.8.18.222:17771
62.210.36.112:27117
62.210.36.112:3341
77.72.84.115:17771
85.93.20.42:1191
85.93.20.42:1192
85.93.5.136:50011
91.197.232.26:17771
91.197.232.26:9090
95.154.199.104:27117

Files (SHA1)

Mappers

16dd2043503d8b68075362095214f7fbdbb28a13
2a21258b6954f66d8c29d59e5430b0e139fffc57
31bca61b30feaf4f3d8505ba9ffd54e2a5d1ac25
3511a6d3bb94a59dd776f66a9fcdc8115707355c
5917b72c2e3cd20990036ac5a31e7c62d041afe1
7ebc1745c5f0a6ae42bd287706f01f6db2792ccb
83c2f1bbb94139a9a6028ea2f4e6d8aa39aa1d61
a85439890a3a9538420d63a93dfb6e12ed3a5ce7
bd04b3c0840580e072806074bd309b07e61c7599
cb0e0851ace1e670a6d7826c1d05c738a1bf9e12
e8acf26abdd614a06f435337fe7a21e51893869c

Cleaners

4d181a749cea2fd82aa80f319336b08b8b961e6e
6a5eca33e5fe702ff4fe3eb47a7b42c85b1473ae
7719cd1cf007906e22b1028fe5ee65440eec3d33
860060d72ce8f0a1030110586d7b5db6d2bb8036
8eea84d8926dce44663ae1993f2623af3f40ab3b
b07baff55d9a43d93246583d34f62db7127787ca
d0af2c082d8e6ca707e4fb768715dc8974ca62be
e8fee73aaafd8b9e75441c9767ab50a7ce5f9c31

Files (SHA1)

Memory scrapers

00a46a475d56b0e56e0522d6736330935aa64984
051286924a39d9c100c131f7d48600d20d465cb7
115eaef370396843a9e28215b7267ec9559f45f3
15e8c23c989ebf7df86f831b4c400abdde9f631b
1ad1019b1463216bde562ab1a60c877b8da4d7f5
1b7fc7aaaca65c0c12222ac51e7f02f198266b07
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About the Author

Robert Neumann is a Senior Security Researcher in Forcepoint X-Labs. He focuses on various short- and long-term research projects, ranging from small scale malicious campaigns through niche malware and file formats to in-depth investigations and threat actor attribution.

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About Forcepoint

Forcepoint is the leading user and data protection cybersecurity company, entrusted to safeguard organizations while driving digital transformation and growth. Forcepoint's humanly-attuned solutions adapt in real-time to how people interact with data, providing secure access while enabling employees to create value. Based in Austin, Texas, Forcepoint creates safe, trusted environments for thousands of customers worldwide.

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