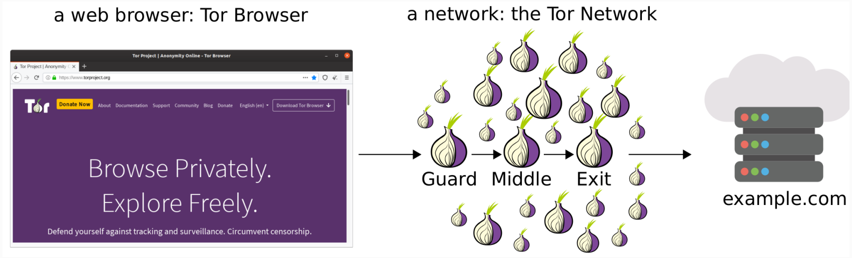
# Certificate Transparency in Tor and Sigsum Logging

March 7, 2022

Rasmus Dahlberg

## CT in Tor · · · Halftime · · · Sigsum Logging

## Tor crash course


a web browser: Tor Browser
a network: the Tor Network
Tor Project | Anonymity Online - Tor Browser
https://www.torproject.org
Donate Now
About
Documentation
Support
Community
Blog
Donate
English (en)
Download Tor Browser
Browse Privately.
Explore Freely.
Defend yourself against tracking and surveillance. Circumvent censorship.
Guard
Middle
Exit
example.com

[1]Credit: figure created by Tobias Pulls

[2]Design: https://murdoch.is/papers/tor14design.pdf

## Tor Browser

- Firefox derivative
- Route all traffic through Tor
- Prevent user activity on one site from being linked to activity on another
- Do not write any state to disk
- ...

[1] Credit: Tom Ritter, see https://ritter.vg/p/tor-v1.6.pdf
[2] Design: https://2019.www.torproject.org/projects/torbrowser/design/

sciendo Proceedings on Privacy Enhancing Technologies ; 2021 (2):194–213

Rasmus Dahlberg*, Tobias Pulls, Tom Ritter, and Paul Syverson

Privacy-Preserving & Incrementally-Deployable Support for Certificate Transparency in Tor

**Abstract:** The security of the web improved greatly throughout the last couple of years. A large majority of the web is now served encrypted as part of HTTPS,

1 Introduction

Metrics reported by Google and Mozilla reveal that en-

Privacy-Preserving and Incrementally-Deployable Support for Certificate Transparency in Tor

by Rasmus Dahlberg, Tobias Pulls, Tom Ritter, and Paul Syverson | November 30, 2021

## Problem statement

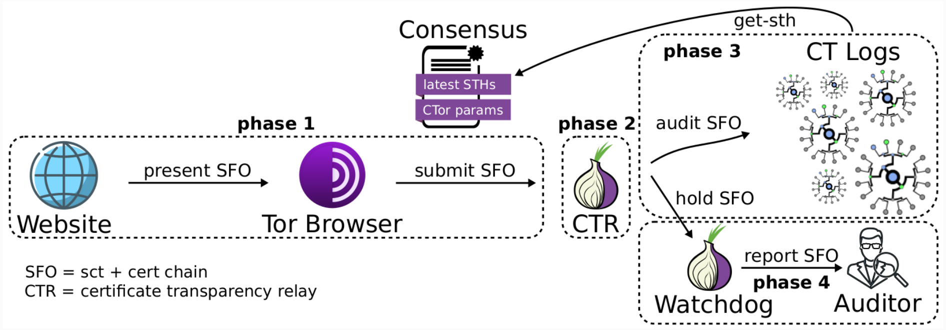
- Tor Browser does not enforce CT
- Guard against prominent threats
  - DigiNotar style attacks
  - Interception to deanonymize
- Go beyond "just CT compliance"

Attacker in Tor's threat model + controls a CA and two CT logs

## Incremental deployment

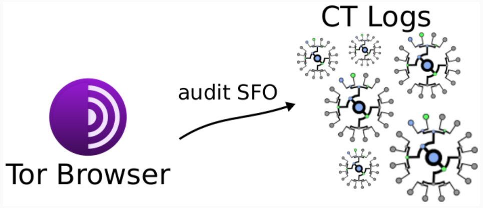
| | |
|---|---|
| 1. Catch up with CT compliant browsers | *pairs of logs* are trusted blindly |
| 2. Steps towards decentralized verification | *some log* is trusted blindly |
| 3. Fully decentralized verification | *no log* is trusted blindly |

## Full design

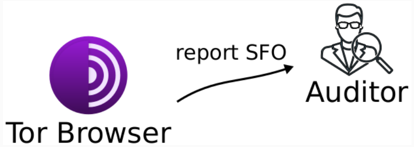


Security? Difficult to interfere without detection in any phase

## Why not just...?

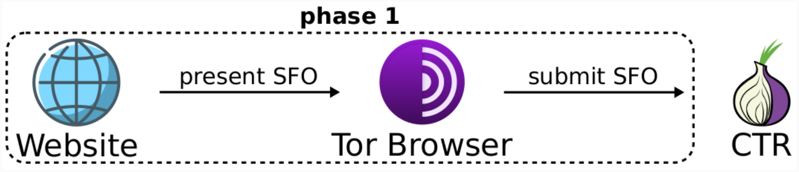


Fetch an inclusion proof



Rely on a centralized party

## Phase 1: Submission

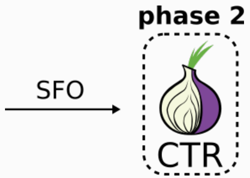


1. Probabilistic submit
2. Random CTR

Best attack: quickly take control over Tor Browser

## Phase 2: Buffering

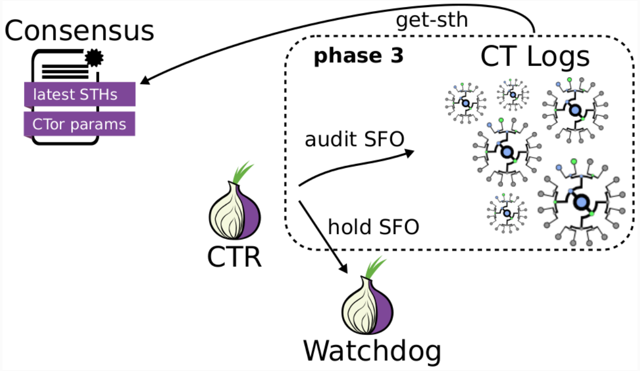
1. Buffer until logging is required
2. Add a random delay to leak less
3. Cache audited SFOs to leak less



Best attack: network-wide flush

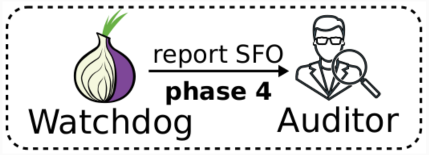
## Phase 3: Auditing

1. Fetch inclusion proof
2. STH from Tor's consensus
3. Collaborate with a watchdog
    - CTR identification
    - "Tagging"



Best attack: quickly take control over CTR

## Phase 4: Reporting

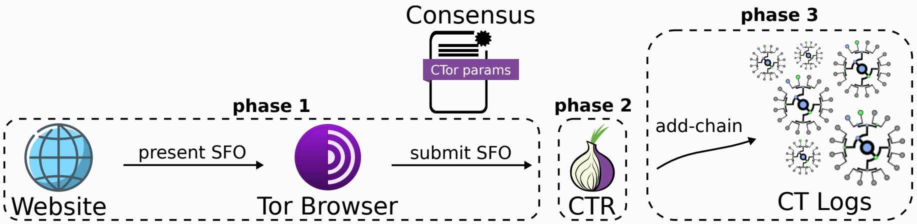


1. Report SFO on timeout

Best attack: n/a

**This is quite the leap from “just CT compliance”**

## Incremental design



Use the log ecosystem against the attacker

## Conclusion

- Tor's setting is quite different
- Delegated audiding is key here
- Roadmap from start to finnish

## Resources

- PETS paper[1]
- PETS talk[2]
- Tor blog post[3]

## Next steps

- Torspec proposal(s)
- Browser implementation
- Relay implementation

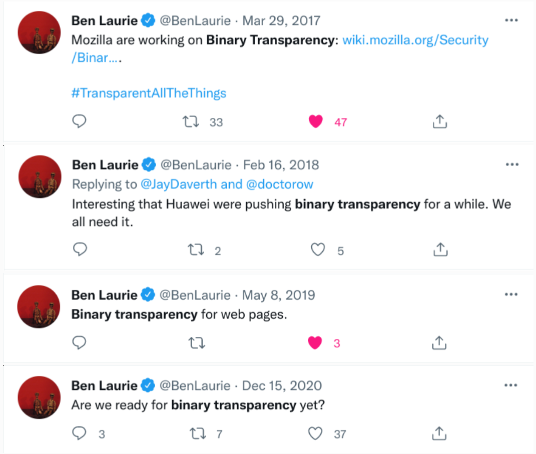
[1] https://petsymposium.org/2021/files/papers/issue2/popets-2021-0024.pdf

[2] https://www.youtube.com/watch?v=f7yDJOd6g3U

[3] https://blog.torproject.org/tor-certificate-transparency/

## Halftime Q/A

## Tweets you can probably relate to



**Ben Laurie** @BenLaurie · Mar 29, 2017

Mozilla are working on **Binary Transparency**: wiki.mozilla.org/Security/Binar… .

#TransparentAllTheThings

33 47

**Ben Laurie** @BenLaurie · Feb 16, 2018

Replying to @JayDaverth and @doctorow

Interesting that Huawei were pushing **binary transparency** for a while. We all need it.

2 5

**Ben Laurie** @BenLaurie · May 8, 2019

**Binary transparency** for web pages.

3

**Ben Laurie** @BenLaurie · Dec 15, 2020

Are we ready for **binary transparency** yet?

3 7 37

2022?

More initatives than can be counted on two hands

https://binary.transparency.dev

...

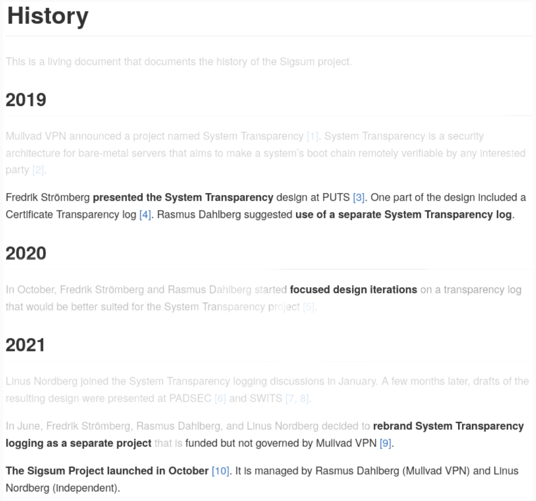
## Common denominator?

Certificates
Executable binaries
Source code
TPM quotes
Onion address rulesets
Official documents
...

## Where is the low-hanging fruit?

## Meet the Sigsum project

- FOSS
- Signed checksums
- Enforcement of logging
- Minimal building block
- “Transparent key-usage”



## History

This is a living document that documents the history of the Sigsum project.

### 2019

Mullvad VPN announced a project named System Transparency [1]. System Transparency is a security architecture for bare-metal servers that aims to make a system's boot chain remotely verifiable by any interested party [2].

Fredrik Strömberg **presented the System Transparency** design at PUTS [3]. One part of the design included a Certificate Transparency log [4]. Rasmus Dahlberg suggested **use of a separate System Transparency log**.

### 2020

In October, Fredrik Strömberg and Rasmus Dahlberg started **focused design iterations** on a transparency log that would be better suited for the System Transparency project [5].

### 2021

Linus Nordberg joined the System Transparency logging discussions in January. A few months later, drafts of the resulting design were presented at PADSEC [6] and SWITS [7, 8].

In June, Fredrik Strömberg, Rasmus Dahlberg, and Linus Nordberg decided to **rebrand System Transparency logging as a separate project** that is funded but not governed by Mullvad VPN [9].

**The Sigsum Project launched in October** [10]. It is managed by Rasmus Dahlberg (Mullvad VPN) and Linus Nordberg (independent).

https://git.sigsum.org/sigsum/tree/doc/history.md

## Use-case - Signature Transparency

“Oh, a new signature was created. That’s weird. I’m at the gym.”

## Use-case - Binary Transparency

“Oh, that’s the key binaries are signed with”
“By policy binaries are located at releases.example.com/$CHECKSUM”

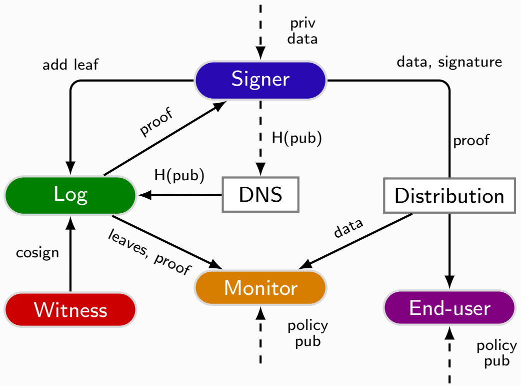
## s/binary/something else/

## Many answers and trade-offs

- Purpose of logging
- What is (not) logged
- Auditing, SCTs
- Gossip
- Anti-poison
- Anti-spam
- Sharding
- Privacy
- Simple API

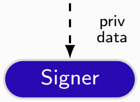
Accept latency, no rich metadata, no complicated protocols and parsers

## System overview



## A step-by-step breakdown

## Signing



```
#define MAGIC_PREAMBLE "SSHSIG"

byte[6] MAGIC_PREAMBLE
string  namespace
string  reserved
string  hash_algorithm
string  H(message)
```

https://github.com/openssh/openssh-portable/blob/master/PROTOCOL.sshsig#L81

```
Values used by Sigsum (only Ed25519)


"tree_leaf:v0:<shard_hint>@sigsum.org"
""
"sha256"
message = H(data)
```

https://git.sigsum.org/sigsum/tree/doc/proposals/2021-11-ssh-signature-format.md

`ssh-keygen -Y` `signify` `minisign`

## Why not support more signing formats and tools?

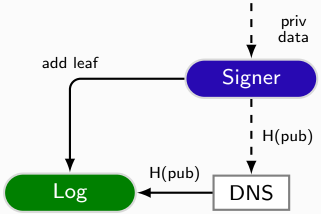
## Submission

HTTP POST ASCII

- Shard hint
  - $\in$ [shard_start, now()]
- Message
- Signature
- Public key
- Domain hint
  - `_sigsum_v0.*` $\rightarrow$ H(pub)

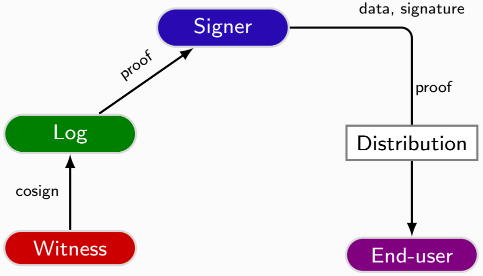
Stored leaf (136 bytes)

- Shard hint
- Checksum
- Signature
- Key hash



## Bundling and Distribution

- Signer must **wait** for witnessing[1]
  - Append-only
  - Freshness
  - Some simplifications
- Proof of logging
  - Cosigned tree head
  - Inclusion proof

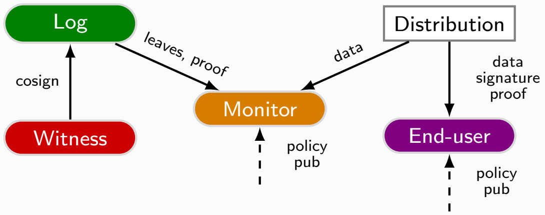


[1] Originally proposed by Syta et al.: https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=7546521

Example policy

- Known logs
- Known witnesses
- M-of-N (co)signatures

## Verification



No reactive gossip/audit, offline verification by end-users (!)

## Current status

- Solid foundation, hopefully(!)
- V0 design[1] and API[2] is pretty stable
- Public prototypes, log and witness
- Tooling? Kind of "pipe into `curl`"
- https://git.sigsum.org

https://bygg.se/valj-ratt-husgrund-till-din-villa/

Next steps: more feedback, tooling, mature code, SLA for a v0 log, eventually v1 spec

1 https://git.sigsum.org/sigsum/tree/doc/design.md
2 https://git.sigsum.org/sigsum/tree/doc/api.md

## Take away

- Minimal building block
- Log a signed checksum
- Offline end-user verification
- Many potential use-cases
- Reach out to get involved[1]

[1] irc, matrix, email list, etc., are linked from https://www.sigsum.org

## Q/A