Analysis of SSHFP records in the DNS

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Agenda

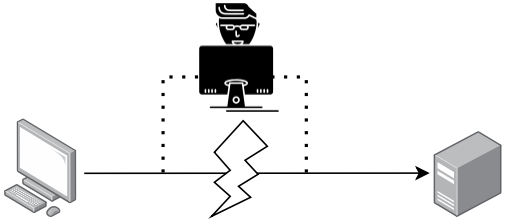
1. What is SSH host key verification?
2. What are SSHFP records?
3. What are our large-scale analysis results?

Why do we need SSH host key verification?

- Establish the authenticity of the server we connect to.

```
[sneef@WorkTop ~]$ ssh -o VisualHostKey=no -o UserKnownHostsFile=/dev/null opendev.org
The authenticity of host 'opendev.org (38.108.68.124)' can't be established.
ED25519 key fingerprint is SHA256:vgW8X1bV3yT2jtmmYZBLZ7o8uVhtvZq59dDNUVUYTRw.
This key is not known by any other names
Are you sure you want to continue connecting (yes/no/[fingerprint])?
```

- If not, malice-in-the-middle attacks are possible:



⇒ Login credentials or sessions could get compromised.

How (not) to do SSH host key verification?

Manual process

1. Ask the admin for the fingerprints
2. Manually compare both fingerprints
3. Continue or abort connecting

DNS-based process

1. The admin publishes the fingerprints in the DNS (using DNSSEC!)
2. The openssh-client does the comparison
3. Continue or abort connecting

⇒ One method requires manual work and is error prone, the other requires a little more administrative work.

SSHFP DNS records

- RFCs 4255, 6594, 7479, 8709 define and extend SSHFP
- Format: SSHFP <KEY-ALGO> <HASH-TYPE> <FINGERPRINT>

Table 1: Values for the SSHFP `KEY-ALGO` field.

Value	Algorithm	RFC
0	reserved	4255
1	RSA	4255
2	DSA	4255
3	ECDSA	6594
4	ED25519	7479
5	unassigned[1]	-
6	ED448	8709

Table 2: Values for the SSHFP `HASH-TYPE` field.

Value	Algorithm	RFC
0	reserved	4255
1	SHA1	4255
2	SHA256	6594

SSHFP DNS records

```
[sneef@WorkTop ~]$ dig SSHFP opendev.org +noall +answer +question
;opendev.org.                  IN      SSHFP
opendev.org.           3600    IN      SSHFP   3 2 C9B288FF042ED0934FEB313BE277B546896C8C585FAED5C3057189A9 8585C5FD
opendev.org.           3600    IN      SSHFP   4 1 1D866A8F892294F28DB9E3CA7827FE8D4E93588E
opendev.org.           3600    IN      SSHFP   4 2 BE05BC5F56D5DF24F68ED9A661904B67BA3CB9586DBD9AB9F5D0CD51 55184D1C
opendev.org.           3600    IN      SSHFP   1 1 15D5F6642C9424BBE5DA0D8A99C0558B790A6C4D
opendev.org.           3600    IN      SSHFP   1 2 E9749FDE703418C5D810CEA7DDCF6639B2070CFA64020AC8F31B4671 FA6CAF01
opendev.org.           3600    IN      SSHFP   3 1 2E8E854928BE740BE49C754F99DEE256545338EE
```

```
[sneef@WorkTop ~]$ ssh-keyscan -D opendev.org
; opendev.org:22 SSH-2.0-OpenSSH_7.6p1 Ubuntu-4ubuntu0.7
opendev.org IN SSHFP 1 1 15d5f6642c9424bbe5da0d8a99c0558b790a6c4d
opendev.org IN SSHFP 1 2 e9749fde703418c5d810cea7ddcf6639b2070cfa64020ac8f31b4671fa6caf01
; opendev.org:22 SSH-2.0-OpenSSH_7.6p1 Ubuntu-4ubuntu0.7
opendev.org IN SSHFP 3 1 2e8e854928be740be49c754f99dee256545338ee
opendev.org IN SSHFP 3 2 c9b288ff042ed0934feb313be277b546896c8c585faed5c3057189a98585c5fd
```

SSHFP DNS records

```
[sneef@WorkTop ~]$ ssh -v -o UserKnownHostsFile=/dev/null -o VerifyHostKeyDNS=yes opendev.org 2>&1 | grep -P '(host.key)|(fingerprint)'
debug1: kex: host key algorithm: ssh-ed25519
debug1: Server host key: ssh-ed25519 SHA256:vgW8X1bV3yT2jtmmYZBLZ7o8uVhtvZq59dDNUVUYTRw
debug1: found 6 secure fingerprints in DNS
debug1: verify_host_key_dns: matched SSHFP type 4 fptype 2
debug1: verify_host_key_dns: matched SSHFP type 4 fptype 1
debug1: matching host key fingerprint found in DNS
```

Large-scale analysis: Results (1)

Tranco 1M

- 1M domains scanned
- 105 domains use SSHFP (0.011%)
- 75 servers run SSH
- 66 with ≥ 1 matching fingerprint
- 28 use DNSSEC

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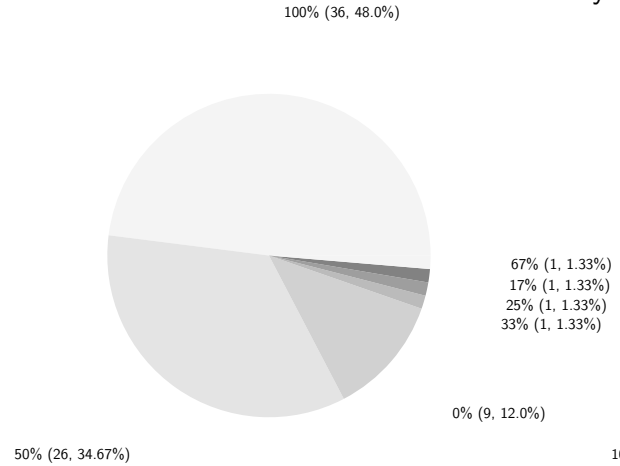
Certificate Transparency Logs

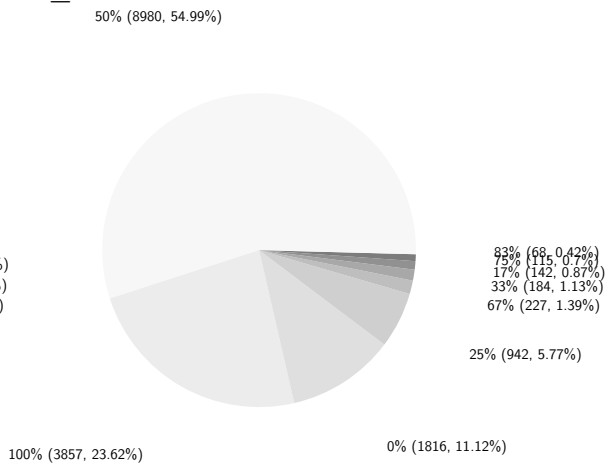
- 515M domains scanned (136M unique)
- 17,672 SSHFP sets (11,524 unique domains)
- 16,331 servers run SSH
- 14,515 with ≥ 1 matching fingerprint
- 3,896 unique domains use DNSSEC

Large-scale analysis: Results (2)

- Identical DNS-FPs and Server-FPs only in $\leq 50\%$ of cases

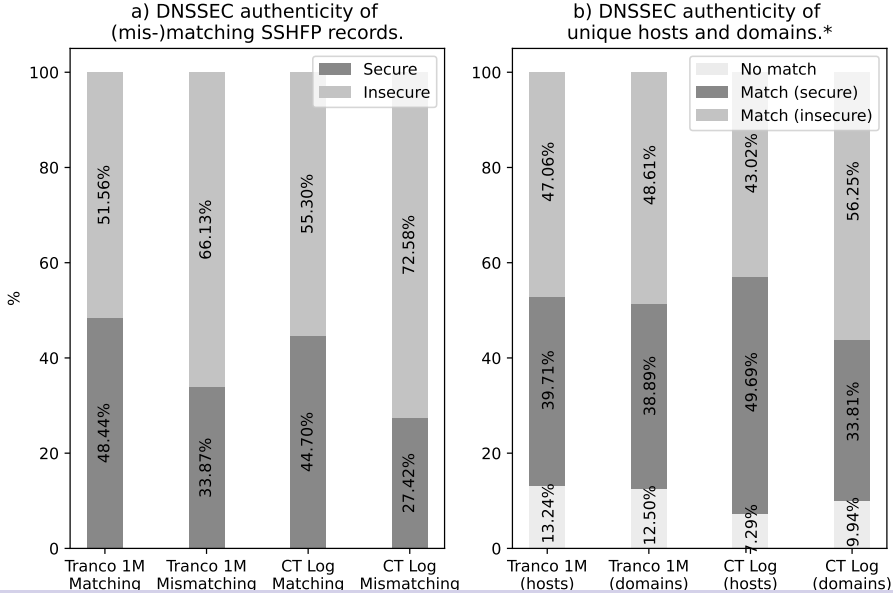


(a) Tranco 1M



(b) Certificate Transparency Log

Large-scale analysis: Results (3)



Conclusion

- Very few use SSHFP DNS records, although it is easy to setup.
- $\leq 50\%$ use DNSSEC, the rest misses out on security benefits.
- Try to make SSHFP records + DNSSEC more popular?

Questions & Answers

Thanks for listening!

Questions?

Feel free to reach out: neef@tu-berlin.de

1. "Oh SSH-it, what's my fingerprint? A Large-Scale Analysis of SSH Host Key Fingerprint Verification Records in the DNS" - S. Neef, N. Wisiol
2. Repo with code & data - `https://github.com/gehaxelt/sshfp-dns-measurement`