The Sound of a Targeted Attack

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A **TrendLabs**SM Research Brief

for Raimund Genes (1963-2017)

Contents

Internet-connected devices are growing in popularity every day. It's becoming more and more difficult to buy a device that isn't internet connected. Having devices connected to help user functionality, as well as size and cost, is a driver of why the popularity is growing. Despite knowing the risks in a lot of cases, we find ourselves looking at newer devices all the time, ones that add the functionality of having information in the cloud or use services that we already subscribe to.

For this research, we focused on internet-connected speakers. To look at the security implications of these devices, we wanted to find ones that are popular, have the ability to connect to the internet directly via Wi-Fi or Ethernet, and can pair with multiple devices such as duplicates of the device and mobile phones for remote access. This led us to the speaker systems of Sonos, a brand that has grown a strong reputation over the years due to good sound quality and a price that attracts a wide variety of people.

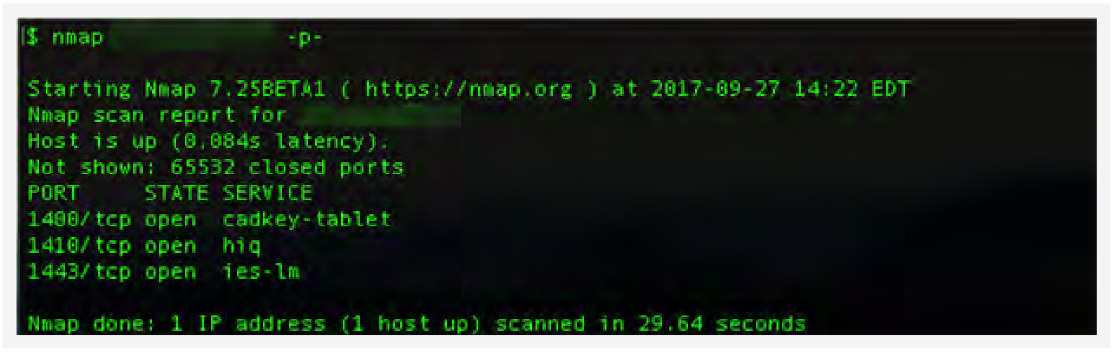
While the subject of this paper is the Sonos speaker because of availability and access to the device, the intent of the research is to focus on a larger issue that we are facing as internet-controlled sound devices are making their way into the home as well as businesses: Are there common issues across devices? From this stance, we also looked at other IoT speaker systems like the Bose SoundTouch Systems.

We have reached out to both Sonos and Bose regarding our findings. Sonos was quick to act and fix the issues regarding information leakage. The update they immediately released is discussed at the end of this study. We are also currently waiting for Bose to reply or come up with an update to address the gaps in security we found.

Exposed Services

The setup process for the Sonos speakers is straightforward and common to many IoT (Internet of Things) type devices. In this case, there are two methods for setup. You can plug an Ethernet cable into the back of the Sonos or you can connect the speaker over Wi-Fi. We set the devices up over Wi-Fi, and to do this the speaker creates an ad hoc access point that you connect to. And then follow the instructions within the mobile application on setup. If you chose the Ethernet method, your Sonos would be detected by the application and you skip the setup process over Wi-Fi.

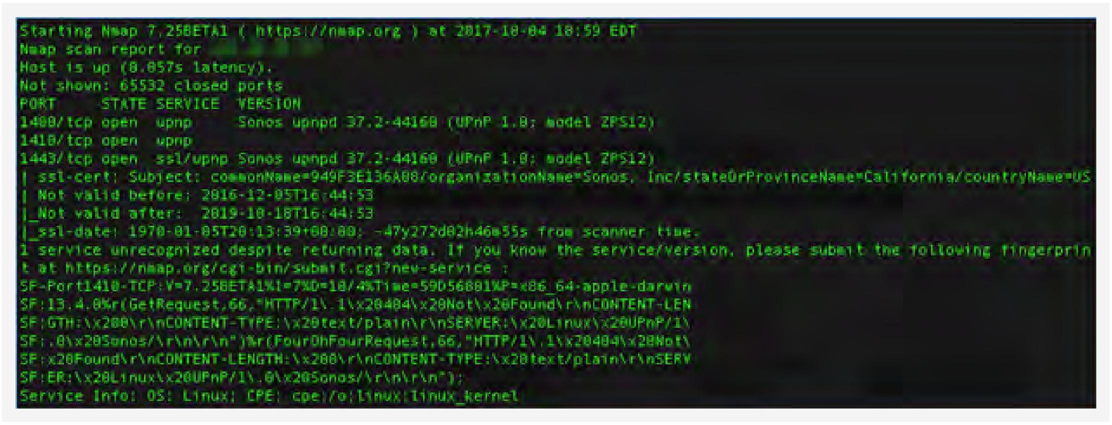
Once connected to the network, we decided to see what ports were open on the Sonos to see if there were any basic issues, such as an FTP server or telnet running.



```
$ nmap [redacted] -p-

Starting Nmap 7.25BETA1 ( https://nmap.org ) at 2017-09-27 14:22 EDT
Nmap scan report for [redacted]
Host is up (0.084s latency).
Not shown: 65532 closed ports
PORT     STATE SERVICE
1400/tcp open  cadkey-tablet
1410/tcp open  hiq
1443/tcp open  ies-lm

Nmap done: 1 IP address (1 host up) scanned in 29.64 seconds
```

Figure 1. Nmap results for Sonos speaker

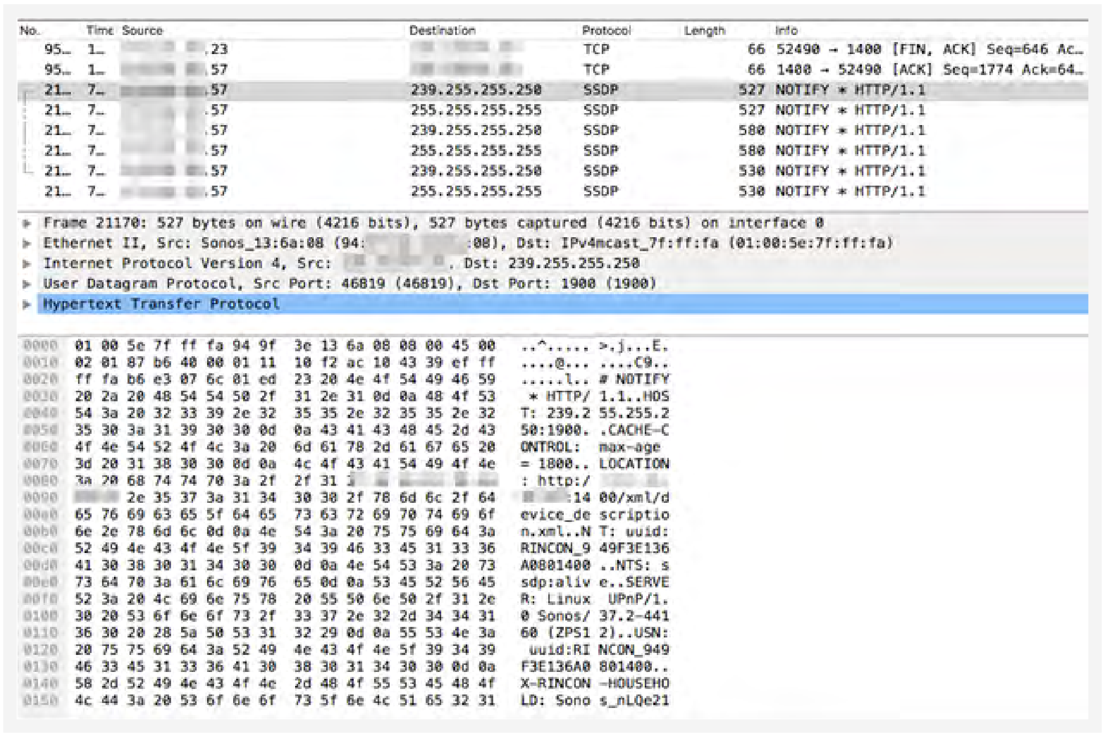
Unsure what each of these ports are, we ran nmap with the version probes (-sV) and ran the default nmap scripts (-A) to see if we could gather some more information about each of the ports and services that were running on the Sonos.



```
Starting Nmap 7.25BETA1 ( https://nmap.org ) at 2017-10-04 18:59 EDT
Nmap scan report for [redacted]
Host is up (0.057s latency).
Not shown: 65532 closed ports
PORT     STATE SERVICE  VERSION
1400/tcp open  upnp     Sonos upnpd 37.2-44160 (UPnP 1.0; model ZPS12)
1410/tcp open  upnp
1443/tcp open  ssl/upnp Sonos upnpd 37.2-44160 (UPnP 1.0; model ZPS12)
| ssl-cert: Subject: commonName=949F3E136A08/organizationName=Sonos, Inc/stateOrProvinceName=California/countryName=US
| Not valid before: 2016-12-05T16:44:53
|_Not valid after:  2019-10-18T16:44:53
|_ssl-date: 1970-01-05T20:13:39+00:00; -47y272d02h46m55s from scanner time.
1 service unrecognized despite returning data. If you know the service/version, please submit the following fingerprin
t at https://nmap.org/cgi-bin/submit.cgi?new-service :
SF-Port1410-TCP:V=7.25BETA1%I=7%D=10/4%Time=59D56801%P=x86_64-apple-darwin
SF:13.4.0%r(GetRequest,66,"HTTP/1\.1\x20404\x20Not\x20Found\r\nCONTENT-LEN
SF:GTH:\x200\r\nCONTENT-TYPE:\x20text/plain\r\nSERVER:\x20Linux\x20UPnP/1\
SF:.0\x20Sonos/\r\n\r\n")%r(FourOhFourRequest,66,"HTTP/1\.1\x20404\x20Not\
SF:x20Found\r\nCONTENT-LENGTH:\x200\r\nCONTENT-TYPE:\x20text/plain\r\nSERV
SF:ER:\x20Linux\x20UPnP/1\.0\x20Sonos/\r\n\r\n");
Service Info: OS: Linux; CPE: cpe:/o:linux:linux_kernel
```

Figure 2. Services shown from nmap scan

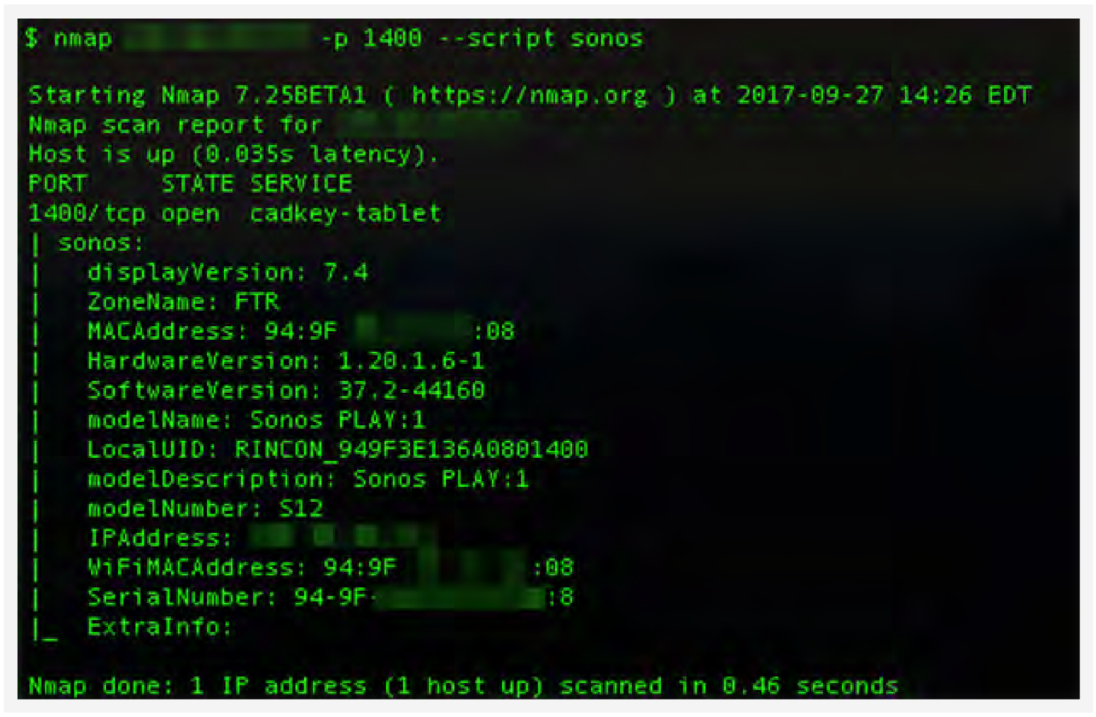
While checking to see which ports and services were open, we found that only three ports were open on the Sonos itself. These were two Universal Plug and Play (UPnP) services and one encrypted UPnP service. Launching the Sonos application while running Wireshark showed that over SSDP (Simple Service Discovery Protocol), the applications were pointed to communicate with http://<ip>:1400/xml/device_description.xml. Following some communications, it also appeared most of the communications were over TCP/1400 as the SSDP message below shows.



```
No.    Time Source              Destination         Protocol   Length  Info
  95…  1…   [redacted].23       [redacted]          TCP            66  52490 → 1400 [FIN, ACK] Seq=646 Ac…
  95…  1…   [redacted].57       [redacted]          TCP            66  1400 → 52490 [ACK] Seq=1774 Ack=64…
  21…  7…   [redacted].57       239.255.255.250     SSDP          527  NOTIFY * HTTP/1.1
  21…  7…   [redacted].57       255.255.255.255     SSDP          527  NOTIFY * HTTP/1.1
  21…  7…   [redacted].57       239.255.255.250     SSDP          580  NOTIFY * HTTP/1.1
  21…  7…   [redacted].57       255.255.255.255     SSDP          580  NOTIFY * HTTP/1.1
  21…  7…   [redacted].57       239.255.255.250     SSDP          530  NOTIFY * HTTP/1.1
  21…  7…   [redacted].57       255.255.255.255     SSDP          530  NOTIFY * HTTP/1.1

▸ Frame 21170: 527 bytes on wire (4216 bits), 527 bytes captured (4216 bits) on interface 0
▸ Ethernet II, Src: Sonos_13:6a:08 (94:[redacted]:08), Dst: IPv4mcast_7f:ff:fa (01:00:5e:7f:ff:fa)
▸ Internet Protocol Version 4, Src: [redacted], Dst: 239.255.255.250
▸ User Datagram Protocol, Src Port: 46819 (46819), Dst Port: 1900 (1900)
▸ Hypertext Transfer Protocol

0000  01 00 5e 7f ff fa 94 9f  3e 13 6a 08 08 00 45 00   ..^..... >.j...E.
0010  02 01 87 b6 40 00 01 11  10 f2 ac 10 43 39 ef ff   ....@... ....C9..
0020  ff fa b6 e3 07 6c 01 ed  23 20 4e 4f 54 49 46 59   .....l.. # NOTIFY
0030  20 2a 20 48 54 54 50 2f  31 2e 31 0d 0a 48 4f 53    * HTTP/ 1.1..HOS
0040  54 3a 20 32 33 39 2e 32  35 35 2e 32 35 35 2e 32   T: 239.2 55.255.2
0050  35 30 3a 31 39 30 30 0d  0a 43 41 43 48 45 2d 43   50:1900. .CACHE-C
0060  4f 4e 54 52 4f 4c 3a 20  6d 61 78 2d 61 67 65 20   ONTROL:  max-age
0070  3d 20 31 38 30 30 0d 0a  4c 4f 43 41 54 49 4f 4e   = 1800.. LOCATION
0080  3a 20 68 74 74 70 3a 2f  2f 31 [redacted]         : http:/ [redacted]
0090  [redacted] 2e 35 37 3a 31 34  30 30 2f 78 6d 6c 2f 64   [redacted]:14 00/xml/d
00a0  65 76 69 63 65 5f 64 65  73 63 72 69 70 74 69 6f   evice_de scriptio
00b0  6e 2e 78 6d 6c 0d 0a 4e  54 3a 20 75 75 69 64 3a   n.xml..N T: uuid:
00c0  52 49 4e 43 4f 4e 5f 39  34 39 46 33 45 31 33 36   RINCON_9 49F3E136
00d0  41 30 38 30 31 34 30 30  0d 0a 4e 54 53 3a 20 73   A0801400 ..NTS: s
00e0  73 64 70 3a 61 6c 69 76  65 0d 0a 53 45 52 56 45   sdp:aliv e..SERVE
00f0  52 3a 20 4c 69 6e 75 78  20 55 50 6e 50 2f 31 2e   R: Linux  UPnP/1.
0100  30 20 53 6f 6e 6f 73 2f  33 37 2e 32 2d 34 34 31   0 Sonos/ 37.2-441
0110  36 30 20 28 5a 50 53 31  32 29 0d 0a 55 53 4e 3a   60 (ZPS1 2)..USN:
0120  20 75 75 69 64 3a 52 49  4e 43 4f 4e 5f 39 34 39    uuid:RI NCON_949
0130  46 33 45 31 33 36 41 30  38 30 31 34 30 30 0d 0a   F3E136A0 801400..
0140  58 2d 52 49 4e 43 4f 4e  2d 48 4f 55 53 45 48 4f   X-RINCON -HOUSEHO
0150  4c 44 3a 20 53 6f 6e 6f  73 5f 6e 4c 51 65 32 31   LD: Sono s_nLQe21
```

Figure 3. SSDP packet captured in Wireshark

Based on this information and other work and postings on the Sonos, it became obvious that port TCP/1400 was the port we wanted to focus on first. In fact, a developer named Barry Caruth had already written an Nmap script to parse some information from this port. Figure 3 shows the results from that Nmap script showing basic information about the Sonos device.



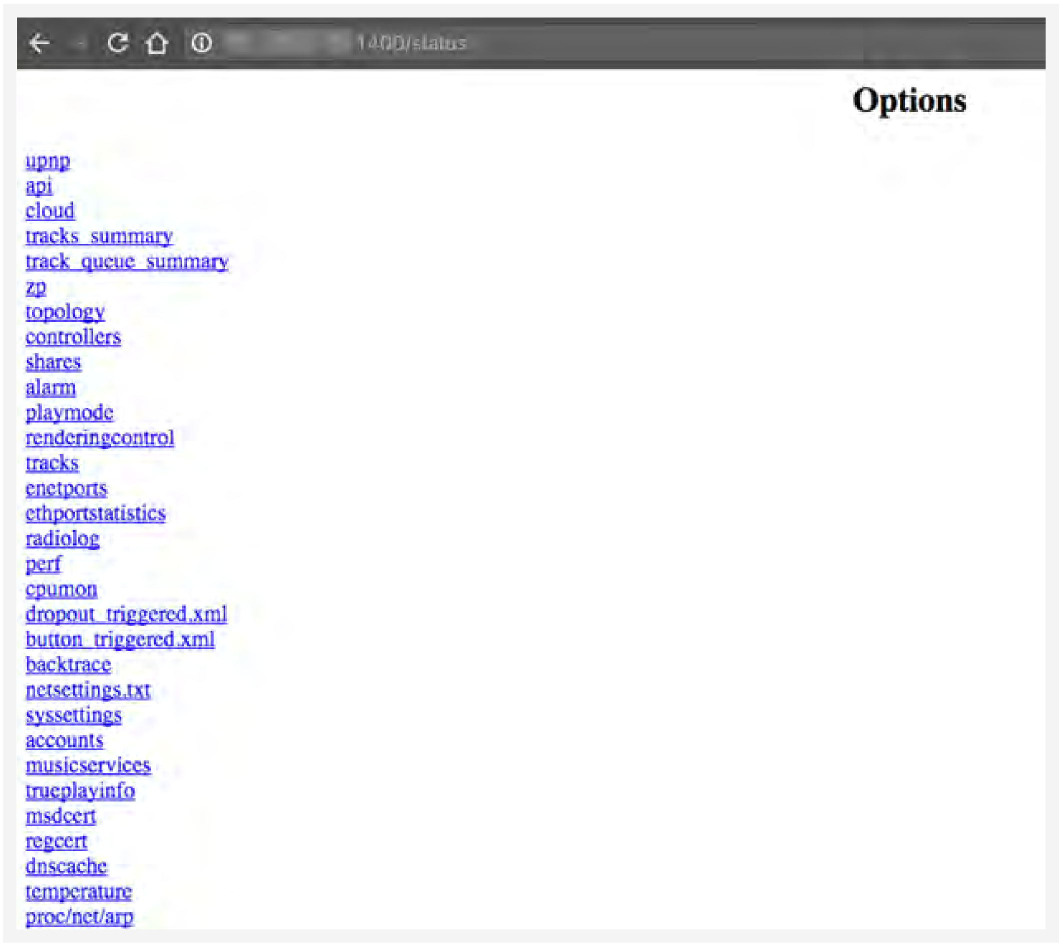
```
$ nmap [redacted] -p 1400 --script sonos

Starting Nmap 7.25BETA1 ( https://nmap.org ) at 2017-09-27 14:26 EDT
Nmap scan report for [redacted]
Host is up (0.035s latency).
PORT     STATE SERVICE
1400/tcp open  cadkey-tablet
| sonos:
|   displayVersion: 7.4
|   ZoneName: FTR
|   MACAddress: 94:9F [redacted] :08
|   HardwareVersion: 1.20.1.6-1
|   SoftwareVersion: 37.2-44160
|   modelName: Sonos PLAY:1
|   LocalUID: RINCON_949F3E136A0801400
|   modelDescription: Sonos PLAY:1
|   modelNumber: S12
|   IPAddress: [redacted]
|   WiFiMACAddress: 94:9F [redacted] :08
|   SerialNumber: 94-9F-[redacted]:8
|_  ExtraInfo:

Nmap done: 1 IP address (1 host up) scanned in 0.46 seconds
```

Figure 4. Sonos Nmap script output

When looking into the script itself, it looked like the information was coming from a specific URI path of /status on the device (http://xxx.xxx.xxx.xxx:1400/status).

Debug Information

When browsing to the local Sonos system on the URI that was provided in the Nmap script, a lot of subpages were shown via a simple website. This site contained things that are obviously being utilized to populate the applications that control the Sonos system as well as some items that are used for the initial setup.


1400/status

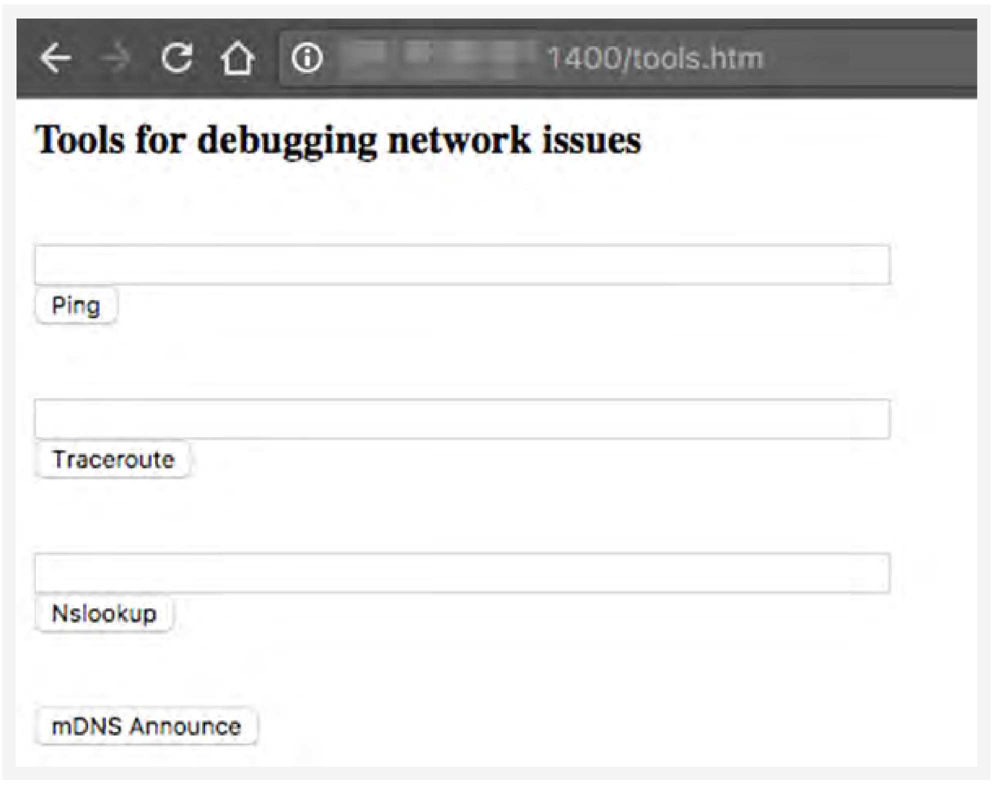
Options

upnp
api
cloud
tracks_summary
track_queue_summary
zp
topology
controllers
shares
alarm
playmode
renderingcontrol
tracks
enetports
ethportstatistics
radiolog
perf
cpumon
dropout_triggered.xml
button_triggered.xml
backtrace
netsettings.txt
syssettings
accounts
musicservices
trueplayinfo
msdcert
regcert
dnscache
temperature
proc/net/arp

Figure 5. Contents of the status page on the Sonos

Some of the interesting subpages have content that Sonos probably never thought would be exposed directly to the internet. This site, with no authentication, allows you to see information about the tracks currently being played, what music libraries it knows about, what devices have ever connected to it to control it, and down to personal information such as emails associated with specific audio streaming services like Spotify.

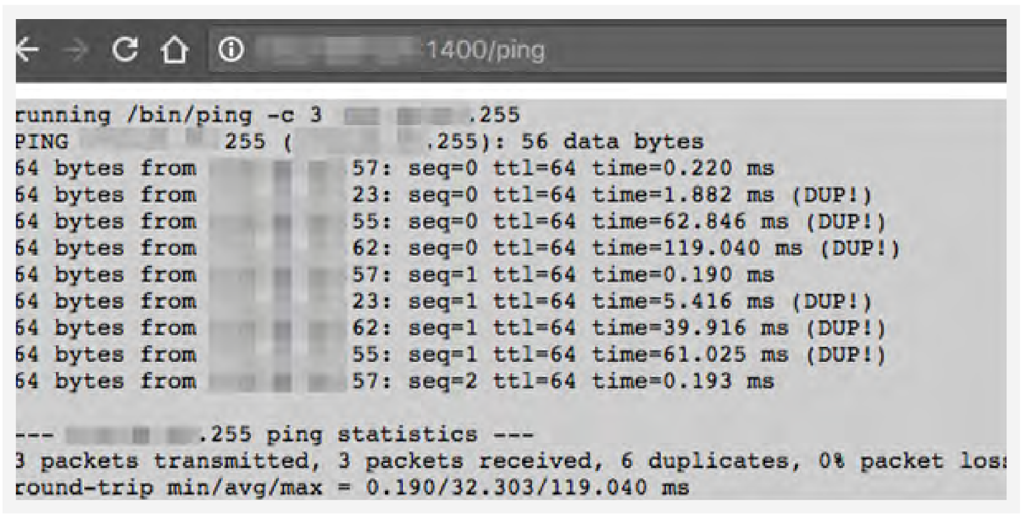
Sonos has also allowed many debug functions to be exposed via this website. This includes the ability to traceroute, ping, and even make an mDNS announcement via a simple website.



Tools for debugging network issues

Figure 6. tools.htm page within the Sonos system

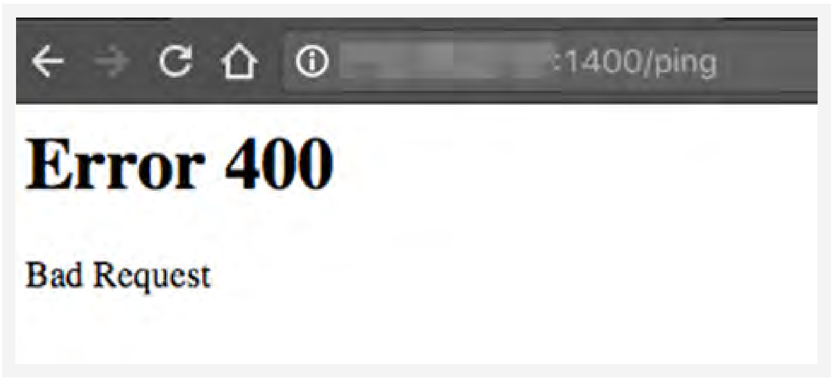
Using the ping utility, you can easily find out the list of other active devices on the network by pinging the devices individually (given that you have collected the internal IP address of the Sonos device from the ifconfig page within the /status menus), or you can see what also responds via a broadcast ping.



```
running /bin/ping -c 3 [redacted].255
PING [redacted] 255 ( [redacted] .255): 56 data bytes
64 bytes from [redacted] 57: seq=0 ttl=64 time=0.220 ms
64 bytes from [redacted] 23: seq=0 ttl=64 time=1.882 ms (DUP!)
64 bytes from [redacted] 55: seq=0 ttl=64 time=62.846 ms (DUP!)
64 bytes from [redacted] 62: seq=0 ttl=64 time=119.040 ms (DUP!)
64 bytes from [redacted] 57: seq=1 ttl=64 time=0.190 ms
64 bytes from [redacted] 23: seq=1 ttl=64 time=5.416 ms (DUP!)
64 bytes from [redacted] 62: seq=1 ttl=64 time=39.916 ms (DUP!)
64 bytes from [redacted] 55: seq=1 ttl=64 time=61.025 ms (DUP!)
64 bytes from [redacted] 57: seq=2 ttl=64 time=0.193 ms

--- [redacted].255 ping statistics ---
3 packets transmitted, 3 packets received, 6 duplicates, 0% packet los
round-trip min/avg/max = 0.190/32.303/119.040 ms
```

Figure 7. Example of a broadcast ping

We looked into these pages to see if there were any vulnerabilities that could be exploited to take over the Sonos Play:1 test unit. Sonos had some good designs, in at least the firmware versions we were testing on, that have input validations as well as a CSRF-token to prevent some attacks. For example, if you type 127.0.0.1;ls in the ping field, you would get a response of Error 400 Bad Request.



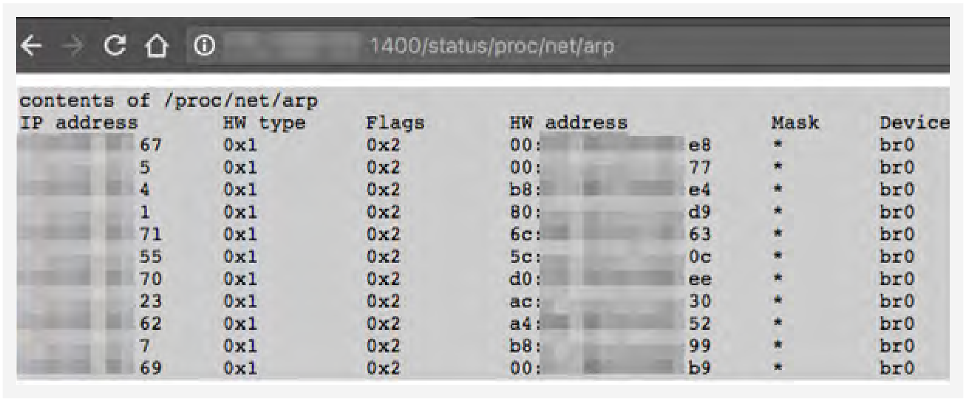
[redacted]:1400/ping

Error 400

Bad Request

Figure 8. Error shown if command injection is attempted

Ultimately, if attackers wanted to see and collect all the hosts and what types of hosts they may be after doing various discovery methods via the Sonos system itself, they would then browse to /status/proc/net/arp page and collect more information about the devices on the network that the Sonos has been able to contact.



[redacted]1400/status/proc/net/arp

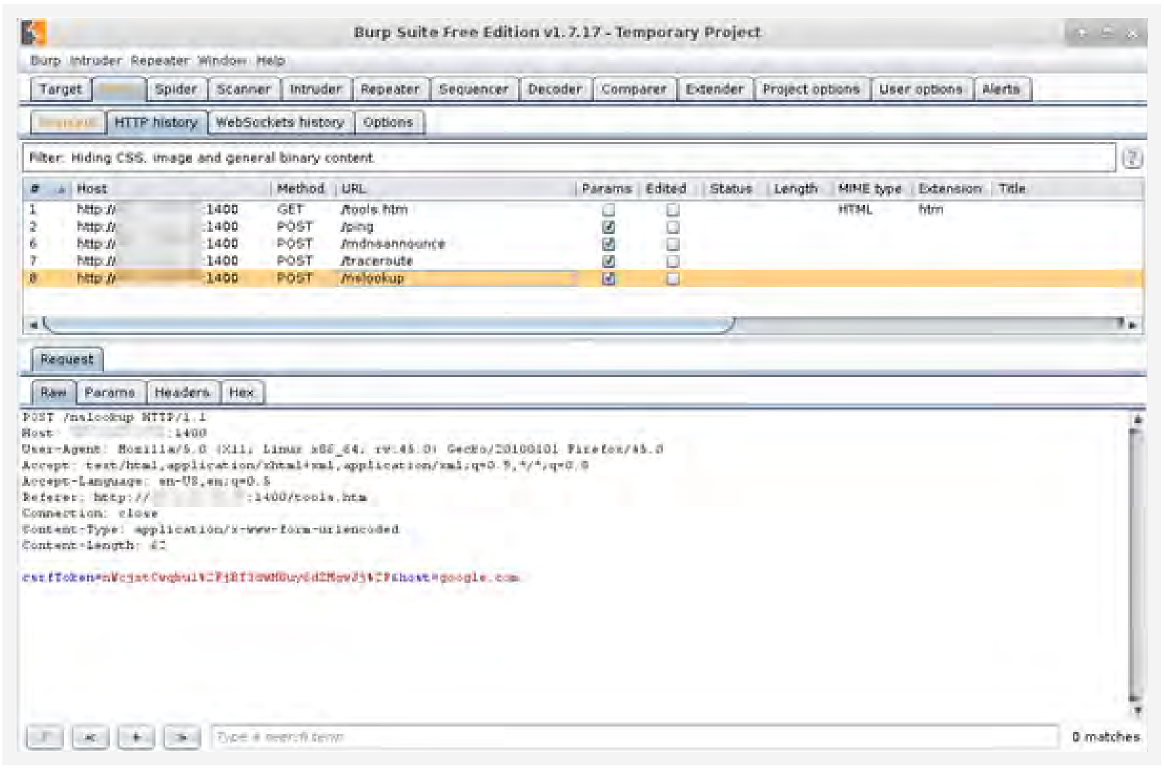
```
contents of /proc/net/arp
IP address        HW type     Flags       HW address              Mask     Device
[redacted]67      0x1         0x2         00:[redacted]e8         *        br0
[redacted]5       0x1         0x2         00:[redacted]77         *        br0
[redacted]4       0x1         0x2         b8:[redacted]e4         *        br0
[redacted]1       0x1         0x2         80:[redacted]d9         *        br0
[redacted]71      0x1         0x2         6c:[redacted]63         *        br0
[redacted]55      0x1         0x2         5c:[redacted]0c         *        br0
[redacted]70      0x1         0x2         d0:[redacted]ee         *        br0
[redacted]23      0x1         0x2         ac:[redacted]30         *        br0
[redacted]62      0x1         0x2         a4:[redacted]52         *        br0
[redacted]7       0x1         0x2         b8:[redacted]99         *        br0
[redacted]69      0x1         0x2         00:[redacted]b9         *        br0
```

Figure 9. ARP table from the Sonos device

Let's say an attacker knows the target uses a Sonos device. The attacker can then take the information collected here to tailor better attacks against the target. This could include mobile devices, printers, and even types of computers on the networks.

Within the status page, there is also a page that is titled “scan results.” This runs a command that looks for wireless access points nearby. This would be utilized during the setup process to determine which wireless network you would want to connect the Sonos system to, and we will detail more about the risks of this sort of information in the information leakage section of this paper. First, however, let us examine the amount of exposed Sonos systems on the internet.

According to W3.org, the 400 Bad Request states, “The request could not be understood by the server due to malformed syntax. The client SHOULD NOT repeat the request without modifications.” Meaning that adding the semicolon caused an issue and the request could no longer be understood. This is likely due to some back-end argument checking. To further check through the webpages, we used Burp Suite to look for any other issues within these pages that may be exploitable. However, we were not able to find any vulnerabilities from an external web interface within the pages listed on /status.



Burp Suite Free Edition v1.7.17 - Temporary Project
Burp Intruder Repeater Window Help
Target Spider Scanner Intruder Repeater Sequencer Decoder Comparer Extender Project options User options Alerts
HTTP history WebSockets history Options
Request
Raw Params Headers Hex
0 matches

Filter: Hiding CSS, image and general binary content

#	Host	Method	URL	Params	Edited	Status	Length	MIME type	Extension	Title
1	http://[redacted]:1400	GET	/tools.htm	☐	☐			HTML	htm	
2	http://[redacted]:1400	POST	/ping	✓	☐					
6	http://[redacted]:1400	POST	/mdnsannounce	✓	☐					
7	http://[redacted]:1400	POST	/traceroute	✓	☐					
8	http://[redacted]:1400	POST	/nslookup	✓	☐					

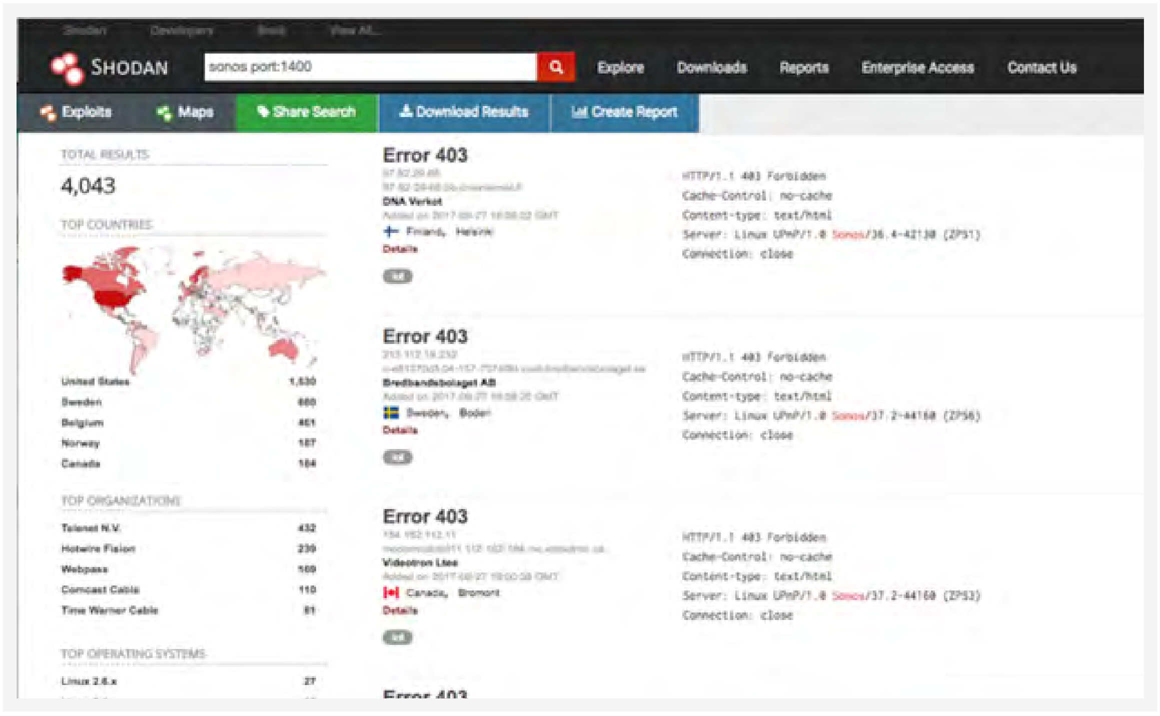
```
POST /nslookup HTTP/1.1
Host: [redacted]:1400
User-Agent: Mozilla/5.0 (X11; Linux x86_64; rv:45.0) Gecko/20100101 Firefox/45.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Referer: http://[redacted]:1400/tools.htm
Connection: close
Content-Type: application/x-www-form-urlencoded
Content-Length: 62

csrfToken=nWcjstCvqbul%2FjBfI3WMDuy6d2Mqv2j%2F&host=google.com
```

Figure 10. Showing Burp Suite and the csrfToken values

With this information we set out to see how many of these devices were exposed on the internet.

Sonos on the Internet

We worked with Shodan to scan the internet for Sonos devices based on the Nmap script that we previously discussed. To query Sonos devices within Shodan, you will want to use the query parameter "Sonos port:1400."



TOTAL RESULTS

4,043

TOP COUNTRIES

United States	1,530
Sweden	660
Belgium	461
Norway	187
Canada	164

TOP ORGANIZATIONS

Telenet N.V.	432
Hotwire Fision	239
Webpass	169
Comcast Cable	110
Time Warner Cable	81

TOP OPERATING SYSTEMS

Linux 2.6.x	27

Error 403
DNA Verkot
Finland, Helsinki
Details

```
HTTP/1.1 403 Forbidden
Cache-Control: no-cache
Content-type: text/html
Server: Linux UPnP/1.0 Sonos/36.4-42130 (ZPS1)
Connection: close
```

Error 403
Bredbandsbolaget AB
Sweden, Boden
Details

```
HTTP/1.1 403 Forbidden
Cache-Control: no-cache
Content-type: text/html
Server: Linux UPnP/1.0 Sonos/37.2-44160 (ZPS6)
Connection: close
```

Error 403
Videotron Ltee
Canada, Bromont
Details

```
HTTP/1.1 403 Forbidden
Cache-Control: no-cache
Content-type: text/html
Server: Linux UPnP/1.0 Sonos/37.2-44160 (ZPS3)
Connection: close
```

Error 403

Figure 11. Sonos devices in Shodan

The number of Sonos devices have changed from around 4,000 shown here to up to around 5,000 devices during the course of this research. A lot of this is due to the fact that the IPs that these are on are not fixed IP address ranges; often they are on residential lines. But what remains the same is that the United States and Sweden are the top two places where Sonos speakers are exposed on the internet.

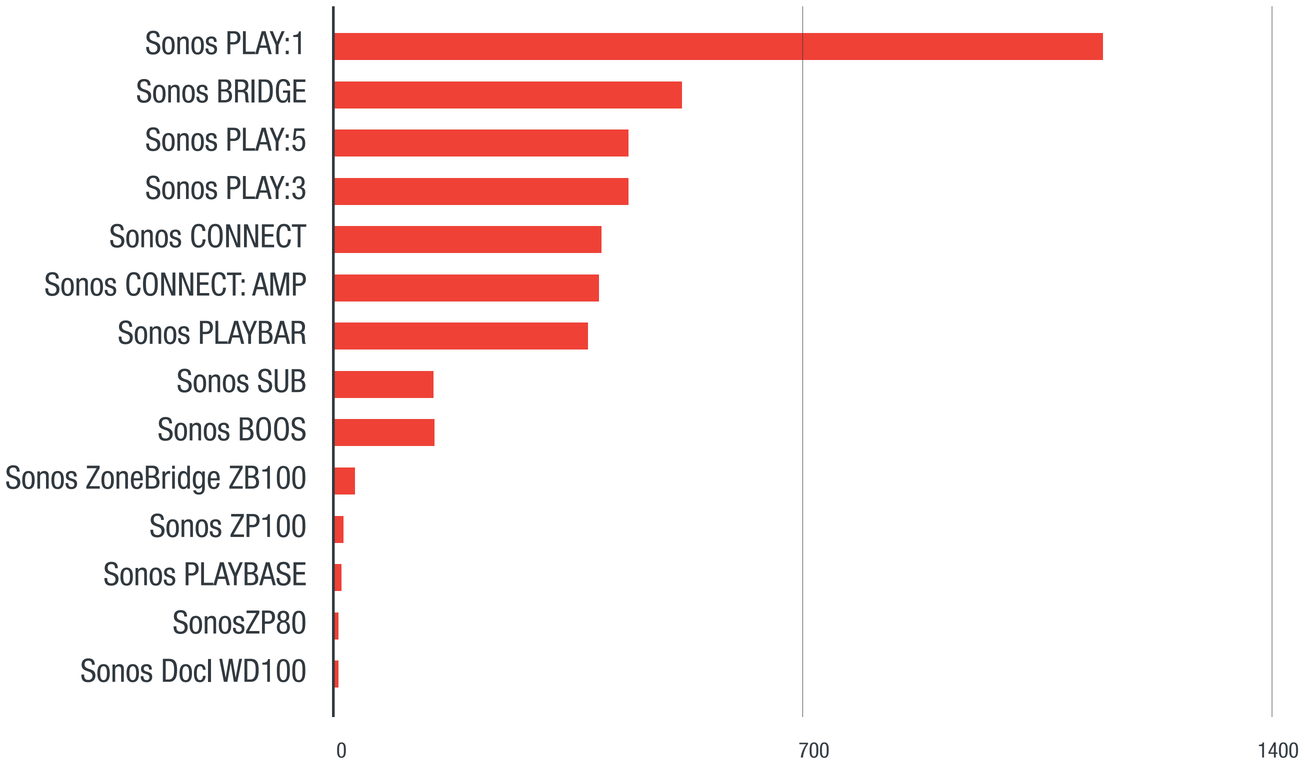
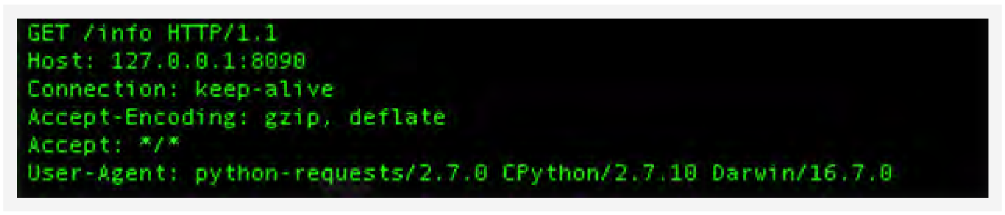


Figure 12. Breakdown of types of Sonos exposed on the internet

What is surprising about this is that new products that have been released recently are showing up online. The PLAYBASE is a new product that allows you to connect your TV's audio output to a Sonos system. This product was released early 2017.

Although the Bose SoundTouch line has fewer units that have built-in Ethernet connectivity, this doesn't prevent them from winding up exposed online. Much like the Sonos system, the SoundTouch has an unauthenticated API that allows full control over the speakers. A lot of work has also already gone into making libraries that work with these speakers. In fact, there is also a Python library.

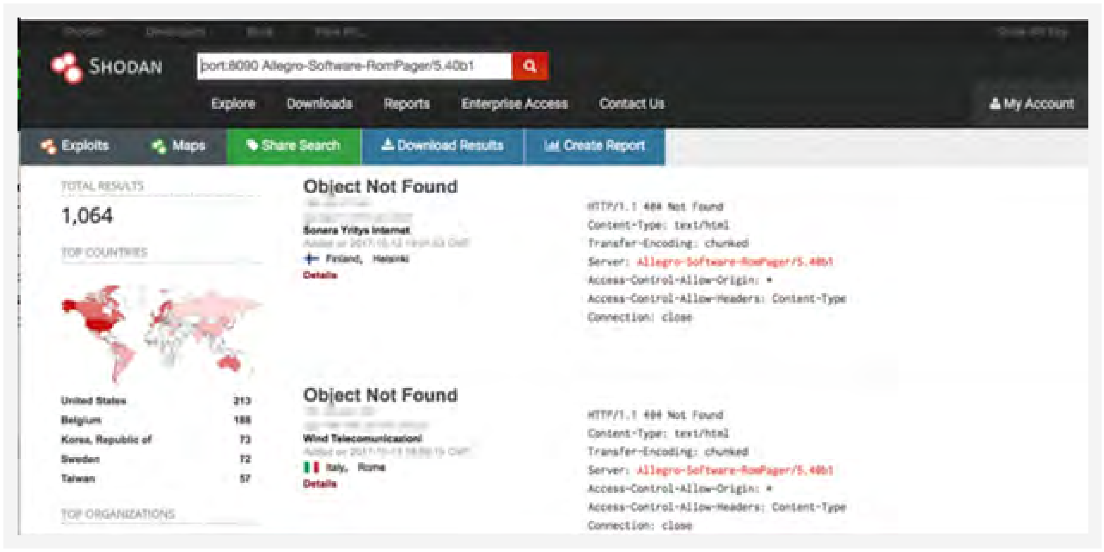


```
GET /info HTTP/1.1
Host: 127.0.0.1:8090
Connection: keep-alive
Accept-Encoding: gzip, deflate
Accept: */*
User-Agent: python-requests/2.7.0 CPython/2.7.10 Darwin/16.7.0
```

Figure 13. Using Python Libraries to connect to netcat running on TCP/8090

Based on this, we can determine that on port 8090 there is a web service running and that /info has some of the basic information that is needed to connect to the device. Based on this information, we did some digging in Shodan to see if we could locate any online.

Looking first into port 8090 and keyword Bose got us to a single host. This host had a server type of Bose-Software. We then searched based on that to find anything else without the port number and this led us to a lot of UPnP devices that had the server type of Server: Allegro-Software-RomPager. Partnering this with the port number of 8090, we searched for what we believe to be Bose SoundTouch devices. While there were fewer than the number of Sonos devices, the numbers are significant and likely to grow as these devices are being directly exposed to the internet.



TOTAL RESULTS

1,064

TOP COUNTRIES

United States	213
Belgium	188
Korea, Republic of	73
Sweden	72
Taiwan	57

TOP ORGANIZATIONS

Object Not Found

Sonera Yritys Internet

Finland, Helsinki

Details

```
HTTP/1.1 404 Not Found
Content-Type: text/html
Transfer-Encoding: chunked
Server: Allegro-Software-RomPager/5.40b1
Access-Control-Allow-Origin: *
Access-Control-Allow-Headers: Content-Type
Connection: close
```

Object Not Found

Wind Telecomunicazioni

Italy, Rome

Details

```
HTTP/1.1 404 Not Found
Content-Type: text/html
Transfer-Encoding: chunked
Server: Allegro-Software-RomPager/5.40b1
Access-Control-Allow-Origin: *
Access-Control-Allow-Headers: Content-Type
Connection: close
```

Figure 14. Bose SoundTouch devices online

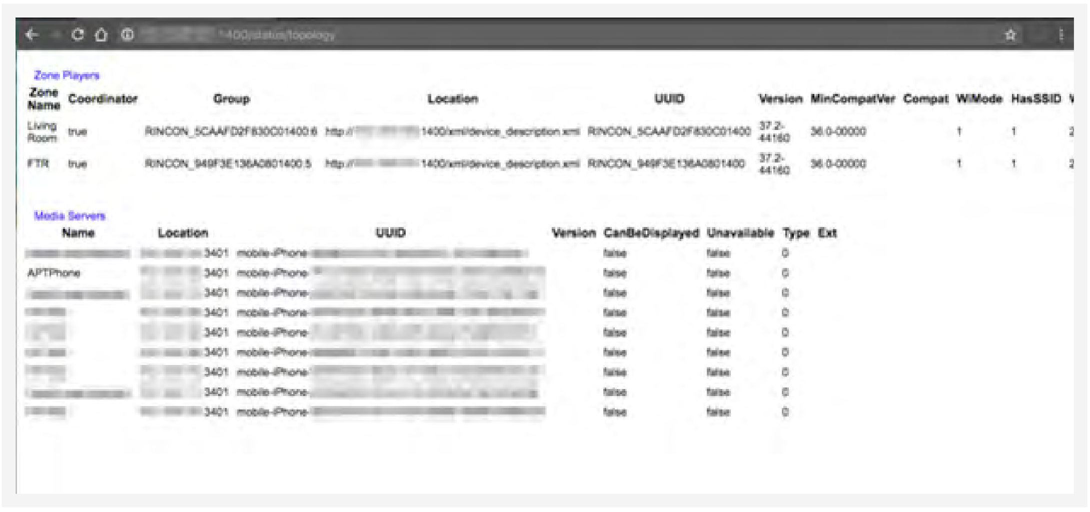
The Bose SoundTouch 10 does not have an Ethernet port, so these devices are being exposed directly to the internet via a misconfigured wireless router, or via UPnP which is being allowed to open to any host to connect to it.

Information Leakage

Within the Sonos control website are pages that have a plethora of information depending on how things are configured. One of the first pages we explored was a page labeled “topology” from the status page. This page keeps up with what devices have connected to the Sonos system to control it, and what other speakers this Sonos knows about. In Figure 15 we have a list of mobile phones that have connected to the Sonos system.

The Name field is the name configured on the device. Here we see that one of the phones was called APTPhone. This is the name that is under the about section of the iPhone in settings. The Location mentioned is the IP address of the remote device. This could be used to help gain some reconnaissance information regarding devices within the same network as the Sonos unit, and where they may be inside the network segments.

Next, we have the UUID, which, in this case, is what type of device it is, plus a random string afterwards that is not tied to a serial number or anything on the device. In fact, it looks like this changes every so often as we have five devices that have the same name. Given that the devices that were connected to it weren’t altered, this led us to believe that these are changing because of something else within the application that was downloaded from the app store. Other names we saw were Android phones that controlled the devices; names like “ASUS Transformer Pad TF300T” and “Samsung SGH-T599” and other variations of Samsung and other vendor phones like Motorola, HTC, and so on. What this gives an attacker is some ability to find out what devices are in the networks or that a person may specifically have.


[redacted]1400/status/topology

Zone Players

Zone Name	Coordinator	Group	Location	UUID	Version	MinCompatVer	Compat	WiMode	HasSSID	V
Living Room	true	RINCON_5CAAFD2F830C01400:6	http://[redacted]1400/xml/device_description.xml	RINCON_5CAAFD2F830C01400	37.2-44160	36.0-00000		1	1	2
FTR	true	RINCON_949F3E136A0801400:5	http://[redacted]1400/xml/device_description.xml	RINCON_949F3E136A0801400	37.2-44160	36.0-00000		1	1	2

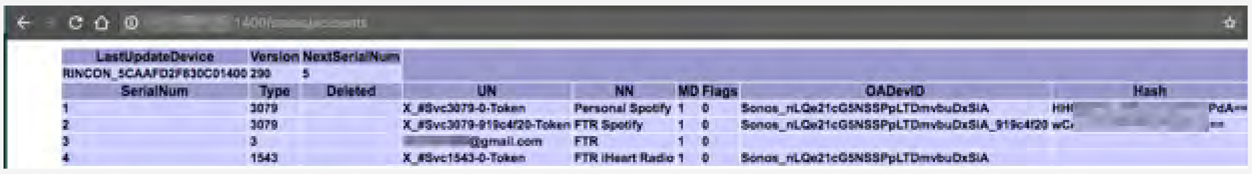
Media Servers

Name	Location	UUID	Version	CanBeDisplayed	Unavailable	Type	Ext
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
APTPhone	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	
[redacted]	[redacted]3401	mobile-iPhone-[redacted]		false	false	0	

Figure 15. Topology page showing what devices have connected to the Sonos

Not only were some of the devices we observed local to the Sonos device (meaning within RFC 1918 space), but we also saw addresses that were on the same internet routable IP space as the device. This could be because the device was plugged straight into the network, or because someone had used NAT to route the IP address through to the internet, allowing anyone to connect to the Sonos, and then the application on the controlling device used TCP/1400 to connect to the devices' SOAP XML interface to control the devices.

While this provides a good deal of information about the users, we can also find out more about the person if we go and take a look within the accounts page of the Sonos status page. This page keeps track of the accounts that are tied to the Sonos system. We tried a few music services such as Spotify, iHeart Radio, and Pandora, to name a few. This page includes a Serial Number that is just a basic number to keep track of the number of accounts, and a Type, which appears to denote the type of account (in our case, 3079 was Spotify and 3 was Pandora). The UN is the username for the account. Pandora was the only one that had an email address shown in our tests while the rest of the accounts used some kind of token that was generated. Next, NN is the Name applied to the account when configuring the device. This is a user-defined field and can be edited at any time. It defaulted to the first name of the person on the account; in the case of our test unit, it defaulted to 'stephen' for all the accounts. The OADevID looks like an ID used by the Sonos systems to communicate with the services. And then finally a Hash, in which only Spotify had a Hash. Initially, this Hash looked like it could have been base64 but it is not. And based on some additional looking, it does change with the length of the password for the Spotify account.



[redacted] 1400/[redacted]

LastUpdateDevice	Version	NextSerialNum
RINCON_5CAAFD2F630C01400	290	5

SerialNum	Type	Deleted	UN	NN	MD	Flags	OADevID	Hash
1	3079		X_#Svc3079-0-Token	Personal Spotify	1	0	Sonos_nLQe21cG5NSSPpLTDmvbuDxSIA	HH[redacted]PdA==
2	3079		X_#Svc3079-919c4f20-Token	FTR Spotify	1	0	Sonos_nLQe21cG5NSSPpLTDmvbuDxSIA_919c4f20	wC[redacted]==
3	3		[redacted]@gmail.com	FTR	1	0		
4	1543		X_#Svc1543-0-Token	FTR iHeart Radio	1	0	Sonos_nLQe21cG5NSSPpLTDmvbuDxSIA	

Figure 16. Accounts page on Sonos

Based on information on these pages, we coded a small script that would query the publicly available Sonos systems on the internet, read the accounts page, and parse out these fields. When we finished the parsing, we had 1,293 emails of which 727 were unique. Email addresses were then loaded into Maltego, an open source intelligence (OSINT) tool, and we ran multiple transforms on them. One transform was one that queries the website https://haveibeenpwned.com/, which keeps track of whether your email address has been seen in any breaches.

The Maltego graph got a little large given the size of the breach data and the number of email addresses. Showing the most common breached sites was a little cumbersome to show in the full Maltego graph as the one in Figure 17 is zoomed out to 10% to have all the nodes fit.

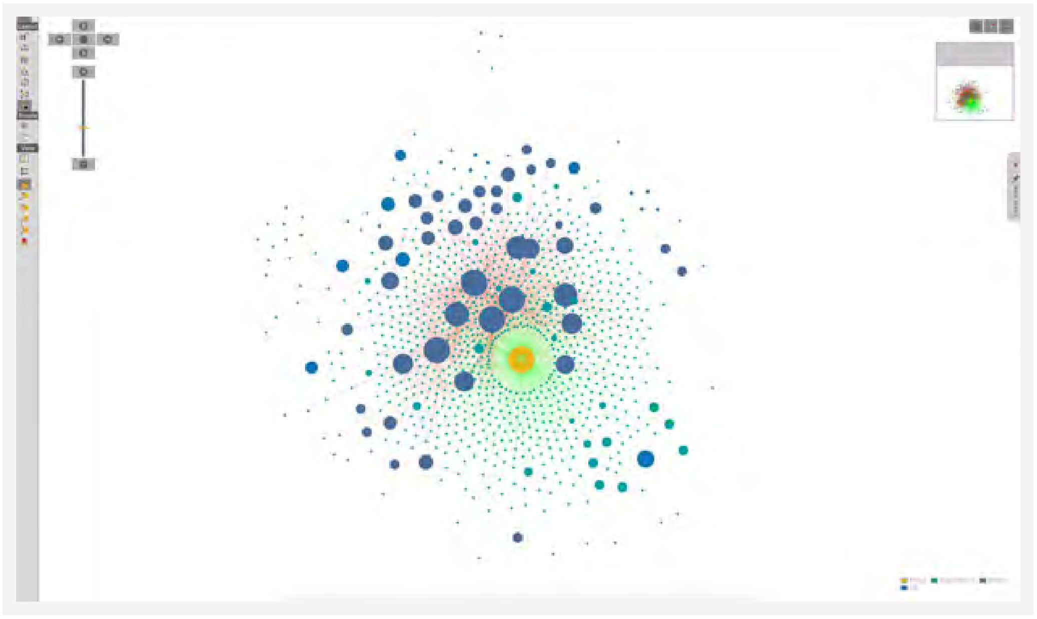


Figure 17. Maltego graph showing results of haveibeenpwnd.com

When you zoom in, you can see some of the top breaches listed, the ones we all know and likely had to deal with by changing passwords, or other issues that may have been caused by these breaches.

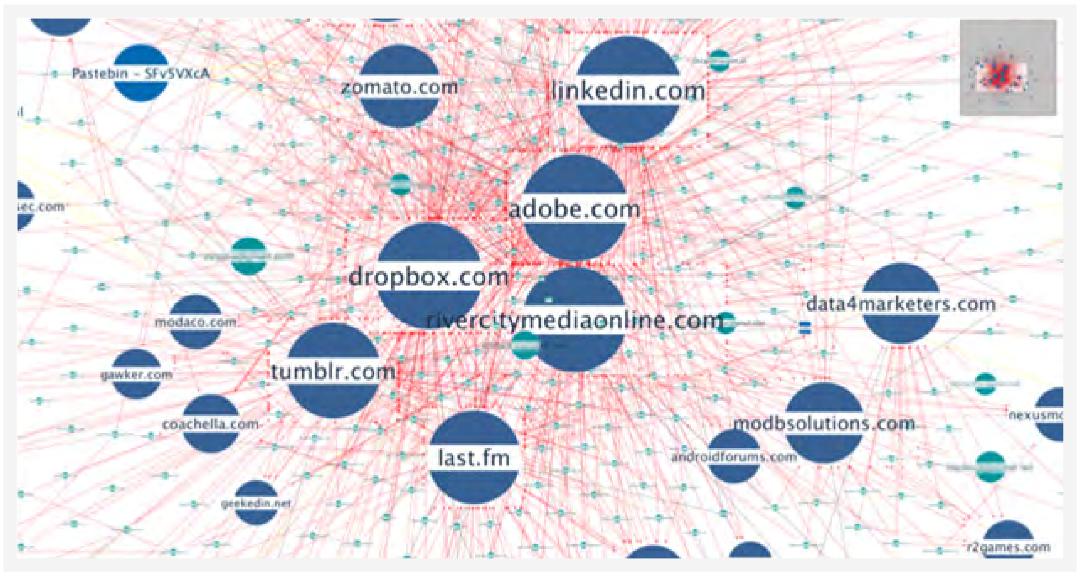


Figure 18. Zoomed in Maltego graph showing common breaches

The most common breach was the LinkedIn breach, with 177 accounts. This breach also had the password hashes released and people around the globe have cracked these passwords to use with penetration tests, or as malicious actors trying to break into accounts. Knowing these breaches and also what sites they came from could then lead an attacker to log into the users' accounts identified from the Sonos. Attackers can also check if the user hasn't changed passwords after the breach – an all too common occurrence.

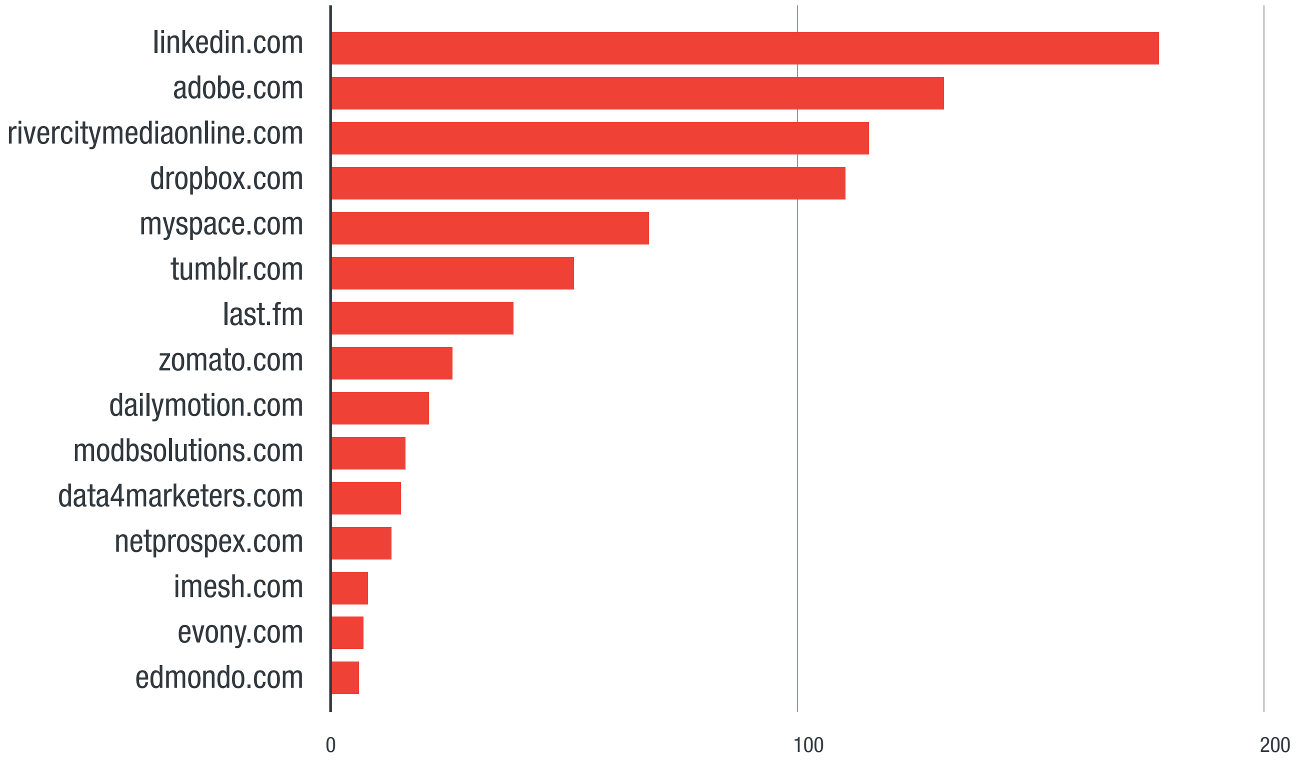
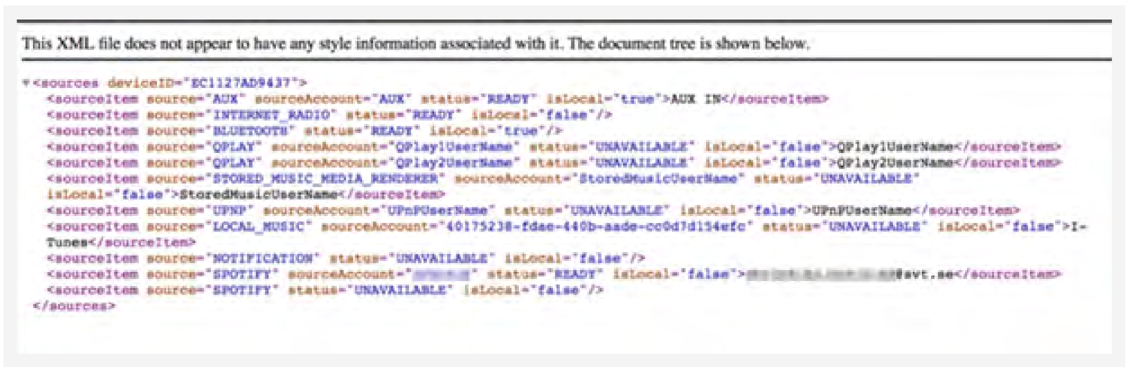


Figure 19. Sonos exposed emails per site breach

Much like the Sonos, the Bose SoundTouch also has a page that keeps track of the accounts that are linked to the device. Here we show the /sources page from the SoundTouch that shows the Spotify username which is the source account, as well as the email address that is linked to this Spotify account. Using the same methods from above, we could perform the same steps against any email addresses that were found within the Bose SoundTouch sources page.

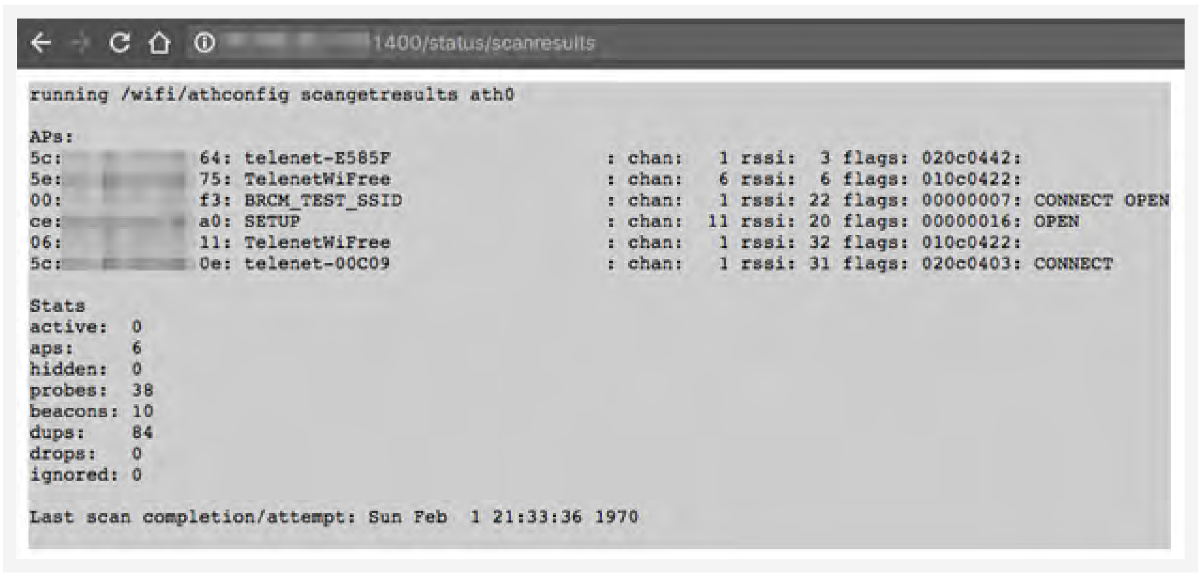


This XML file does not appear to have any style information associated with it. The document tree is shown below.

```
▾<sources deviceID="EC1127AD9437">
   <sourceItem source="AUX" sourceAccount="AUX" status="READY" isLocal="true">AUX IN</sourceItem>
   <sourceItem source="INTERNET_RADIO" status="READY" isLocal="false"/>
   <sourceItem source="BLUETOOTH" status="READY" isLocal="true"/>
   <sourceItem source="QPLAY" sourceAccount="QPlay1UserName" status="UNAVAILABLE" isLocal="false">QPlay1UserName</sourceItem>
   <sourceItem source="QPLAY" sourceAccount="QPlay2UserName" status="UNAVAILABLE" isLocal="false">QPlay2UserName</sourceItem>
   <sourceItem source="STORED_MUSIC_MEDIA_RENDERER" sourceAccount="StoredMusicUserName" status="UNAVAILABLE"
   isLocal="false">StoredMusicUserName</sourceItem>
   <sourceItem source="UPNP" sourceAccount="UPnPUserName" status="UNAVAILABLE" isLocal="false">UPnPUserName</sourceItem>
   <sourceItem source="LOCAL_MUSIC" sourceAccount="40175238-fdae-440b-aade-cc0d7d134efc" status="UNAVAILABLE" isLocal="false">I-
   Tunes</sourceItem>
   <sourceItem source="NOTIFICATION" status="UNAVAILABLE" isLocal="false"/>
   <sourceItem source="SPOTIFY" sourceAccount="[redacted]" status="READY" isLocal="false">[redacted]@svt.se</sourceItem>
   <sourceItem source="SPOTIFY" status="UNAVAILABLE" isLocal="false"/>
 </sources>
```

Figure 20. SoundTouch sources page

This is not the only page that an attacker may want to scrape to see information from the Sonos device. To aid in finding what is near the Sonos speaker, the speaker scans for nearby wireless access points (AP). This is done during the setup process to have the Sonos know what Wi-Fi AP you want to connect to. During setup, you'll choose the one you want to connect to, and what the password for the connection is. This is done over an SSID that the Sonos starts and you connect to. Once the speaker is associated to a wireless access point, you don't see this option unless you want to change what Wi-Fi it will connect to. Based on testing, if you are using the Ethernet port on the Sonos, this does not happen.



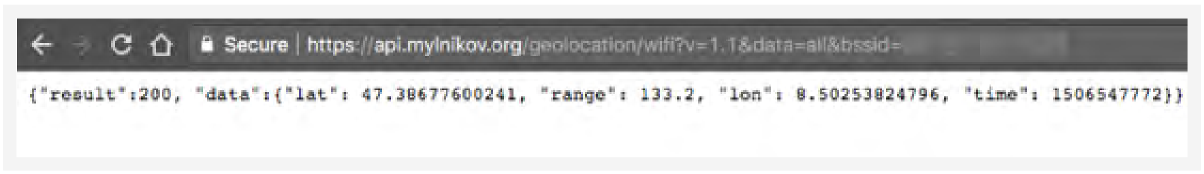
[redacted]1400/status/scanresults

```
running /wifi/athconfig scangetresults ath0

APs:
5c:[redacted]64: telenet-E585F                  : chan:   1 rssi:  3 flags: 020c0442:
5e:[redacted]75: TelenetWiFree                  : chan:   6 rssi:  6 flags: 010c0422:
00:[redacted]f3: BRCM_TEST_SSID                 : chan:   1 rssi: 22 flags: 00000007: CONNECT OPEN
ce:[redacted]a0: SETUP                          : chan:  11 rssi: 20 flags: 00000016: OPEN
06:[redacted]11: TelenetWiFree                  : chan:   1 rssi: 32 flags: 010c0422:
5c:[redacted]0e: telenet-00C09                  : chan:   1 rssi: 31 flags: 020c0403: CONNECT

Stats
active:   0
aps:      6
hidden:   0
probes:   38
beacons:  10
dups:     84
drops:    0
ignored:  0

Last scan completion/attempt: Sun Feb  1 21:33:36 1970
```

Figure 21. Scan results page from the Sonos system

While trying to figure out how to use this information to identify the owner of the Sonos system, we came across a website that compounds multiple sources of Wi-Fi geolocation. The website of Alexander Mylnikov has an API that you can use to query specific BSSIDs and find the latitude, longitude, and the approximate range in meters of where the access point is.

Based on the BRCM_TEST_SSID BSSID above, the API shows the latitude, longitude, and the range of 133.2 meters for the information pertaining to the test device.



Secure | https://api.mylnikov.org/geolocation/wifi?v=1.1&data=all&bssid=[redacted]

```
{"result":200, "data":{"lat": 47.38677600241, "range": 133.2, "lon": 8.50253824796, "time": 1506547772}}
```

Figure 22. API results for BRCM_TEST_SSID

This information can then be plotted on Google Maps to get a better picture of where the BSSID may be seen in the world. According to the API results, this particular BSSID is located in Zurich, Switzerland.

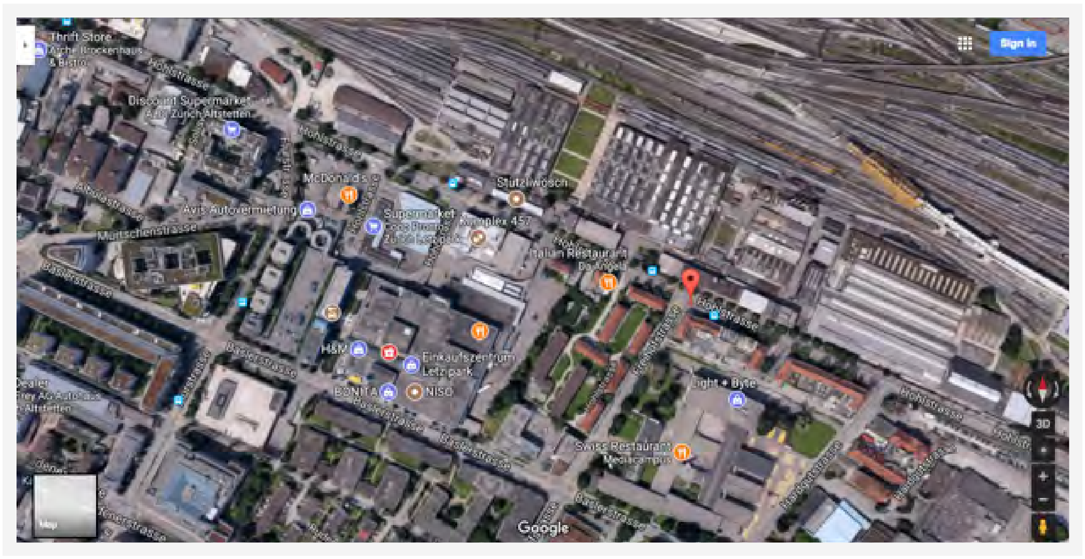


Figure 23. Approximate location of BRCM_TEST_SSID

To expand on this information, we once more wrote a script to scan publicly accessible Sonos systems on the internet. This time, we tried looking for BSSID and SSID details, then looked them up in the mentioned API for location, and stored them as a KML file to load into Google Earth. There were multiple things we wanted to see while trying to do this. For example, we wanted to see how accurate the grouping of the SSIDs were in a given area to figure out approximate locations of the Sonos systems.

At the time of our survey of exposed Sonos units online, we found 12,311 BSSIDs. Out of these, 10,219 had geolocations inside the API. A quick scroll around in Google Earth showed that there was some pretty good accuracy in the location of these access points. Here is an example showing the location of SSIDs in a location in the Netherlands. Based on the groupings of these SSIDs, you can get a general location down to a few blocks where the Sonos speaker is likely located. While completely possible, we chose not to narrow down the locations of these devices even further for this case study.

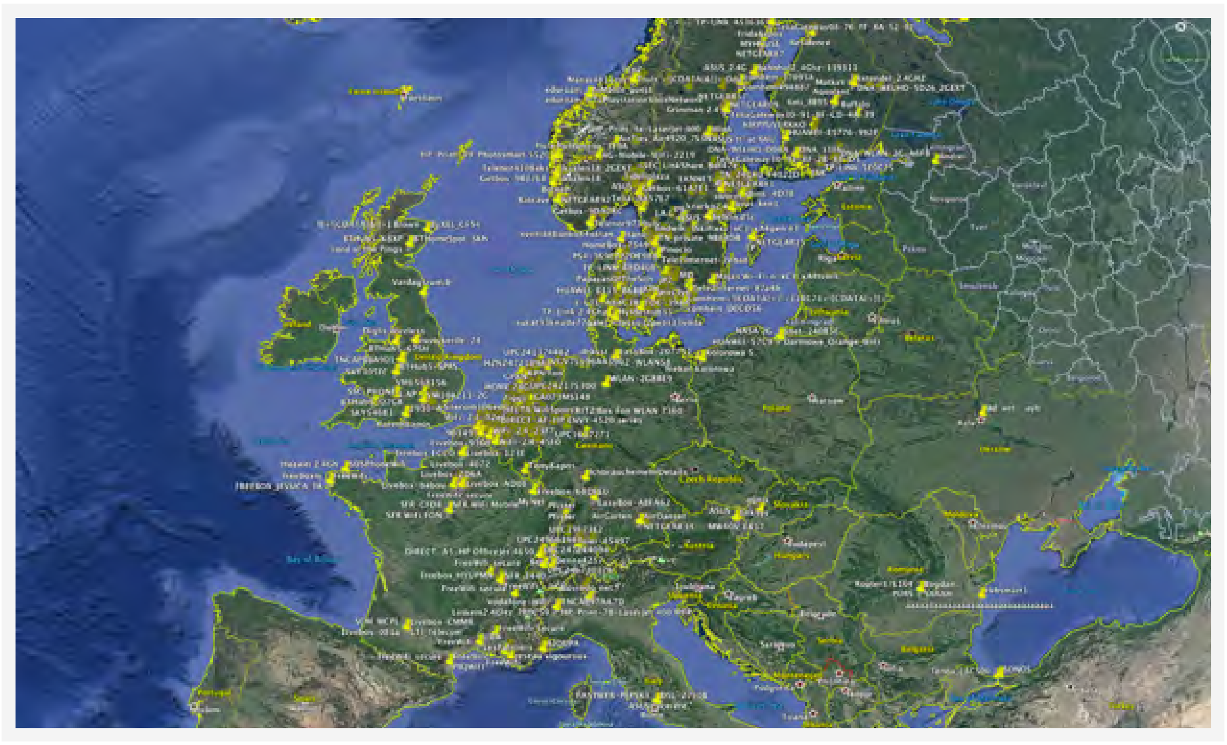


Figure 24. High-level view of parts of Europe with exposed Sonos devices

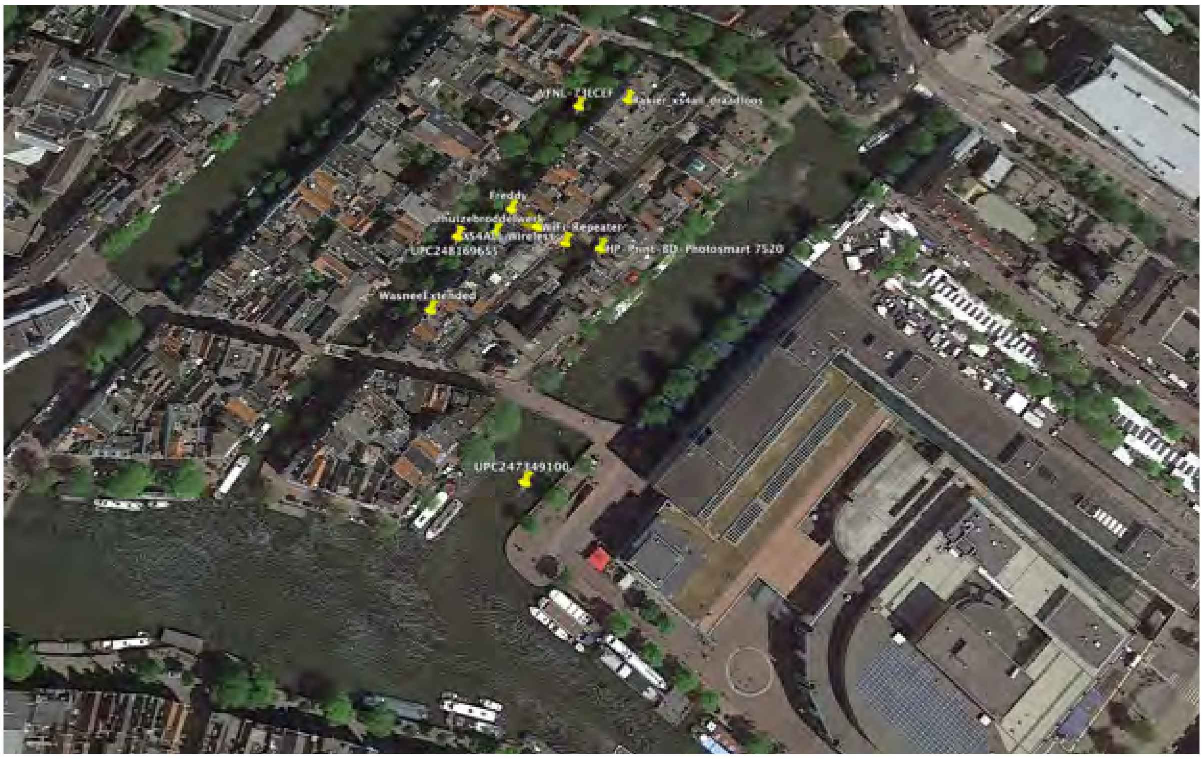


Figure 25. Zoomed-in area in The Netherlands

These are just a few of the pages wherein we examined information. There are plenty of other types of information on a few other pages that could be utilized. For example, in the "wpa_supplicant.log" page, you can see what access point the Sonos is joining, and partner this with the already-collected information to get a closer approximation of the location of the Sonos speaker. Sifting through the collected SSIDs, we were able to see the AP names as well.

^_^	Princess Leia 's
Hogwarts Great Hall WiFi	This is Wifiiiiii
NoFreeWifiForYou	Back office
Pretty fly for a Wifi	Nacho WiFi
A_LAN_DOWN_BY_THE_RIVER	Bill_Wi_the_science_Fi
Ermarhgerd We Fer	404 Server Error
Router? I hardly know her	2ez4me

Table 1. Some of the Wi-Fi SSIDs we found

The Bose SoundTouch had a more limited view, based on what we have seen that from the port 8080 on the device, there is a configuration page that shows you the neighboring SSIDs and allows you to connect to one. While this doesn't present you the same information such as the BSSID or RSSI that the Sonos does, using services like Wigle, it is possible to look up approximate locations based on the SSID itself.

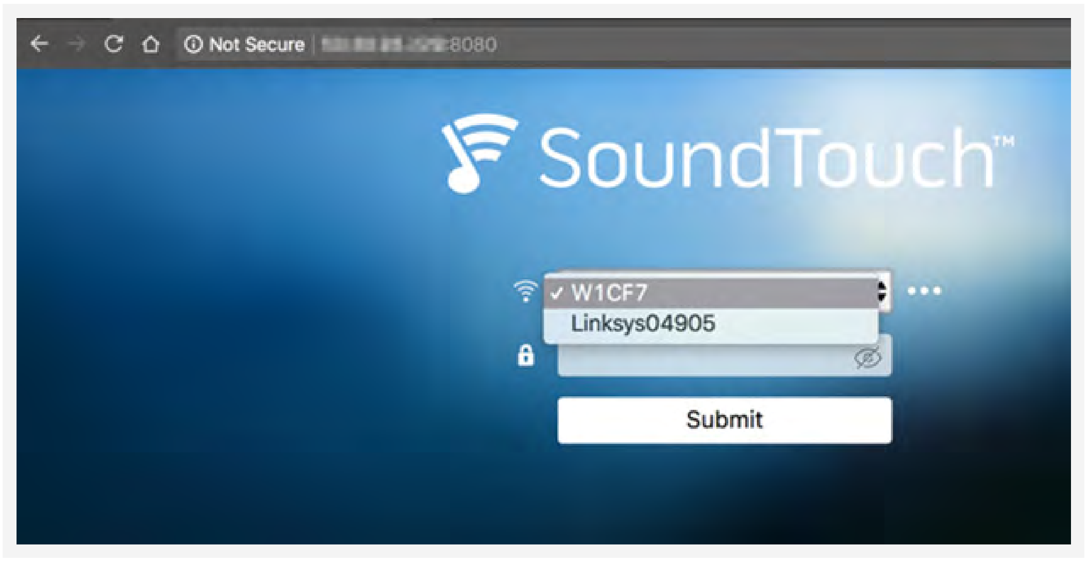


Figure 26. SoundTouch Wi-Fi configuration page

Using a Wigle account, it is possible to search the SSID and find a location based off of the SSID. If there are multiple SSIDs, you can partner this information with the IP address geolocation to figure out a more accurate location for the SSID. Figure 27 is an example of searching for the SSID shown in Figure 26 in Wigle. This shows that the Bose SoundTouch device is in the Baltimore area. We can perform with the same results as we did with the Sonos with multiple SSIDs.

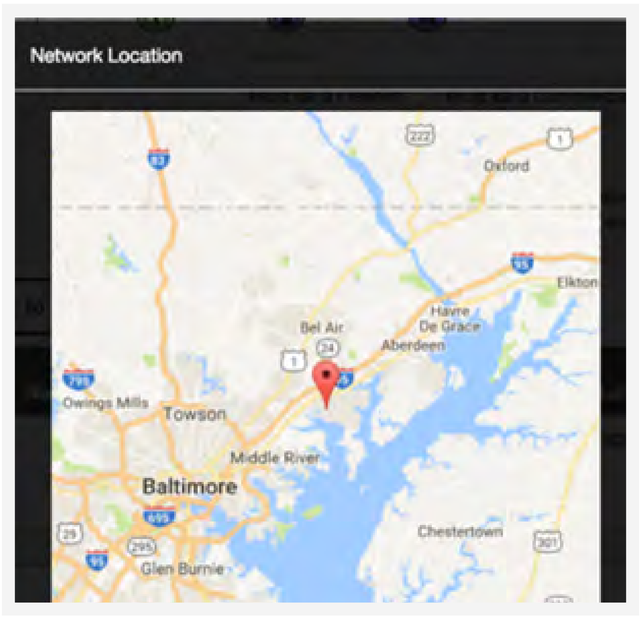


Figure 27. Location of SSID according to Wigle

Another cause for concern is the shares page. This page shows any mounted shared drives that are used in the library. We tested this and it provided a list of all songs that were on the shared drive that were playable by the Sonos system. This also includes any local folders you have shared with your Sonos speaker. When setting up the Sonos you have to manually add these — they are not auto-discovered.

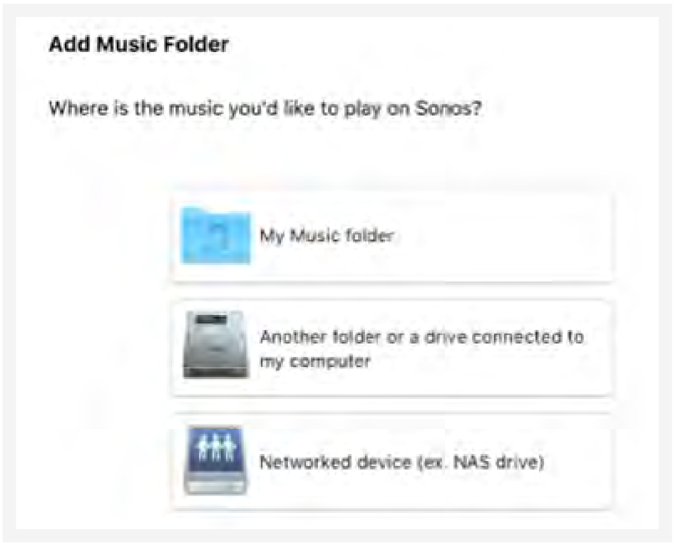

Add Music Folder
Where is the music you'd like to play on Sonos?
My Music folder
Another folder or a drive connected to my computer
Networked device (ex. NAS drive)

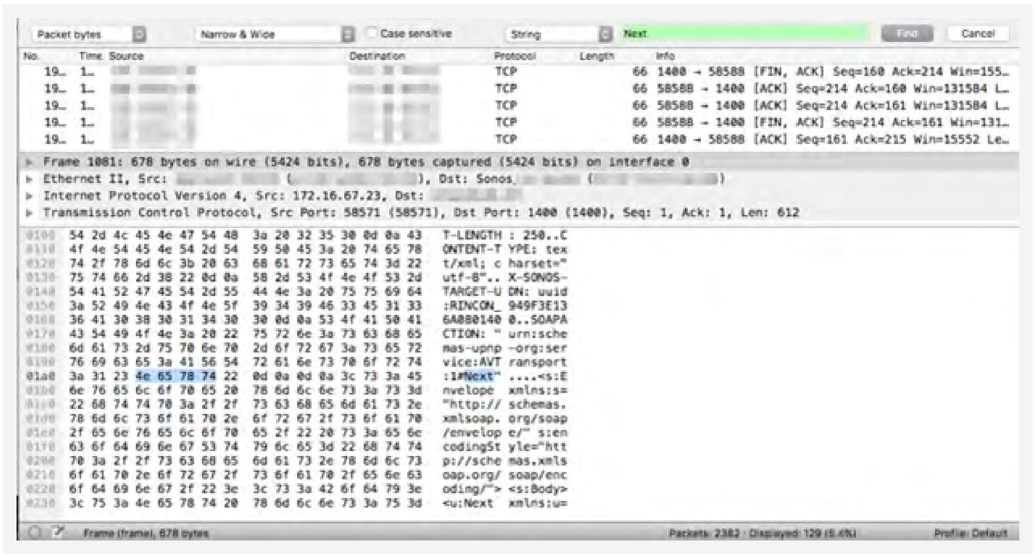
Figure 28. Example of the Sonos Add Music folder page

Once you have added any of the above options, they will show up in the shares page on the Sonos status page. This information could be utilized to collect more information about a potential target of an attack. If an attacker finds out what type of music or even an artist the user liked, it may provide an avenue for an attack. For example, the attacker could craft a spear-phishing email leveraging social engineering, or promising tickets to an upcoming gig of the target's favorite artist.

Knowing that these speakers are very popular, a possible attack scenario is that an attacker could write a web application that scans for this information via a client-side attack. This could be done within a Java Applet, or if there is a vulnerability within the browser, by using a CSRF (Cross Site Request Forgery) to try to scan a local subnet via the browser. This could gather information about the Sonos that are not directly exposed on the internet and gain the same information as shown previously. Also, malware could be utilized for the same attack trying to collect more information about these devices and their owners.

Sonos Control

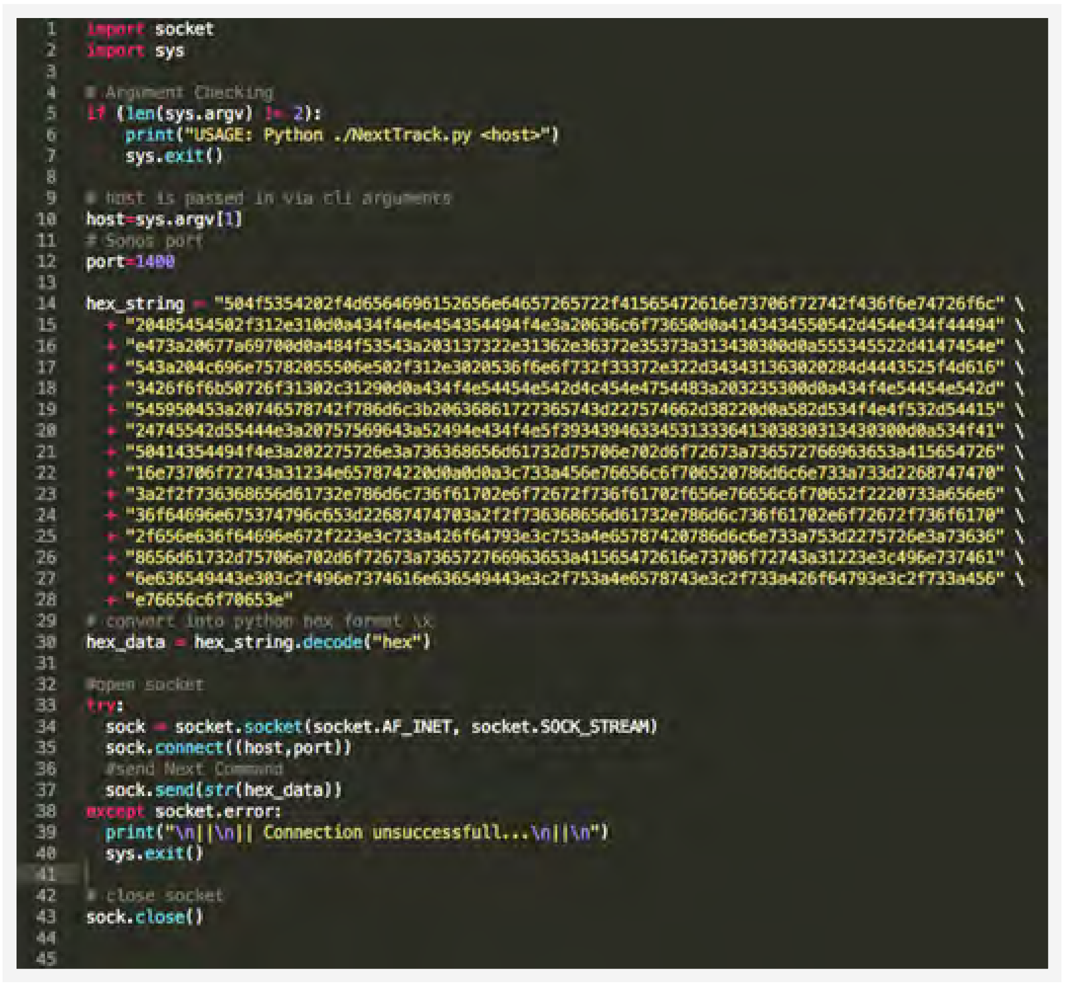
While there is a lot of information that is on the status page of the Sonos, there is still more information we can learn by interfacing directly with the SOAP XML interface. When looking into the information that is sent back and forth between the client and the Sonos system, you find that you can see in plain text the commands that are being used to control the Sonos, such as pause, play, skip to the next track, and change the volume. Of course anything that you can do with the app you can do over this SOAP XML interface also, as we will show it has no authentication or encryption. When you watch the commands in a tool such as Wireshark, you can see all this information. Below is an example of the "Next" command within Wireshark.



```
No.  Time Source      Destination  Protocol Length Info
 19… 1…  [redacted]   [redacted]   TCP      66 1400 → 58588 [FIN, ACK] Seq=160 Ack=214 Win=155…
 19… 1…  [redacted]   [redacted]   TCP      66 58588 → 1400 [ACK] Seq=214 Ack=160 Win=131584 L…
 19… 1…  [redacted]   [redacted]   TCP      66 58588 → 1400 [ACK] Seq=214 Ack=161 Win=131584 L…
 19… 1…  [redacted]   [redacted]   TCP      66 58588 → 1400 [FIN, ACK] Seq=214 Ack=161 Win=131…
 19… 1…  [redacted]   [redacted]   TCP      66 1400 → 58588 [ACK] Seq=161 Ack=215 Win=15552 Le…

▸ Frame 1081: 678 bytes on wire (5424 bits), 678 bytes captured (5424 bits) on interface 0
▸ Ethernet II, Src: [redacted] ([redacted]), Dst: Sonos_[redacted] ([redacted])
▸ Internet Protocol Version 4, Src: 172.16.67.23, Dst: [redacted]
▸ Transmission Control Protocol, Src Port: 58571 (58571), Dst Port: 1400 (1400), Seq: 1, Ack: 1, Len: 612

0100  54 2d 4c 45 4e 47 54 48  3a 20 32 35 30 0d 0a 43   T-LENGTH : 250..C
0110  4f 4e 54 45 4e 54 2d 54  59 50 45 3a 20 74 65 78   ONTENT-T YPE: tex
0120  74 2f 78 6d 6c 3b 20 63  68 61 72 73 65 74 3d 22   t/xml; c harset="
0130  75 74 66 2d 38 22 0d 0a  58 2d 53 4f 4e 4f 53 2d   utf-8".. X-SONOS-
0140  54 41 52 47 45 54 2d 55  44 4e 3a 20 75 75 69 64   TARGET-U DN: uuid
0150  3a 52 49 4e 43 4f 4e 5f  39 34 39 46 33 45 31 33   :RINCON_ 949F3E13
0160  36 41 30 38 30 31 34 30  30 0d 0a 53 4f 41 50 41   6A080140 0..SOAPA
0170  43 54 49 4f 4e 3a 20 22  75 72 6e 3a 73 63 68 65   CTION: " urn:sche
0180  6d 61 73 2d 75 70 6e 70  2d 6f 72 67 3a 73 65 72   mas-upnp -org:ser
0190  76 69 63 65 3a 41 56 54  72 61 6e 73 70 6f 72 74   vice:AVT ransport
01a0  3a 31 23 4e 65 78 74 22  0d 0a 0d 0a 3c 73 3a 45   :1#Next" ....<s:E
01b0  6e 76 65 6c 6f 70 65 20  78 6d 6c 6e 73 3a 73 3d   nvelope  xmlns:s=
01c0  22 68 74 74 70 3a 2f 2f  73 63 68 65 6d 61 73 2e   "http:// schemas.
01d0  78 6d 6c 73 6f 61 70 2e  6f 72 67 2f 73 6f 61 70   xmlsoap. org/soap
01e0  2f 65 6e 76 65 6c 6f 70  65 2f 22 20 73 3a 65 6e   /envelop e/" s:en
01f0  63 6f 64 69 6e 67 53 74  79 6c 65 3d 22 68 74 74   codingSt yle="htt
0200  70 3a 2f 2f 73 63 68 65  6d 61 73 2e 78 6d 6c 73   p://sche mas.xmls
0210  6f 61 70 2e 6f 72 67 2f  73 6f 61 70 2f 65 6e 63   oap.org/ soap/enc
0220  6f 64 69 6e 67 2f 22 3e  3c 73 3a 42 6f 64 79 3e   oding/"> <s:Body>
0230  3c 75 3a 4e 65 78 74 20  78 6d 6c 6e 73 3a 75 3d   <u:Next  xmlns:u=

Frame (frame), 678 bytes          Packets: 2382 · Displayed: 129 (5.4%)          Profile: Default
```

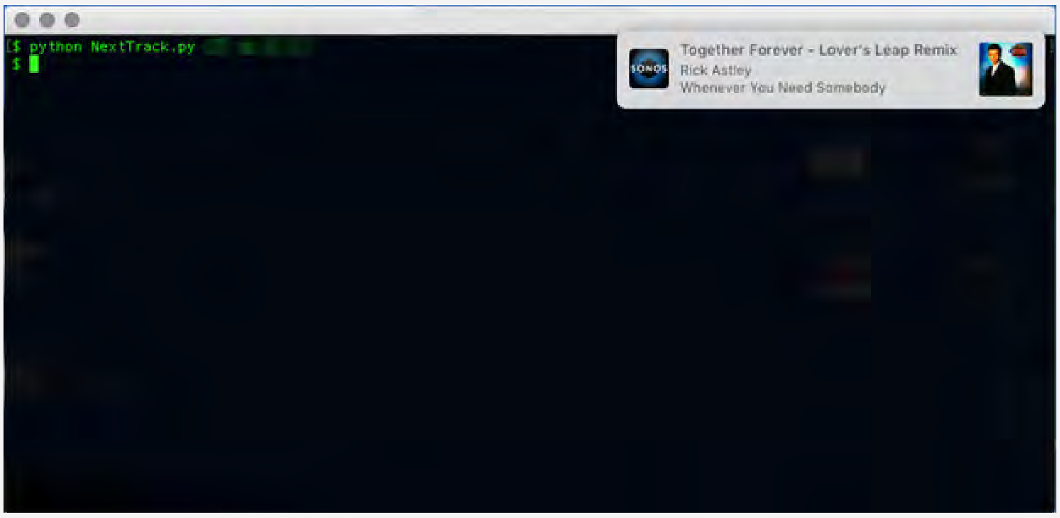
Figure 29. Sonos Next command sent via user interface

We wanted to see if there is anything within this packet that could hinder us from resending the same data again and be able to skip songs. After further inspection of the packet, it was determined that a packet replay would likely successfully change the song on the Sonos system. To test this, we took the packet from Wireshark by selecting it and copying the Hex Stream. We then stripped the Ethernet and IPv4 headers off the packet and sent the information with the code below. As expected, the song went to the next track. Figures 30 and 31 show the script running, and the Sonos application running to alert us that the next track is playing and what it is. The Sonos application does not need to be running to change to the next track — This is only included to visually show the change in this paper.



```python
import socket
import sys

# Argument Checking
if (len(sys.argv) != 2):
    print("USAGE: Python ./NextTrack.py <host>")
    sys.exit()

# host is passed in via cli arguments
host=sys.argv[1]
# Sonos port
port=1400

hex_string = "504f5354202f4d6564696152656e64657265722f41565472616e73706f72742f436f6e74726f6c" \
  + "20485454502f312e310d0a434f4e4e454354494f4e3a20636c6f73650d0a4143434550542d454e434f44494" \
  + "e473a20677a69700d0a484f53543a203137322e31362e37352e35373a313430300d0a555345522d4147454e" \
  + "543a204c696e757820555506e502f312e3020536f6e6f732f33372e322d343431363020284d4443525f4d616" \
  + "3426f6f6b50726f31302c31290d0a434f4e54454e542d4c454e4754483a203235300d0a434f4e54454e542d" \
  + "545950453a20746578742f786d6c3b20636861727365743d227574662d38220d0a582d534f4e4f532d54415" \
  + "24745542d55444e3a20757569643a52494e434f4e5f393439463345313336413038303134303030d0a534f41" \
  + "50414354494f4e3a202275726e3a736368656d61732d75706e702d6f72673a736572766963653a415654726" \
  + "16e73706f72743a31234e657874220d0a0d0a3c733a456e76656c6f706520786d6c6e733a733d2268747470" \
  + "3a2f2f736368656d61732e786d6c736f61702e6f72672f736f61702f656e76656c6f70652f2220733a656e6" \
  + "36f64696e675374796c653d22687474703a2f2f736368656d61732e786d6c736f61702e6f72672f736f6170" \
  + "2f656e636f64696e672f223e3c733a426f64793e3c753a4e65787420786d6c6e733a753d2275726e3a73636" \
  + "8656d61732d75706e702d6f72673a736572766963653a41565472616e73706f72743a31223e3c496e737461" \
  + "6e636549443e303c2f496e7374616e636549443e3c2f753a4e6578743e3c2f733a426f64793e3c2f733a456" \
  + "e76656c6f70653e"
# convert into python hex format \x
hex_data = hex_string.decode("hex")

#open socket
try:
  sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
  sock.connect((host,port))
  #send Next Command
  sock.send(str(hex_data))
except socket.error:
  print("\n||\n|| Connection unsuccessfull...\n||\n")
  sys.exit()

# close socket
sock.close()
```

Figure 30. Python code to change to the next song

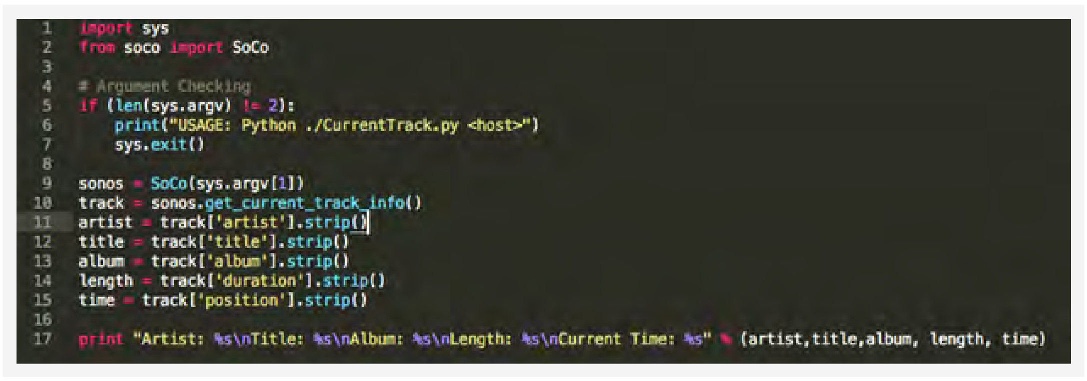


```
$ python NextTrack.py
$ 
```

SONOS
Together Forever - Lover's Leap Remix
Rick Astley
Whenever You Need Somebody

Figure 31. Sonos notification saying the next song is playing

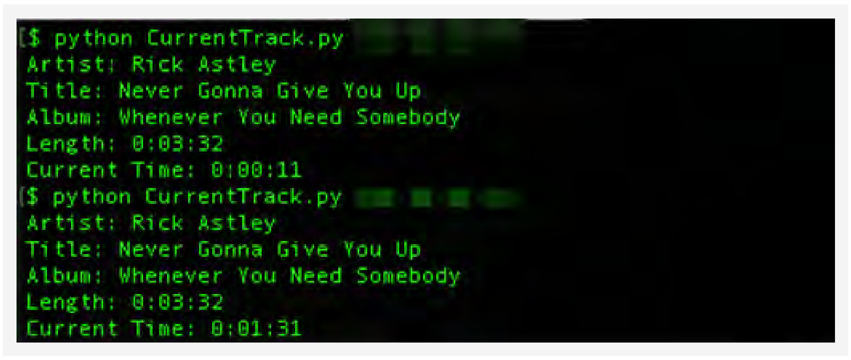
Before going much further in looking into what else we could code to control the device, a simple search showed us that there is a preexisting Python Library called SoCo that was written to help control the devices. There is even an example web application to control your Sonos devices. It's key to point out that there is no authentication for any of the methods on the Sonos SOAP XML interface. This means that anyone can control your device or watch the tracks, or even just monitor what songs you are playing. This could be done to learn more about the person who owns the Sonos, or it could be done to determine when someone is around the Sonos and is listening to music. In the case of attackers, given they already know approximately where the devices are located, they can now use this to determine when a person is physically at home or not by observing these patterns over time. A burglar could also use this knowledge to determine when the property is vacant and go into the house based on these patterns. To test this idea that we could monitor what was being watched, we decided to write up something using SoCo that pulls the currently played track.



```
import sys
from soco import SoCo

# Argument Checking
if (len(sys.argv) != 2):
    print("USAGE: Python ./CurrentTrack.py <host>")
    sys.exit()

sonos = SoCo(sys.argv[1])
track = sonos.get_current_track_info()
artist = track['artist'].strip()
title = track['title'].strip()
album = track['album'].strip()
length = track['duration'].strip()
time = track['position'].strip()

print "Artist: %s\nTitle: %s\nAlbum: %s\nLength: %s\nCurrent Time: %s" % (artist,title,album, length, time)
```

Figure 32. Python code using SoCo to list details about the current track

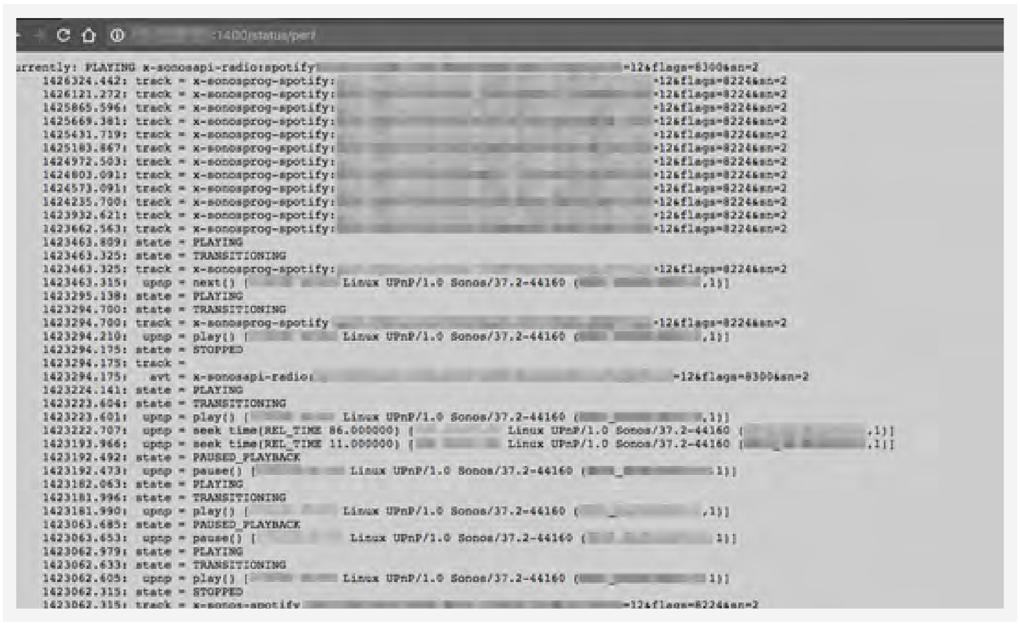
We found that in the response, there is a field that shows how long the song is, and what the current time in the track it is at. This could be used by an attacker to determine if the song is being played or paused as well as to help determine if the person is actively listening to the track, or if it is paused based on the time between queries. Shown here is an example of the above script running on our Sonos test unit. This shows that the Sonos is currently being played.



```
[$ python CurrentTrack.py [redacted]
 Artist: Rick Astley
 Title: Never Gonna Give You Up
 Album: Whenever You Need Somebody
 Length: 0:03:32
 Current Time: 0:00:11
[$ python CurrentTrack.py [redacted]
 Artist: Rick Astley
 Title: Never Gonna Give You Up
 Album: Whenever You Need Somebody
 Length: 0:03:32
 Current Time: 0:01:31
```

Figure 33. Sonos current track current time example

Under the SoCo project, there is an example of playing a song by providing it a URI path. Upon further searching, we found that there is a project called Ghosty that utilizes the Ruby scripting language to play songs on a Sonos at random times that mimic a ghost or a creaking door. While this sounds like a simple piece of fun code, there are real-world examples in the Sonos community forums of this happening to people, and not just creaking doors and ghost sounds. One post described the user's experience of hearing sounds similar to "an explosion from a movie." It is likely a scary encounter to have your speaker turn on and make an explosion sound that repeats until you unplug the device itself. One user responded to the original poster and said they should check out the diagnosis page that is located at status/perf. This information can be used for any forensics you may have to do on these devices as it keeps a record of what IPs are connecting to the Sonos device and what commands they are running. Here is an example of our perf page.



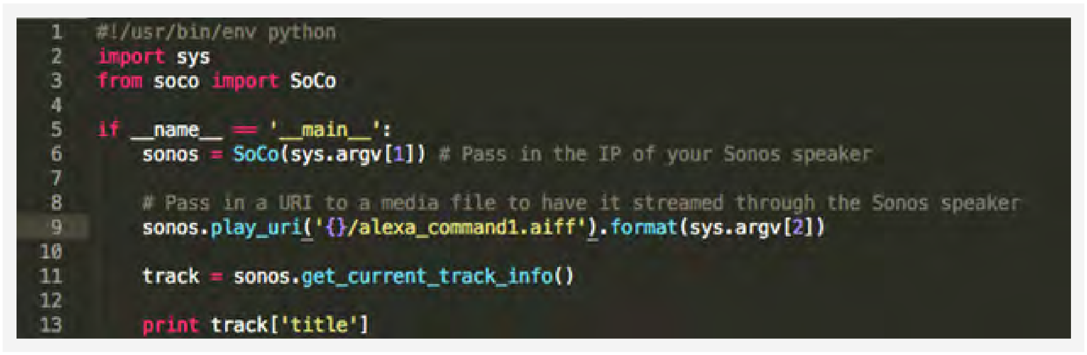
```
[redacted]:1400/status/perf
urrently: PLAYING x-sonosapi-radio:spotify[redacted]=12&flags=8300&sn=2
    1426324.442: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1426121.272: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1425865.596: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1425669.381: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1425431.719: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1425183.867: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1424972.503: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1424803.091: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1424573.091: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1424235.700: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1423932.621: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1423662.563: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1423463.809: state = PLAYING
    1423463.325: state = TRANSITIONING
    1423463.325: track = x-sonosprog-spotify:[redacted]=12&flags=8224&sn=2
    1423463.315:  upnp = next() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423295.138: state = PLAYING
    1423294.700: state = TRANSITIONING
    1423294.700: track = x-sonosprog-spotify [redacted]=12&flags=8224&sn=2
    1423294.210:  upnp = play() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423294.175: state = STOPPED
    1423294.175: track =
    1423294.175:   avt = x-sonosapi-radio:[redacted]=12&flags=8300&sn=2
    1423224.141: state = PLAYING
    1423223.604: state = TRANSITIONING
    1423223.601:  upnp = play() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423222.707:  upnp = seek time(REL_TIME 86.000000) [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423193.966:  upnp = seek time(REL_TIME 11.000000) [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423192.492: state = PAUSED_PLAYBACK
    1423192.473:  upnp = pause() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted]1)]
    1423182.063: state = PLAYING
    1423181.996: state = TRANSITIONING
    1423181.990:  upnp = play() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted],1)]
    1423063.685: state = PAUSED_PLAYBACK
    1423063.653:  upnp = pause() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted]1)]
    1423062.979: state = PLAYING
    1423062.633: state = TRANSITIONING
    1423062.605:  upnp = play() [[redacted] Linux UPnP/1.0 Sonos/37.2-44160 ([redacted]1)]
    1423062.315: state = STOPPED
    1423062.315: track = x-sonos-spotify[redacted]=12&flags=8224&sn=2
```

Figure 34. Sonos status/perf page

After the command such as next(), there is an IP address followed by the OS and also the type of computer at the end of the entry.

In recent news, there was an episode of South Park that made people's Amazon Echo units add things to their Amazon wish list. When we saw the episode, we were amazed because we had tried the exact same thing for this research, but the episode aired before we could publish this. Congratulations Eric Cartman for beating us to this research.

Based on the SoCo example to play a URI path, we coded up an example where we hosted the sounds of Alexa commands as a proof of concept. For the audio content, there were a few options. We could simply record our voice, something that we have done a few times before in earlier research where we showed that you can control an Echo with a human voice. Instead, we chose to use the say command within Linux and created an MP3 and hosted it on a local web server. Once we had the sound file, we ran our script to play a URI path.



```
#!/usr/bin/env python
import sys
from soco import SoCo

if __name__ == '__main__':
    sonos = SoCo(sys.argv[1]) # Pass in the IP of your Sonos speaker

    # Pass in a URI to a media file to have it streamed through the Sonos speaker
    sonos.play_uri('{}/alexa_command1.aiff').format(sys.argv[2])

    track = sonos.get_current_track_info()

    print track['title']
```

Figure 35. Python script to play URI path

Once played, the Echo performed the task that we tested. We tested a few commands, which are listed in the table below along with the outcome.

Command	Result
“Alexa what time is it”	“The time is 3:12 pm”
“Alex rap for me ”	Connect sync link all the pieces of your life I Get it done at the speed of WiFi I’m the player, the coach, the arena, the game If you want something done, you just gotta say my name
“Alexa play song”	“I can’t find any music in your library”
“Alexa What’s on my shopping list”	“Our shopping list is empty”
“Alexa <item> to shopping list”	“I have added <item> to your shopping list”
“Alexa turn off hue light”	Lights turns off “OK”

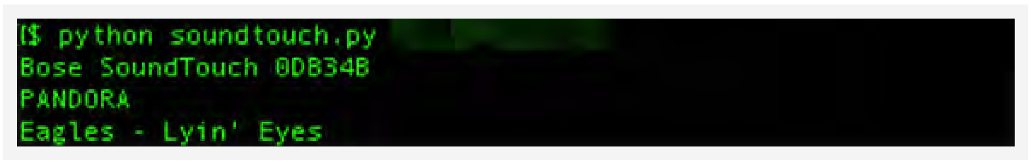
Table 2. Commands sent via Sonos to Alexa

With the Bose SoundTouch devices, you can also play a URL. Inside of the libsoundtouch documentation, it mentions that you can point it to a URL just as with the Sonos systems. This was not tested as we did not have a Bose SoundTouch test unit to issue commands at. However, this allows the same commands to be issued as we have demonstrated above.

```
# Play URL
device.play_url('http://fqdn/file.mp3')
```

Figure 36. play_url function in libsoundtouch

As with the Sonos, it is also possible to get the current track playing on the SoundTouch devices, and this information could be used in the same way as it can be with the Sonos. However, one noticeable difference is that the source in which the track is being played can be gathered easily. Below is the example of a device that was queried.



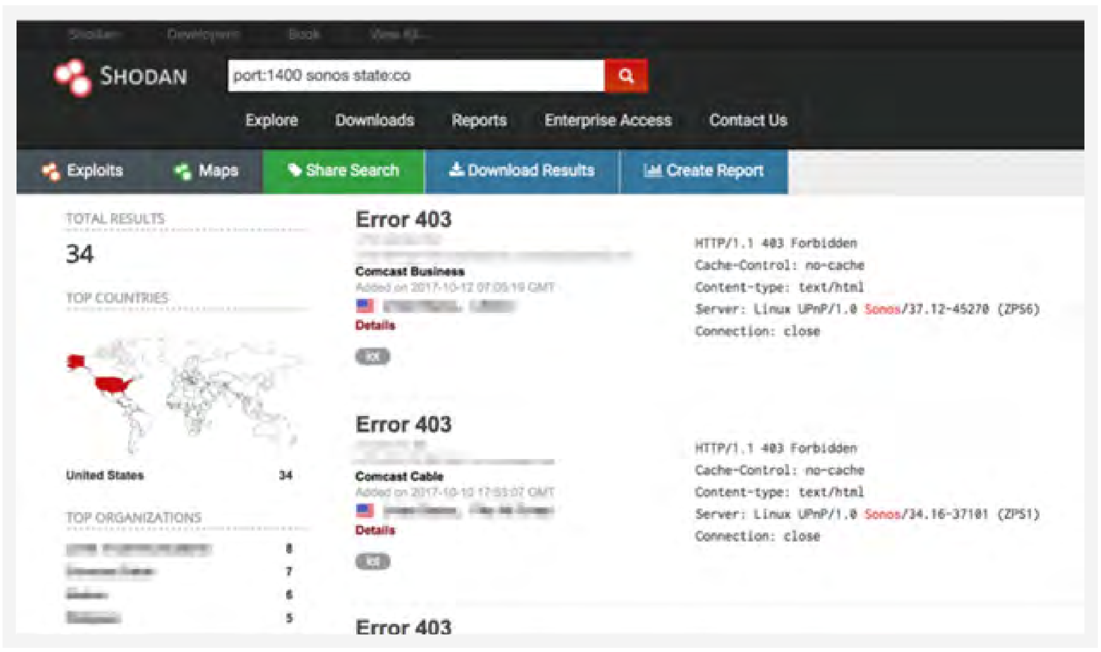
```
[$ python soundtouch.py [redacted]
Bose SoundTouch 0DB34B
PANDORA
Eagles - Lyin' Eyes
```

Figure 37. Song currently playing on the Bose SoundTouch

A Case of Finding the Target

Combining everything we now know about how information was being leaked, and having determined more information about the current state of the Sonos speaker, we decided to do a case study of one user to determine if we could find out more about the person, and the area where they live. We chose a Sonos speaker at random and proceeded. The identity of the person won't be revealed but the steps we took will be outlined.

In Colorado, there were a couple of Sonos devices shown in Shodan. In total, we found six exposed devices online at the time of testing and chose one at random.



TOTAL RESULTS
34

TOP COUNTRIES

United States 34

TOP ORGANIZATIONS

[redacted]	8
[redacted]	7
[redacted]	6
[redacted]	5

Error 403
[redacted]
Comcast Business
[redacted]
Details

```
HTTP/1.1 403 Forbidden
Cache-Control: no-cache
Content-type: text/html
Server: Linux UPnP/1.0 Sonos/37.12-45270 (ZPS6)
Connection: close
```

Error 403
[redacted]
Comcast Cable
[redacted]
Details

```
HTTP/1.1 403 Forbidden
Cache-Control: no-cache
Content-type: text/html
Server: Linux UPnP/1.0 Sonos/34.16-37101 (ZPS1)
Connection: close
```

Error 403

Figure 38. Sonos devices in Colorado showing in Shodan

Once we had the device IP, we browsed to the accounts page, viewed the scan results page, and looked up the BSSIDs as we had done before. This led us to go down classic open source intelligence routes to find more information about the person.

First, the accounts page gave us a Pandora account. We know it's a Pandora account due to the Type being listed as 3, which is the same as the Pandora account that was linked to our Sonos test unit. This email address was recorded and put into Maltego, where we ran a few transforms on the email address and found only one really useful bit of information — which is that the person has a Pandora account with that email address (no surprises there).

Viewing the "scanresults" page provided us with the general location of this Sonos based on the BSSID geolocation lookups via the previously mentioned API.

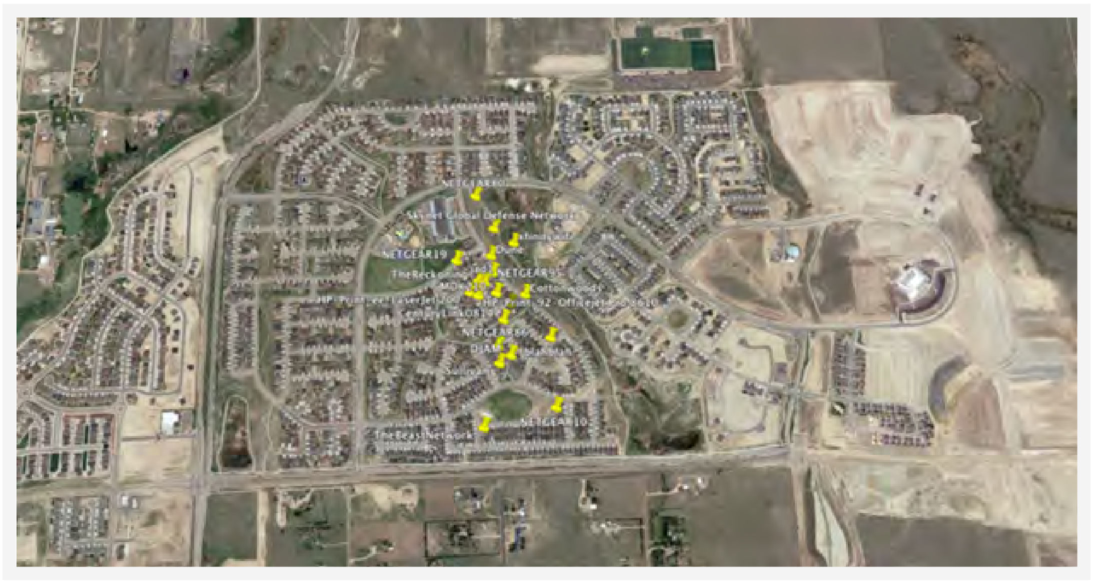


Figure 39. Approximate location of the randomly chosen Sonos unit

Based on this information, we started trying to figure out the exact location of the Sonos based on the other information that is in the Sonos website.

For the email address, we cross-referenced the subject user's email address with Pipl, an online search tool used to locate people based off of public information. In doing so, it was possible to find a name associated with the email address.

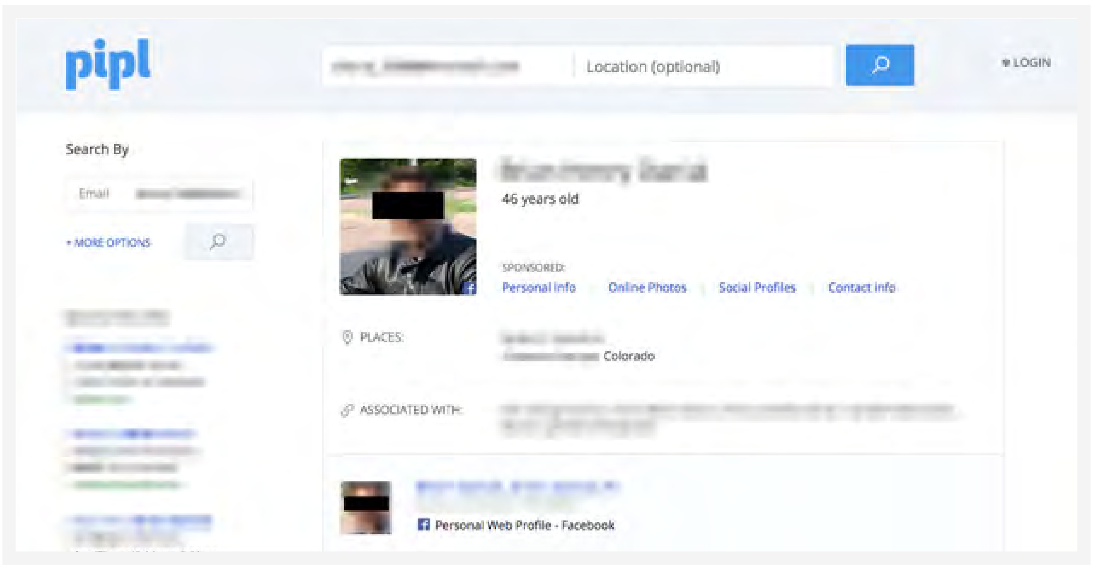
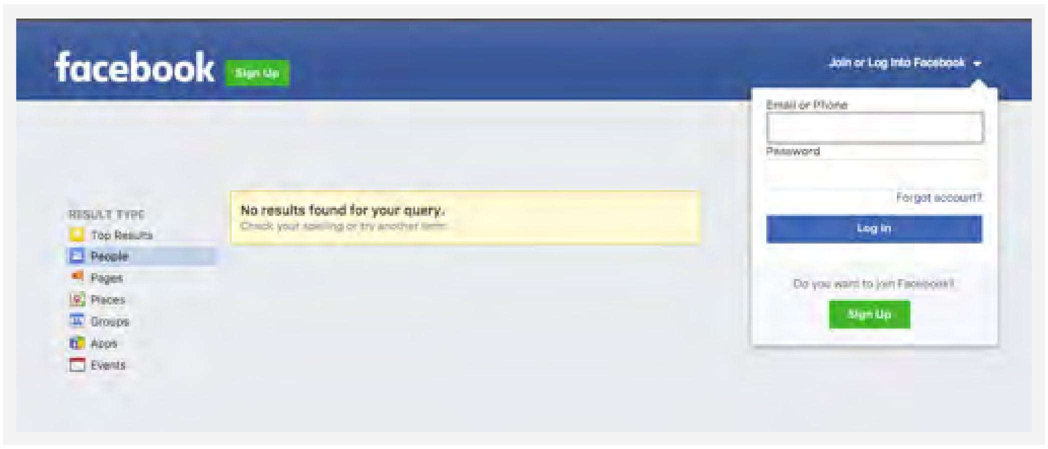


Figure 40. Search result in Pipl

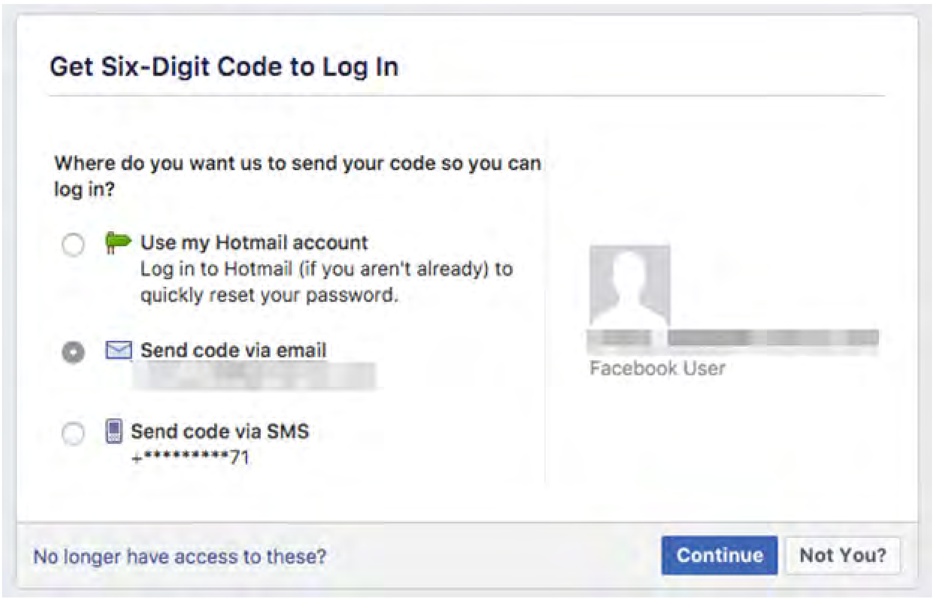
Sites like Pipl should be taken with a grain of salt, so we went on to verify the information by searching for the email address on Facebook to see if we could generate the same account by email address. Using the site IntelTechniques.com, you can search Facebook for an email address. In this case, the result on Facebook was that we could not tie the email address to an account, as shown below.



No results found for your query.
Check your spelling or try another term.

Figure 41. Email address not found on Facebook

This is fine as this could be because of a privacy setting that doesn't allow people to search for the user by email address. So, another way to search for an email address is to click the "Forgot account" link and use the email address as the input.



Get Six-Digit Code to Log In

Where do you want us to send your code so you can log in?

Use my Hotmail account
Log in to Hotmail (if you aren't already) to quickly reset your password.

[✓ Send code via email]
[redacted]

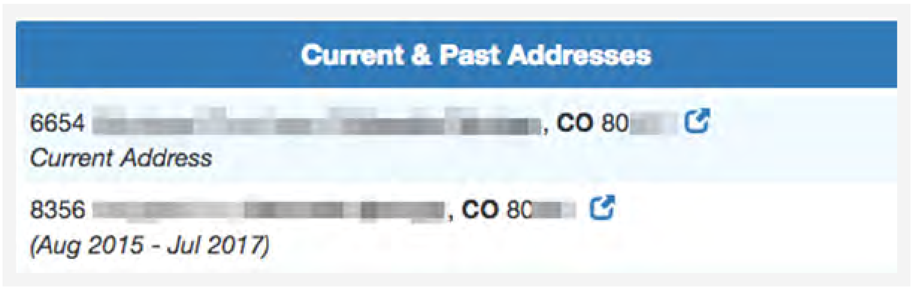
Send code via SMS
+*********71

[redacted]
Facebook User

Figure 42. Reset account screen on Facebook

In this case, we can see that this is a valid email address for someone on Facebook, but we aren't presented with a Facebook profile picture or anything else that may help us tie the two accounts together based on the Pipl search. At this point, we normally wouldn't consider these accounts verified. But knowing the neighboring access points and a possible name of the person who owns that email address, we can attempt to find an address for this person in the town.

Using a website called FamilyTreeNow.com, or any other site that has public records on it, we can start to see if we can find a possible address for this person, and we found a few potential addresses. The state this user was in also has a really interesting public database that gives the current address of a person and their voter information. This information, along with the information from FamilyTreeNow.com, led us to an address that was highly likely to be correct. In normal OSINT, there is no really great way to determine if this is the address of the person, other than based on records.



Current & Past Addresses

6654 [redacted], **CO** 80[redacted]
Current Address

8356 [redacted], **CO** 80[redacted]
(Aug 2015 - Jul 2017)

Figure 43. Possible addresses pulled from FamilyTreeNow.com

Since we already had local scanning of nearby SSIDs and our previously discussed method of mapping these out, we were able to plot the address from our OSINT investigation and see if we were close to those access points. As can be seen in Figure 44, the suspected current address above mapped to a location that is directly beside the previously shown SSIDs.

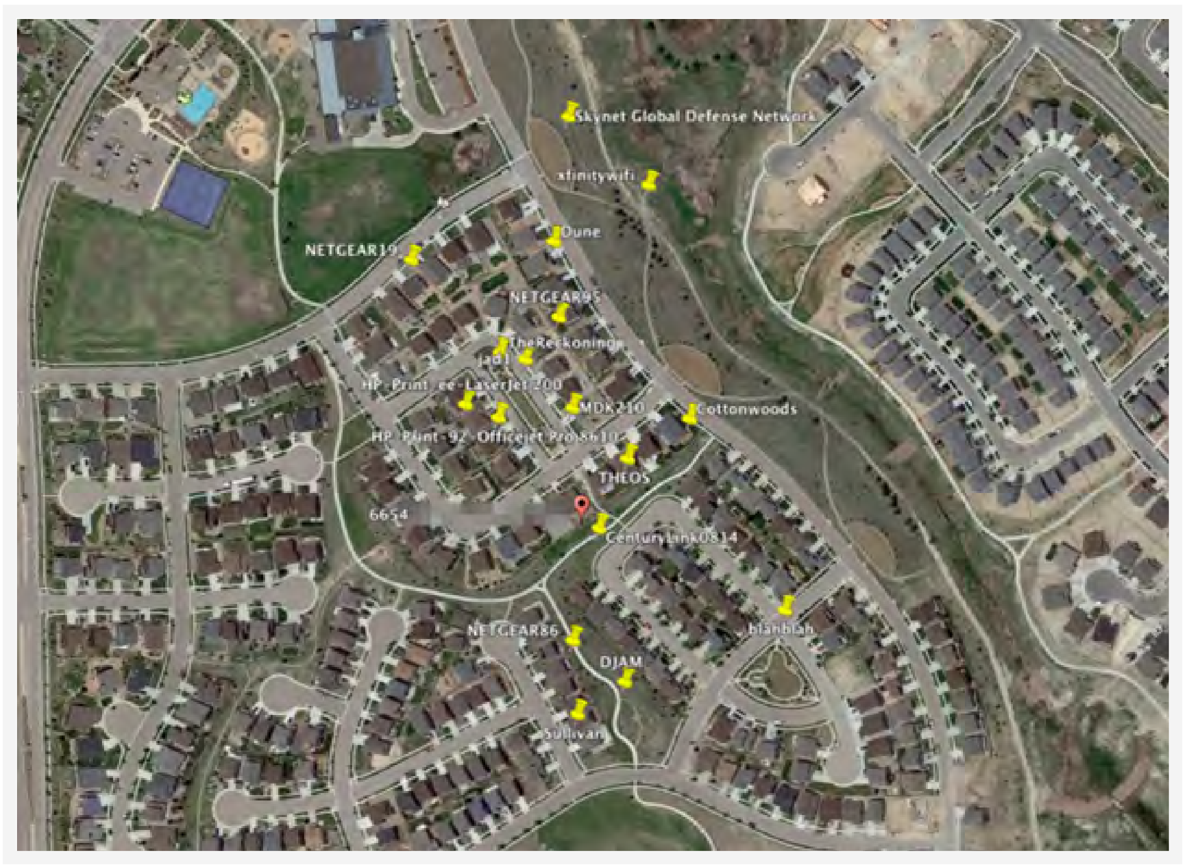
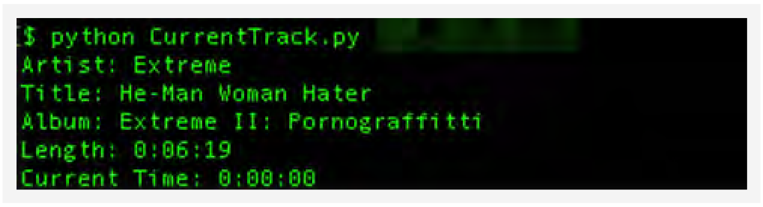


Figure 44. Address mapped with SSIDs

Now we had to figure out if we could find what type of music the person may be into. Running our previous script that pulls the current track revealed that the person may like 80s hair metal, or is into classic rock based on the selection that was currently playing.



```
$ python CurrentTrack.py [redacted]
Artist: Extreme
Title: He-Man Woman Hater
Album: Extreme II: Pornograffitti
Length: 0:06:19
Current Time: 0:00:00
```

Figure 45. Song currently playing on Sonos

Phishing With Sonar

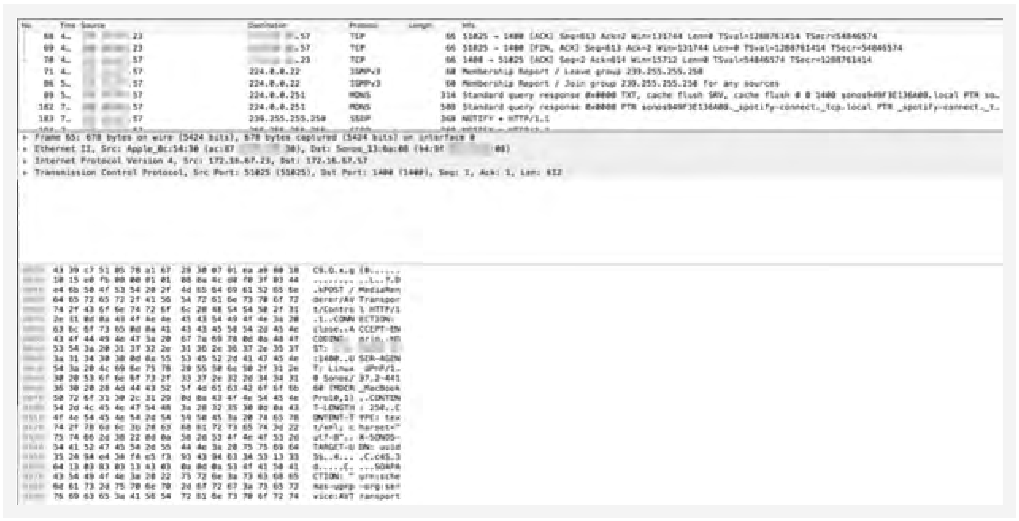
With the ability to target users down to knowing the exact house they are in and then confirming it based on only the information that's within the Sonos and OSINT, an attacker could take the information and send them a targeted phishing attack to try and get them to become a victim of malware. In this attack case, however, we can now add sound to make the phish more believable – much like when people are fishing with fish finders that use sonar, a system that emits sound pulses and listens for them to bounce off an object. In this case, an attacker can use sound as well. However, it won't be a pulse of sounds but a directed message to partner with the email. Needless to say, we did not go so far as to use this attack scenario on the individual in our research. But we did verify everything on our own test setup.

Let's assume that an attacker knows your model number, serial number, and all the other information about your Sonos. They can then take that information and craft a message that states "Sonos System Alert: Your Sonos Play:1 speaker is having some technical difficulties, instructions on how to correct this can be located within an email sent to your email address that you have registered with."

Partnering the email with the audio alert would make the message even more believable to even the most skeptical end user, such that the likelihood of getting the person to fall for the phish would likely be more than if this was just an email sent to the email address that was found within the Sonos system.

Exploitation

During the research, we also wanted to see if we could find any exploits that may be remotely leveraged by fuzzing some of the SOAP XML interface fields. This started with us writing a custom script to first fuzz the UUID field. While playing a song on the Sonos speaker, we ran our script and quickly made the Sonos stop playing songs and remove itself from the application to control the Sonos. As shown here, it sends an IGMPv3 leave group message as well as an MDNS query to flush the cache for the Sonos name. While this is not a buffer overflow or anything at this point in time, there are some mishandling issues if the values are non-ASCII values. In this case, you see the UUID is shown as 0x352494e434f4e5r39343946334531333641303830313430 30a0d. All the UUIDS end with 0x0a0d as that's a new line and a carriage return value in hex. If the values have an ASCII to start with such as AAAAAA_AAAAAAAAAAAAAAAAAA00 and this proved to not crash the system, the music continues to play. So, it appears that parsing non-ASCII values is causing this issue.



```
No.  Time Source          Destination       Protocol  Length Info
  68 4…   [redacted].23   [redacted].57     TCP              66 51025 → 1400 [ACK] Seq=613 Ack=2 Win=131744 Len=0 TSval=1208761414 TSecr=54846574
  69 4…   [redacted].23   [redacted].57     TCP              66 51025 → 1400 [FIN, ACK] Seq=613 Ack=2 Win=131744 Len=0 TSval=1208761414 TSecr=54846574
  70 4…   [redacted].57   [redacted].23     TCP              66 1400 → 51025 [ACK] Seq=2 Ack=614 Win=15712 Len=0 TSval=54846574 TSecr=1208761414
  71 4…   [redacted].57   224.0.0.22        IGMPv3           60 Membership Report / Leave group 239.255.255.250
  86 5…   [redacted].57   224.0.0.22        IGMPv3           60 Membership Report / Join group 239.255.255.250 for any sources
  89 5…   [redacted].57   224.0.0.251       MDNS            314 Standard query response 0x0000 TXT, cache flush SRV, cache flush 0 0 1400 sonos949F3E136A00.local PTR so…
 102 7…   [redacted].57   224.0.0.251       MDNS            580 Standard query response 0x0000 PTR sonos949F3E136A00._spotify-connect._tcp.local PTR _spotify-connect._t…
 103 7…   [redacted].57   239.255.255.250   SSDP            360 NOTIFY * HTTP/1.1
▸ Frame 65: 678 bytes on wire (5424 bits), 678 bytes captured (5424 bits) on interface 0
▸ Ethernet II, Src: Apple_0c:54:30 (ac:87[redacted]30), Dst: Sonos_13:6a:00 (94:9f[redacted]00)
▸ Internet Protocol Version 4, Src: 172.16.67.23, Dst: 172.16.67.57
▸ Transmission Control Protocol, Src Port: 51025 (51025), Dst Port: 1400 (1400), Seq: 1, Ack: 1, Len: 612

[redacted]
43 39 c7 51 05 78 a1 67  28 30 07 01 ea a9 00 10   C9.Q.x.g (0......
10 15 e0 f5 00 00 01 01  08 0a 4c d0 f0 3f 03 44   ........ ..L..?.D
e4 6b 50 4f 53 54 20 2f  4d 65 64 69 61 52 65 6e   .kPOST / MediaRen
64 65 72 65 72 2f 41 56  54 72 61 6e 73 70 6f 72   derer/AV Transpor
74 2f 43 6f 6e 74 72 6f  6c 20 48 54 54 50 2f 31   t/Contro l HTTP/1
2e 31 0d 0a 43 4f 4e 4e  45 43 54 49 4f 4e 3a 20   .1..CONN ECTION: 
63 6c 6f 73 65 0d 0a 41  43 43 45 50 54 2d 45 4e   close..A CCEPT-EN
43 4f 44 49 4e 47 3a 20  67 7a 69 70 0d 0a 48 4f   CODING:  gzip..HO
53 54 3a 20 31 37 32 2e  31 36 2e 36 37 2e 35 37   ST: [redacted]
3a 31 34 30 30 0d 0a 55  53 45 52 2d 41 47 45 4e   :1400..U SER-AGEN
54 3a 20 4c 69 6e 75 78  20 55 50 6e 50 2f 31 2e   T: Linux  UPnP/1.
30 20 53 6f 6e 6f 73 2f  33 37 2e 32 2d 34 34 31   0 Sonos/ 37.2-441
36 30 20 28 4d 44 43 52  5f 4d 61 63 42 6f 6f 6b   60 (MDCR _MacBook
50 72 6f 31 30 2c 31 29  0d 0a 43 4f 4e 54 45 4e   Pro10,1) ..CONTEN
54 2d 4c 45 4e 47 54 48  3a 20 32 35 30 0d 0a 43   T-LENGTH : 250..C
4f 4e 54 45 4e 54 2d 54  59 50 45 3a 20 74 65 78   ONTENT-T YPE: tex
74 2f 78 6d 6c 3b 20 63  68 61 72 73 65 74 3d 22   t/xml; c harset="
75 74 66 2d 38 22 0d 0a  58 2d 53 4f 4e 4f 53 2d   utf-8".. X-SONOS-
54 41 52 47 45 54 2d 55  44 4e 3a 20 75 75 69 64   TARGET-U DN: uuid
35 24 94 e4 34 f4 e5 f3  93 43 94 63 34 53 13 33   5$..4... .C.c4S.3
64 13 03 03 03 13 43 03  0a 0d 0a 53 4f 41 50 41   d.....C. ...SOAPA
43 54 49 4f 4e 3a 20 22  75 72 6e 3a 73 63 68 65   CTION: " urn:sche
6d 61 73 2d 75 70 6e 70  2d 6f 72 67 3a 73 65 72   mas-upnp -org:ser
76 69 63 65 3a 41 56 54  72 61 6e 73 70 6f 72 74   vice:AVT ransport
```

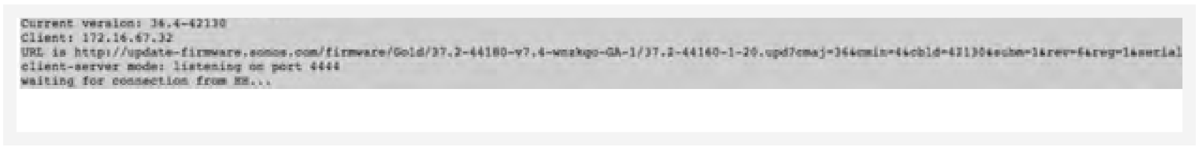
Figure 46. Non-ASCII characters causing the DoS

Because we stopped the tracks at will from playing and we disappeared from the application, an attacker could also do this method to have their phishing attack be more successful. If the attacker sent an email from product support and said that it had noticed the Sonos system is having an issue and to click a link to learn more information and get support on how to fix the Sonos system, again the likelihood of success would go up.

Hardware Hacking

With IoT devices, there is always the question of how the hardware is implemented. With the spread of IoT botnets like Mirai, we looked closer at the exposed systems. We felt like there were enough of these online that if there was an issue found with the firmware, there was a large enough user base for an attacker to create a botnet. Not only can an attacker script a ping-based DDoS bot already (based on the page shown earlier), but we wondered what else could be done if there is access to the hardware?

First we checked what was possible to do with the firmware file. We attempted to capture the files over a network pcap, then extract the firmware from the pcap. This turned out to be a waste of time because there is an “upgrade.log” file on the status page of the Sonos. This page contains a URL string that when you copy and paste into a browser or cURL/wget you will get the firmware file that the Sonos is running. It turned out that, based on the two models we had, there is a PowerPC version and an ARM version of the hardware. We focused on the ARM version because it seemed to be the most prevalent and had the most number of tool sets that could work with the firmware files if extracted.

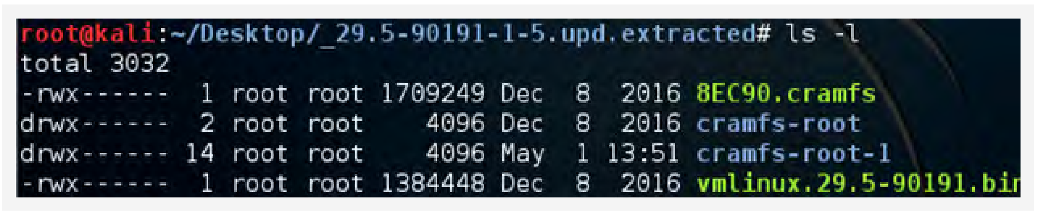


```
Current version: 36.4-42130
Client: 172.16.67.32
URL is http://update-firmware.sonos.com/firmware/Gold/37.2-44180-v7.4-wnzkgo-GA-1/37.2-44160-1-20.upd?cmaj=36&cmin=4&cbld=42130&schm=1&rev=6&reg=1&serial
client-server mode: listening on port 4444
waiting for connection from XX...
```

Figure 47. Example of upgrade.log that shows the URL of the firmware file

We did some looking into this and there were examples of people on forums that had downloaded older versions of the firmware and were able to extract it and read the contents. However, this was not the case for our firmware files that we downloaded. Most of them were gziped firmware with custom entry points.

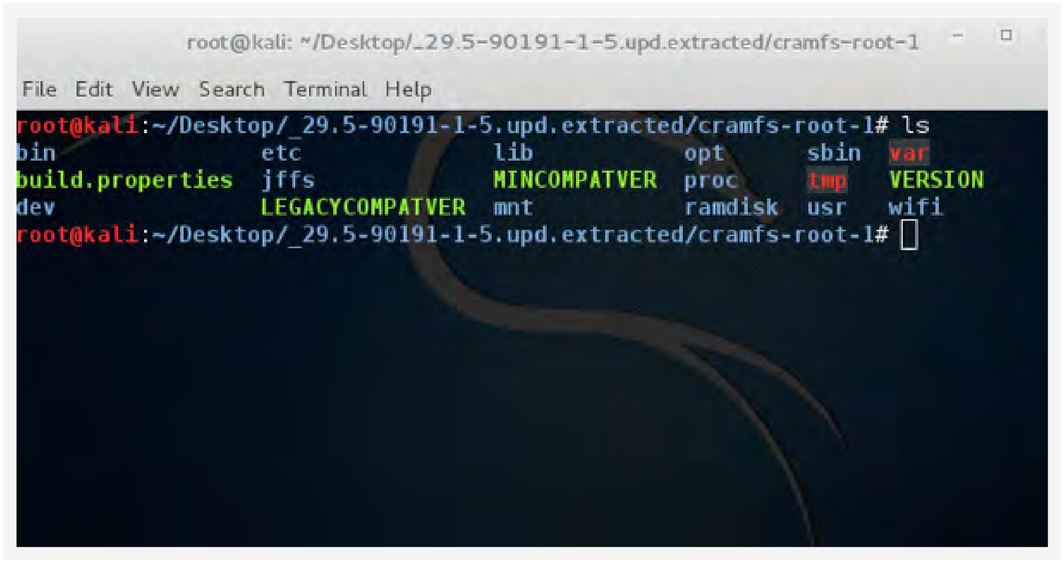
We attempted to find older versions of firmware to see if there were any versions we could locate that were able to be unpacked. We found an older version of 29.5-90191-1-5. This version was able to be extracted via binwalk where we had a few files that were extracted.



```
root@kali:~/Desktop/_29.5-90191-1-5.upd.extracted# ls -l
total 3032
-rwx------  1 root root 1709249 Dec  8  2016 8EC90.cramfs
drwx------  2 root root    4096 Dec  8  2016 cramfs-root
drwx------ 14 root root    4096 May  1 13:51 cramfs-root-1
-rwx------  1 root root 1384448 Dec  8  2016 vmlinux.29.5-90191.bir
```

Figure 48. Firmware extracted with binwalk

The files vmlinux.29.5-90191.bin and 8EC90.cramfs were extracted, then using the uncramfs command from the firmware-mod-kit found on github, we deflated the cramfs to reveal a Linux folder structure.


root@kali: ~/Desktop/_29.5-90191-1-5.upd.extracted/cramfs-root-1
File Edit View Search Terminal Help

```
root@kali:~/Desktop/_29.5-90191-1-5.upd.extracted/cramfs-root-1# ls
bin               etc               lib           opt      sbin  var
build.properties  jffs              MINCOMPATVER  proc     tmp   VERSION
dev               LEGACYCOMPATVER   mnt           ramdisk  usr   wifi
root@kali:~/Desktop/_29.5-90191-1-5.upd.extracted/cramfs-root-1#
```

Figure 49. Contents of extracted firmware

In each of these folders, such as etc, there are typical files such as shadow and passwd. However, these files have no contents. We tried multiple times with multiple tool sets and were never successful in getting an older version unpacked. Based on information online, it looked like we would have had to go back to a version of firmware before 20.0 to be able to get any information from the extracted files anyway. Because of this, we moved on and disassembled the Sonos test unit.

A good resource for IoT devices is iFixit.com, where they have a manual with pictures on how to take apart the Sonos Play:1. Once we had taken it apart based on the instructions on iFixit, we started to look at any areas that we may want to spend some time on to determine if we can locate anything that would lead us to either console access to the OS or a method to extract the firmware.

First thing we started looking at were the chips that were in use. Here is the layout of the front and back of the motherboard in the Sonos (ARM version). Once you remove the RF protection cages around the equipment, you'll see the processor, memory, and a bunch of other components. One interesting note is that as hardware breakdowns go, this one was easy but interesting as things are hot glued and there is foam around areas to prevent rattling inside the speaker.

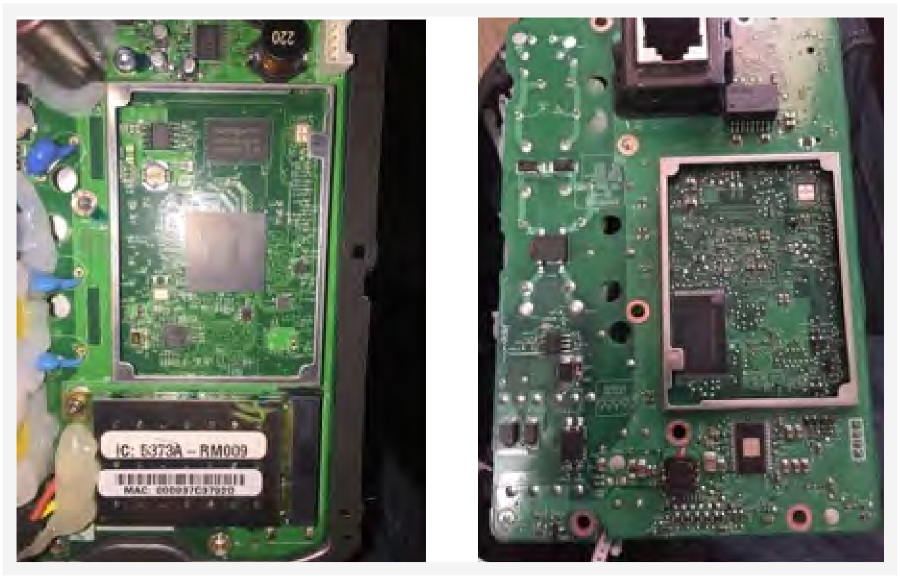


Figure 50. Sonos motherboard

The chips that we dug into were the Freescale CPU and the Winbond chip shown in Figure 51. The Winbond chip in the image on the right is the NAND Flash that is used by the Sonos for storage. On the left is the Freescale ARM processor that is a dual-core ARM chip.

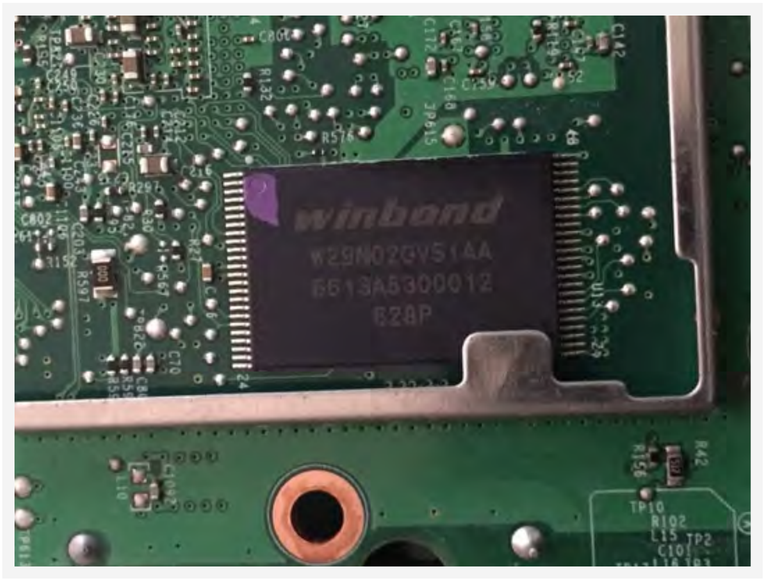


Figure 51. Closeup of the Winbond chip

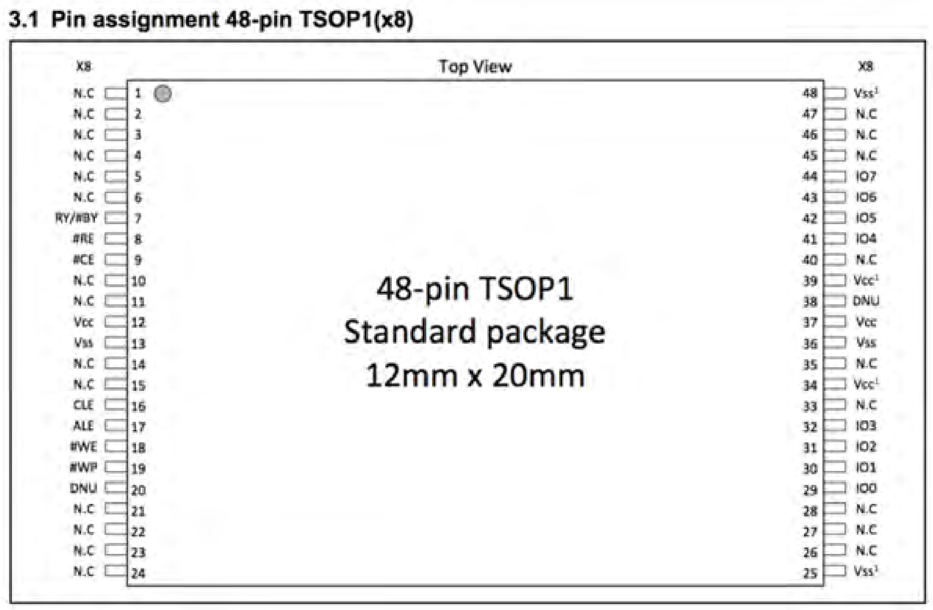


Figure 52. Chip schematic of Winbond chip

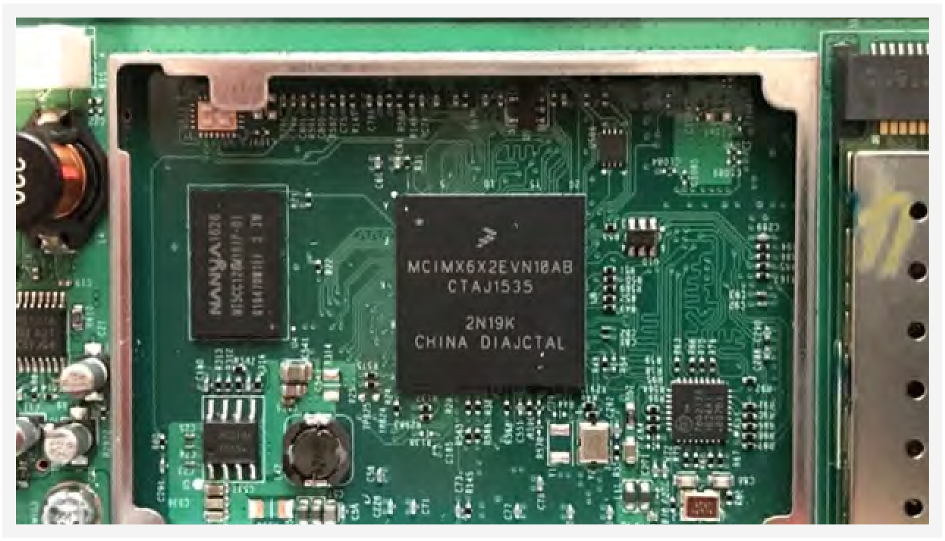


Figure 53. Closeup of the ARM chip by Freescale

Before looking into the chips much further, we looked into whether there was any low-hanging fruit on this board, such as an open serial interface, or a JTAG interface for us to tap and interface with. There were a few different locations that we tried initially to see what kind of data there may be on the board. Next to the Ethernet port were a set of pads that resembled a possible location of a UART port, or another type of interface. However, when we probed this, there were no signals on any of these pads and they appeared to be disabled.

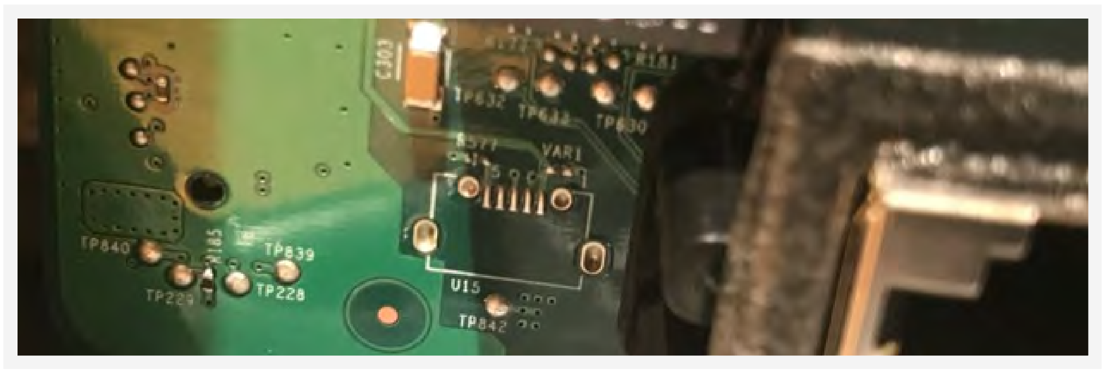


Figure 54. Disabled interface to the Sonos

Below the wireless card, there is another interface that we probed. This interface had data on it and it looked to be a Serial Wire Debug (SWD).

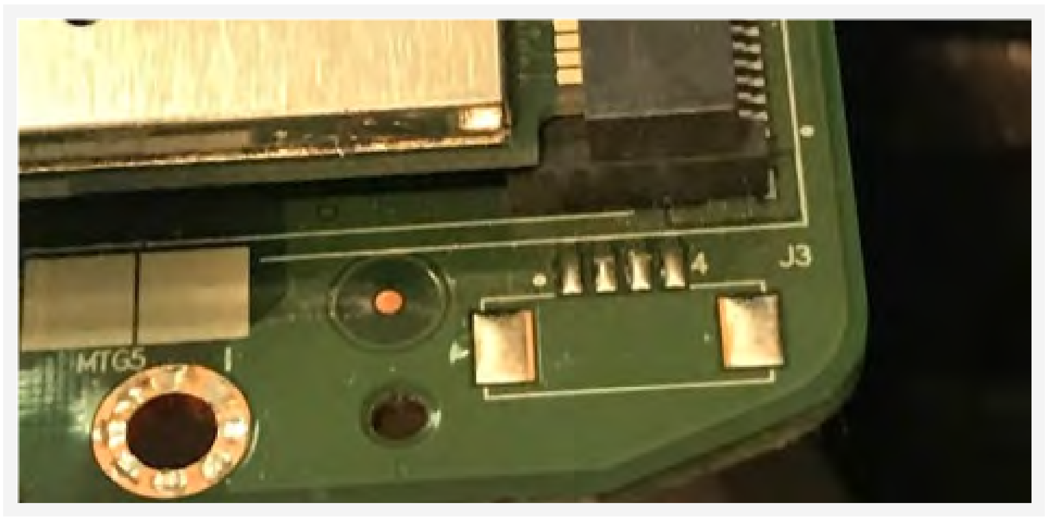
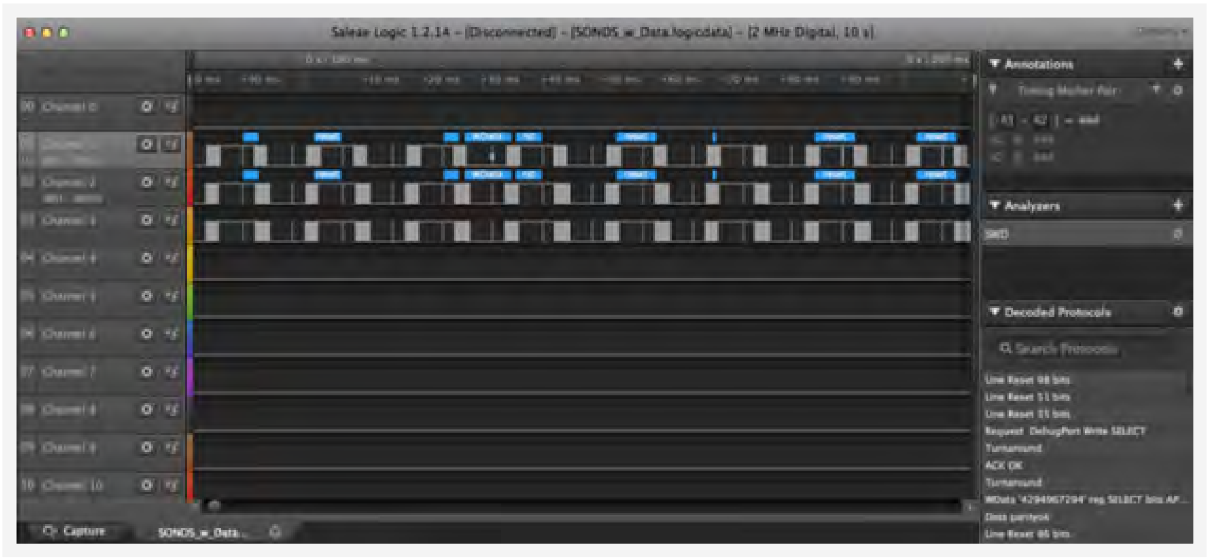


Figure 55. Possible SWD interface

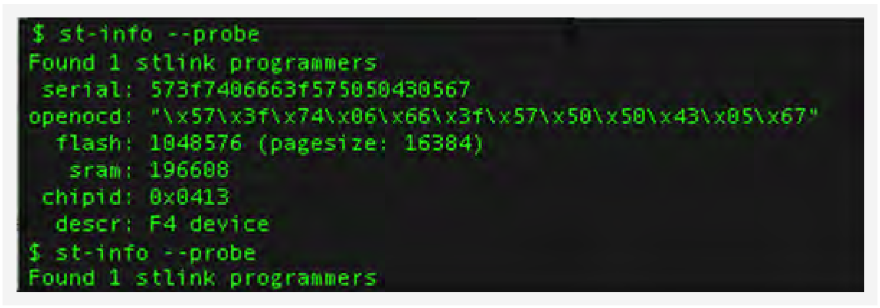
Once we had attached some pins to the pads, we were able to connect our Saleae Logic Analyzer to these ports and attempt to see if we could find any information on it. Allowing the Saleae to auto decode it as SWD and playing with the configuration of which of the pins was what input (SWDIO and SWCLK), the best we could find is shown below, where it appeared to have some SWD on the interface.


Saleae Logic 1.2.14 - [Disconnected] - [SONOS_w_Data.logicdata] - [2 MHz Digital, 10 s]
Annotations
Analyzers
SWD
Decoded Protocols
Search Protocols
Capture

```
Line Reset 98 bits
Line Reset 51 bits
Line Reset 55 bits
Request DebugPort Write SELECT
Turnaround
ACK OK
Turnaround
WData '4294967294' reg SELECT bits AP...
Data parityok
Line Reset 86 bits
```

Figure 56. Signal shown in Saleae logic analyzer

Using an STM32 F4 Discovery and attaching the pins to the corresponding pins on the board, we attempted to see if we could interface directly via SWD. However, we never were able to connect to the device via SWD despite our best efforts. Below is a screenshot showing the st-info command showing that once you remove the CN3 jumpers from the board, this turns the board to Discovery mode. This means that any device attached should show up with a proper serial number much like the device did with the jumpers on. This was never the case no matter what we attempted, so we moved on and assumed this is not SWD anymore.



```
$ st-info --probe
Found 1 stlink programmers
 serial: 573f7406663f575050430567
openocd: "\x57\x3f\x74\x06\x66\x3f\x57\x50\x50\x43\x05\x67"
  flash: 1048576 (pagesize: 16384)
   sram: 196608
 chipid: 0x0413
  descr: F4 device
$ st-info --probe
Found 1 stlink programmers
```

Figure 57. st-link information output

Next, we found what could possibly be a JTAG interface next to the cage where the ARM chip is.

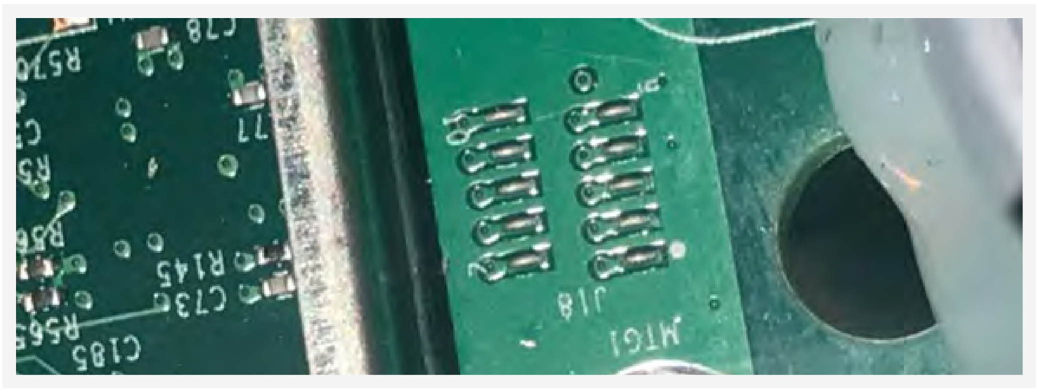


Figure 58. Possible 10 pin JTAG interface

Under the wireless card itself are eight other pins that are in a staggered placement. These pins, much like the JTAG interface, are labeled in order.

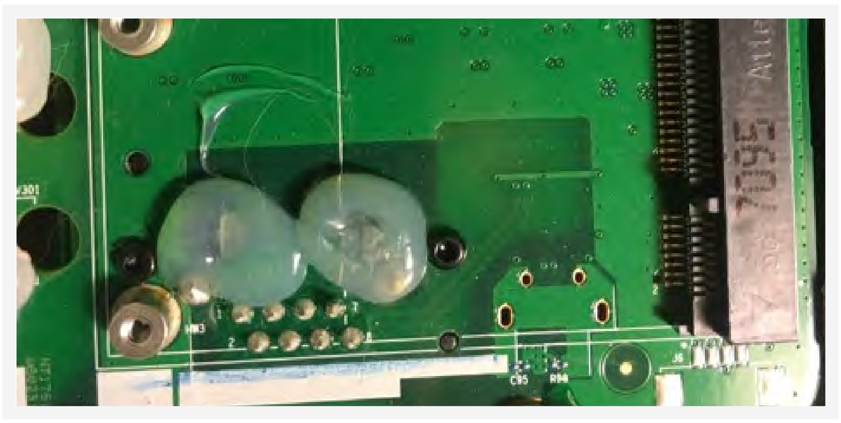


Figure 59. Interface under the wireless card

Next, we found where any of the possible traces coming out of the Freescale processor may have vias that we could probe, and used the Saleae to determine if there were any signals present. This proved to find nothing of value for anything that we knew what to do with. Most of them at the time of probing had no signals on them.

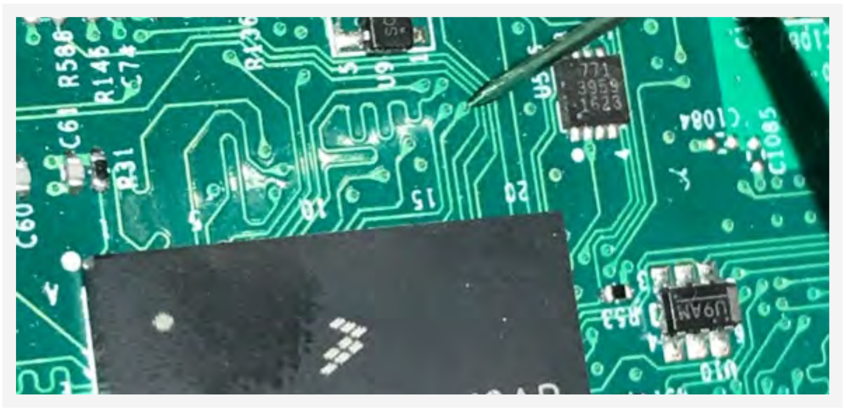


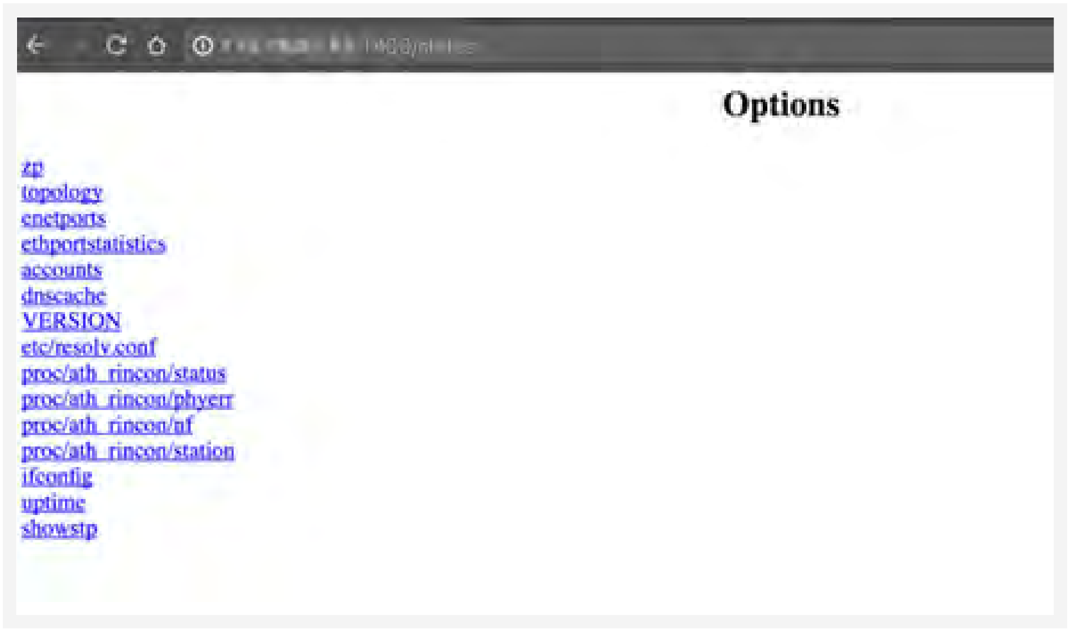
Figure 60. Probing vias with a needle

As with any research, there are successes and failures. In this case, trying to find any interface to directly interact with the Sonos systems via hardware was not a success. While we focused on the Sonos Play:1, some older devices had an exposed UART that was pretty clear; as an example, the Sonos Play:5 is this way according to some of the forum posts that we saw on the internet. This could help provide us with some information that were missing on the Sonos Play:1. These looked to be of the PowerPC variant and not the ARM, but the underlying functionality is almost the same minus some of the features we were using to target some people such as wireless scan results and review log files.

Special thanks to Kevin Finisterre for the hardware help.

Sonos Update

We reported our findings to Sonos before this paper was published. Sonos was quick to respond and started remediating some of the issues. Sonos has fixed the DoS problem and now returns with an HTTP error code 412 (Precondition failed). In addition, now you can no longer see the scanresults page or many of the other pages that provide some information leakage. There are a few left such as the accounts page. Figure 61 shows the Sonos status page after the update.



Options

zp
topology
enetports
ethportstatistics
accounts
dnscache
VERSION
etc/resolv.conf
proc/ath_rincon/status
proc/ath_rincon/phyerr
proc/ath_rincon/nf
proc/ath_rincon/station
ifconfig
uptime
showstp

Figure 61. Updated Sonos status page

While the update is a step in the right direction, you can still control these and gather more information from the devices with what is still being exposed via the status page. This is as of the software date "2017-09-27 16:26:54.868089" and software version number 37.12-45270. If you have not updated to this version of the software, you should update now to limit the personal data that is being exposed via these services, even if you are not directly exposed to the internet.

Conclusion

With the popularity of IoT devices growing every day, it is very important to be knowledgeable of the built-in security of these devices that ultimately could affect the owner and make them a target of an attack. While this research focused on Sonos speakers, we do not at all want to single them out as the only IoT device with security issues on the market today. As we showed, Bose SoundTouch also shared a lot of problems with the Sonos according to our findings. This is a common issue we observe in IoT devices, where there is a lack of security built into the design. With the Sonos, this was the case with the unauthenticated SOAP XML interface, and the web interface that leads to the information leakage. While these devices are never supposed to be exposed on the internet, we have shown that they can and will find their way directly on the internet. We believe that the manufacturers should do whatever they can to make sure that their devices are secured enough that if it is placed on the internet, the likelihood of attack is really low.