Modernizing the Tor Ecosystem

Alexander Færøy

August 8, 2022

BornHack 2022

This presentation explains some of the **ongoing and upcoming efforts within The Tor Project to modernize our ecosystem.**

We will be **focusing on the Tor Network itself** and the components used to run the network.

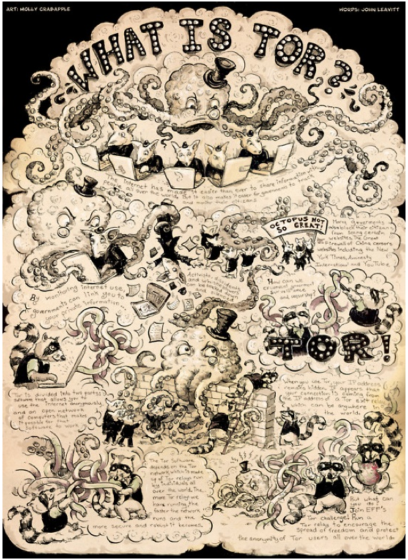
We will not be covering efforts happening around Anti-censorship technology, Tor Browser, Localization, Metrics, UI, UX, and the other exciting things happening inside the Tor Project right now.

About Me

- Core Developer at The Tor Project since early 2017. Team Lead of the Network Team since late 2019.
- Free Software developer since 2006.
- Co-organizing the annual Danish hacker festival BornHack on Funen.
- First hackercamp, out of many, was OHM in 2013.

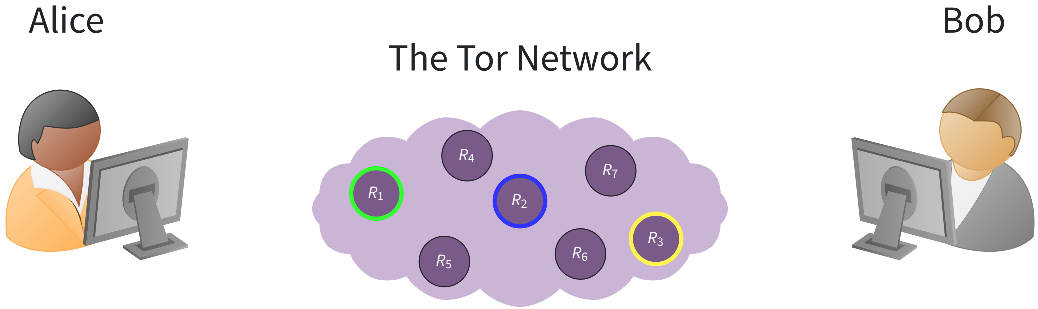
What is Tor?

- Online anonymity, and censorship circumvention.
  - Free software.
  - Open network.
- Community of researchers, developers, users, and relay operators.
- U.S. 501(c)(3) non-profit organization.


ART: MOLLY CRABAPPLE
WORDS: JOHN LEAVITT
WHAT IS TOR?
The Internet has made it easier than ever to share information with people all over the world. But it also makes it easier for governments to track and monitor their citizens
OCTOPUS NOT SO GREAT!
Many governments also block their citizens from seeing certain websites. The Great Firewall of China censors websites including the New York Times, Amnesty International and YouTube
By monitoring internet use, governments can link you to your private information...
Activists, dissidents and whistleblowers can be tracked down and silenced
How can we circumvent government surveillance and censorship?
TOR!
Tor is divided into two parts: software that allows you to use the Internet anonymously and an open network of computers that makes it possible for that software to work.
When you use Tor, your IP address remains hidden. It appears that your connection is coming from the IP address of a Tor exit relay which can be anywhere in the world.
The Tor Software depends on the Tor network, which is made up of Tor relays run by individuals all over the world. The more Tor relays we have running, the faster the network runs and the more secure and robust it becomes.
But what can you do? Join EFF's Tor challenge! Run a Tor relay to encourage the spread of freedom and protect the anonymity of Tor users all over the world.

Somewhere between 2,000,000 and 8,000,000 daily users.

How does Tor work?



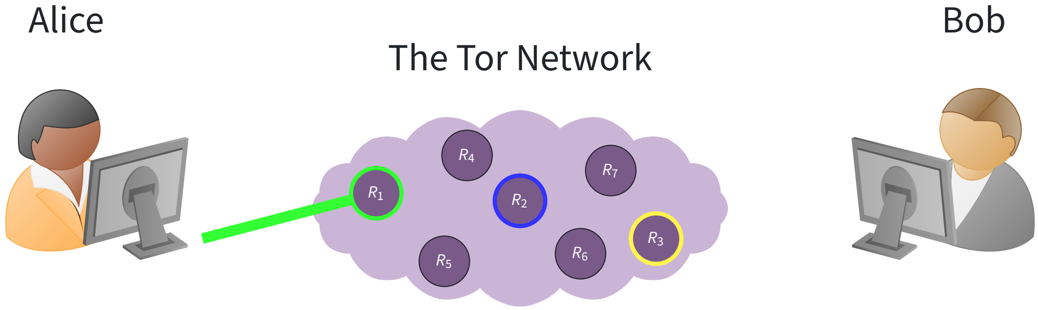
Alice

The Tor Network

Bob

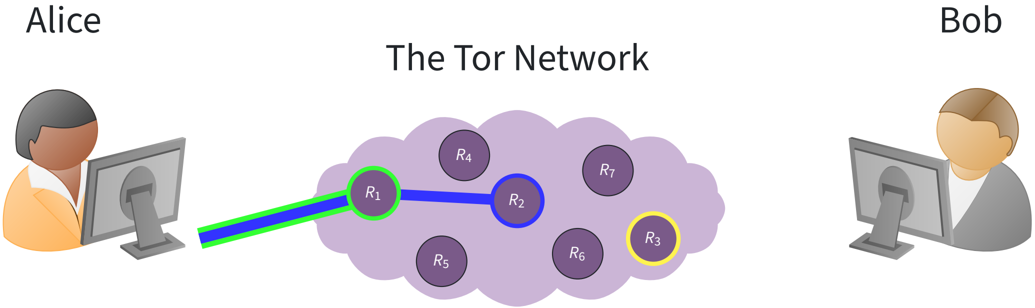
Alice picks a path through the network: R_1, R_2, and R_3 before finally reaching Bob.

How does Tor work?



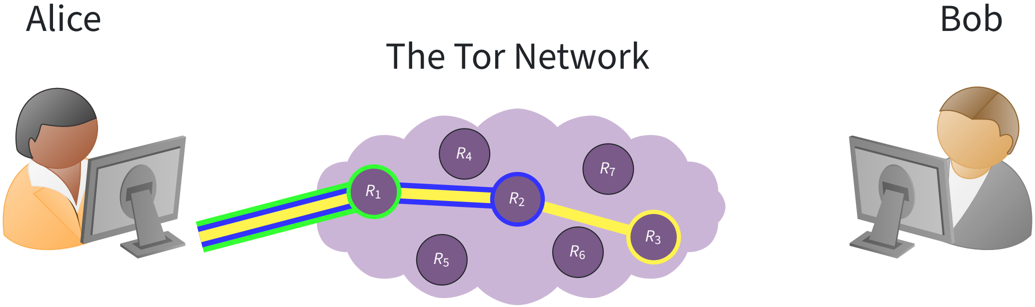
Alice makes a session key with R_1.

How does Tor work?



Alice asks R_1 to extend to R_2.

How does Tor work?



Alice

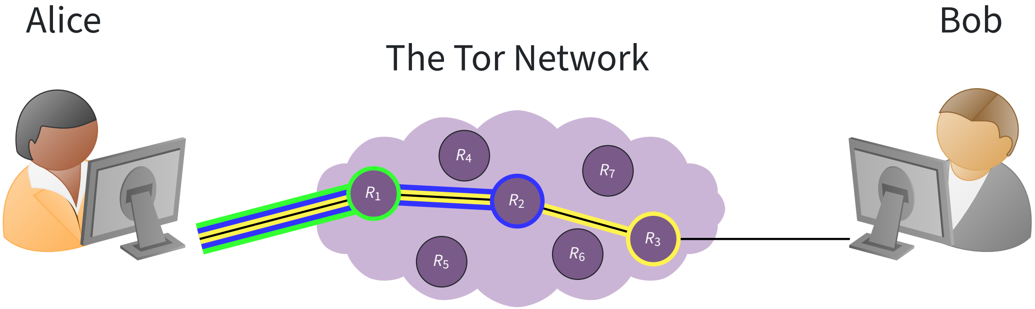
The Tor Network

Bob

R_1 R_2 R_3 R_4 R_5 R_6 R_7

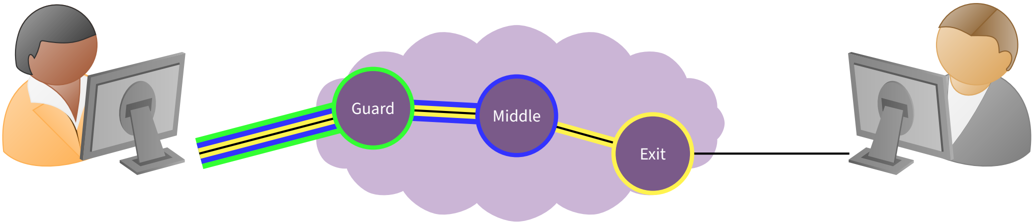
Alice asks R_2 to extend to R_3.

How does Tor work?



Alice finally asks R_3 to connect to Bob.

How does Tor work?



Alice

Bob

The Tor Network

Guard

Middle

Exit

Speed > Blocking > Privacy > Security > UI

Speed > Blocking > Privacy > Security > UI

The performance of the Tor network: its throughput and latency.

Speed > Blocking > Privacy > Security > UI

Website blocking, captcha portals, denial of access, etc.

Speed > Blocking > Privacy > Security > UI

Privacy and anonymity guarantees by Tor.

Speed > Blocking > Privacy > Security > UI

Security of the different Tor components.

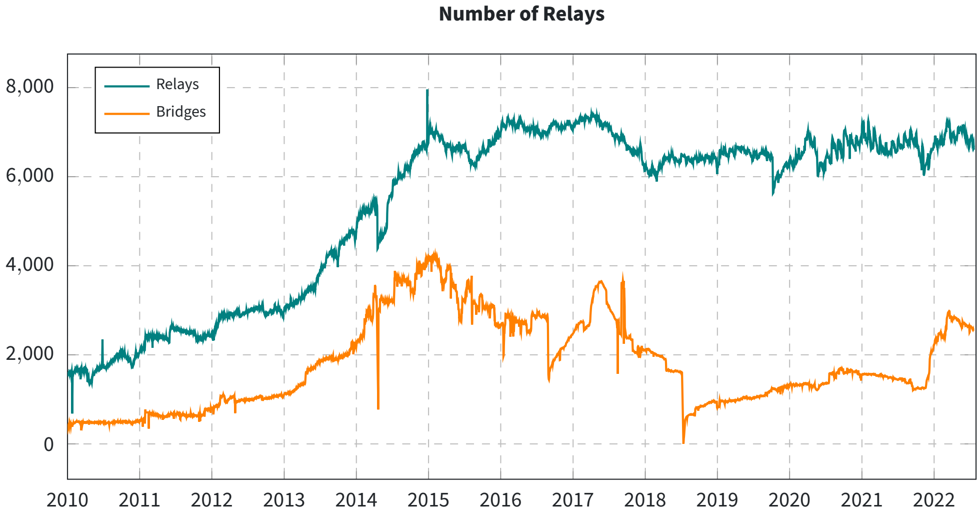
Speed > Blocking > Privacy > Security > UI

User interfaces of our products.

The Tor Network

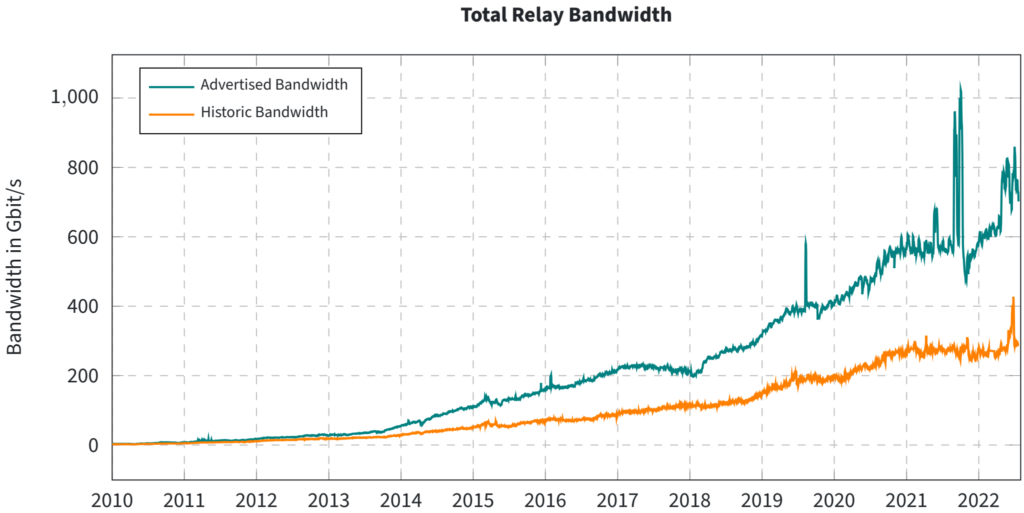
- An open network – **everybody** can join!
- Between 6000 and 7000 relay nodes.
- Kindly hosted by various individuals, companies, and non-profit organisations.
- 9 Directory Authority nodes and 1 Bridge Authority node.

The Tor Network



Source: metrics.torproject.org

The Tor Network



Source: metrics.torproject.org

Packed and Fragmented Cells

Packed cells will allow us to consolidate multiple smaller cells into fewer cells.

Fragmented cells will allow us to split payloads larger than 498-bytes into multiple cells.

See Proposal #340.

Post-quantum Cryptography

We need to apply post-quantum cryptography to two layers of the Tor protocol:

The TLS layer: Protects against an adversary that is able to intercept relay communication.

The Tor Circuit layer: Protects against an adversarial relay intercepting communication.

Fragmented cells are needed due to the large payloads used by the available cryptographic post-quantum handshakes.

Congestion Control

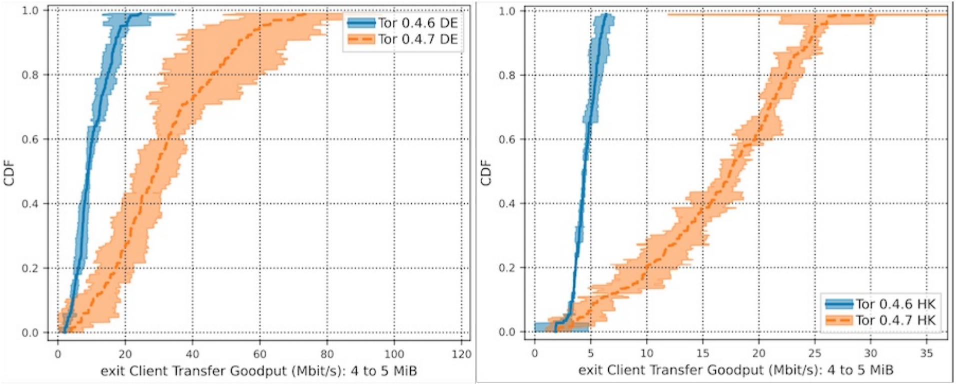
We implemented three congestion control algorithms: Tor-Westwood, Tor-Vegas, and Tor-NOLA. All of them are available in **Tor 0.4.7.**

Both Tor-Westwood and Tor-NOLA exhibited ack compression, which caused them to wildly overestimate the Bandwidth-Delay Product, which lead to runaway congestion conditions.

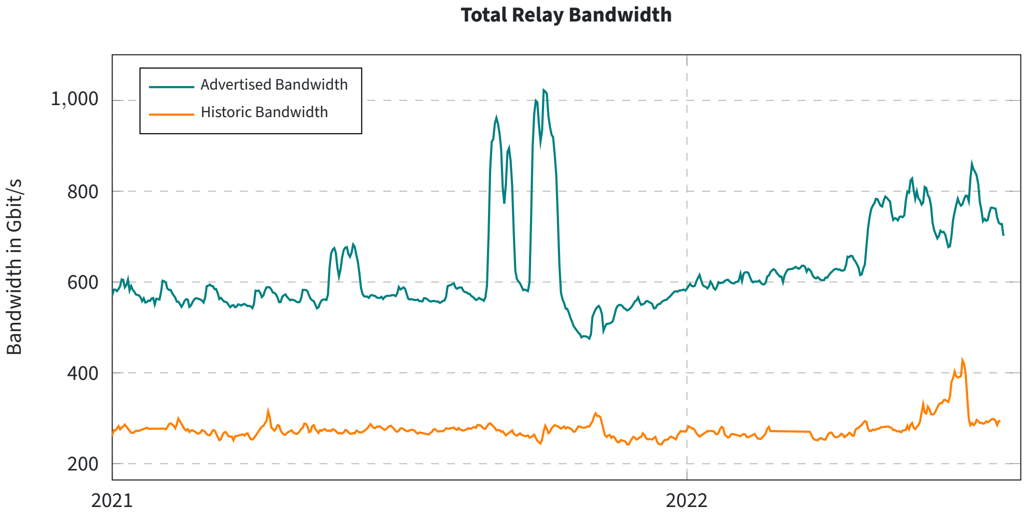
Google’s BBR algorithm also suffers from these problems, and was not implemented in Tor.

Congestion Control

Tor-Vegas performed beautifully, almost exactly as the theory predicted, as seen in the results from **Shadow.**

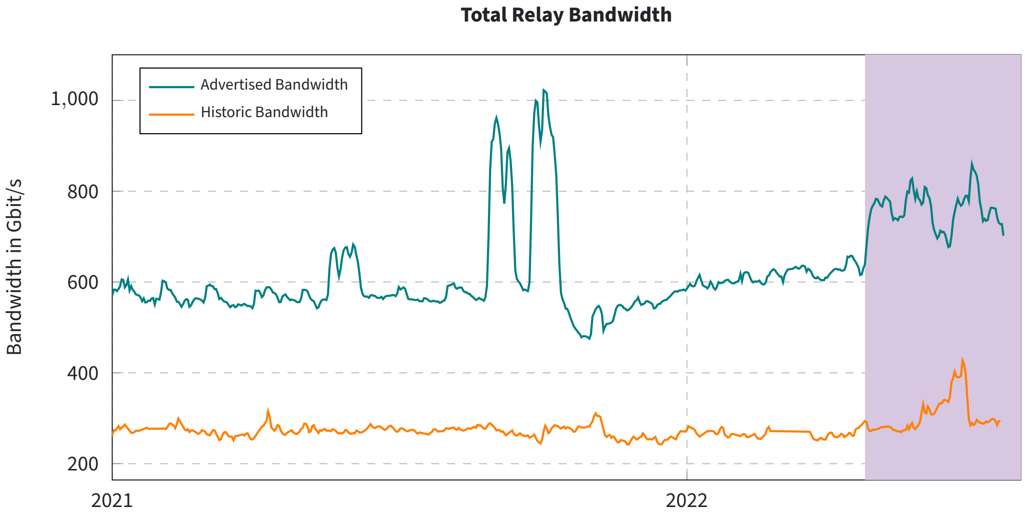


Congestion Control



Source: metrics.torproject.org

Congestion Control



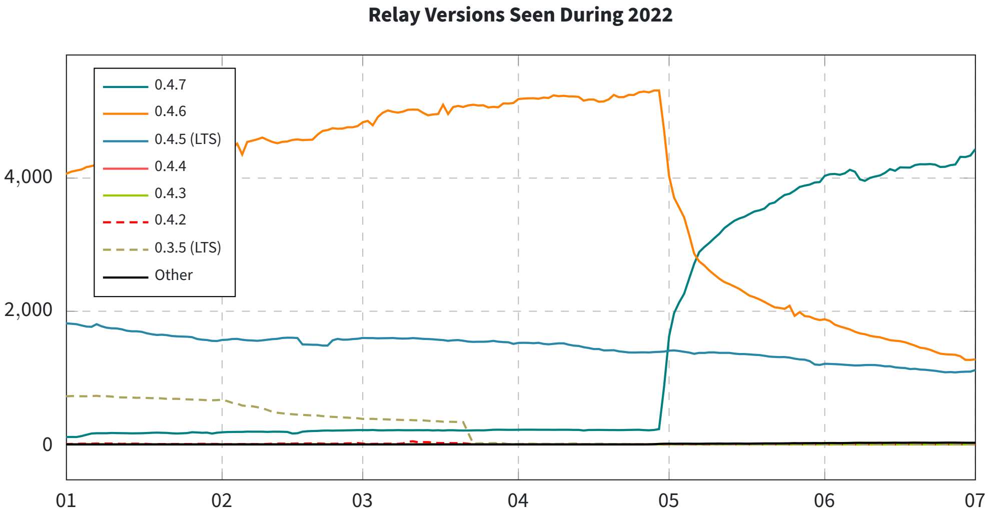
Source: metrics.torproject.org

Ongoing Denial of Service

The ongoing Denial of Service against the Tor network in the last couple of weeks have made it drastically harder to analyse the impact and tuning opportunities related to the deployment of congestion control in the network.

Ongoing efforts to reduce the impact of Denial of Service attacks is helping, but it continues to be a bit of a Whac-A-Mole game.

The Tor Network



Source: metrics.torproject.org

A massive **thank you** for upgrading to **Tor 0.4.7** so quickly!

Further Tuning

We will continue tuning the Congestion Control subsystem in Tor in the near future.

One planned project is changing the bandwidth cut-off values for the **Fast** and **Guard** flags for relays.

Congestion Control

Onion Service operators will also benefit from upgrading to **Tor 0.4.7.**

Relay Operators: be prepared to Set Bandwidth Limits

For more details, please read Mike Perry’s blog post on Congestion Control at blog.torproject.org/congestion-contrl-047

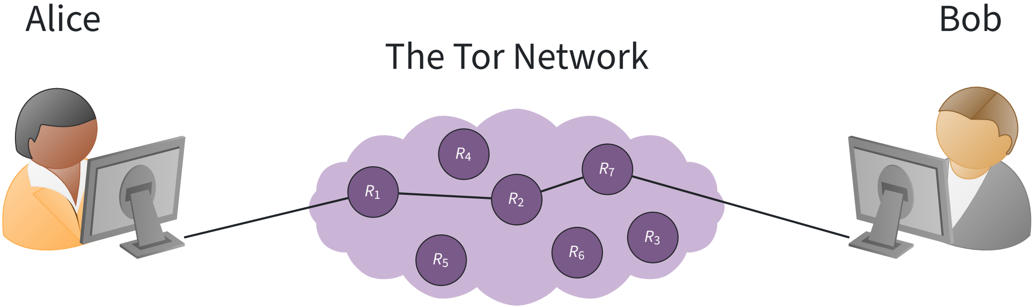
Conflux

The goal is to overcome some of Tor's network performance bottlenecks using **traffic splitting** .

Current work specified by David Goulet and Mike Perry in Tor's Proposal #329.

Based on work by Mashael AlSabah, Kevin Bauer, Tariq Elahi, and Ian Goldberg in the paper The Path Less Travelled: Overcoming Tor's Bottlenecks with Traffic Splitting.

Conflux



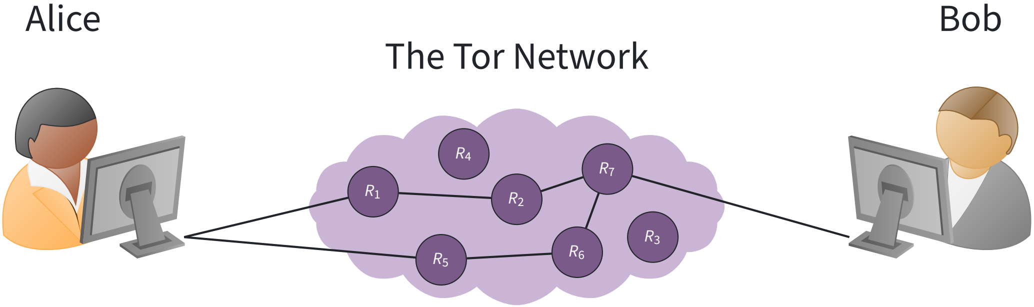
Alice

The Tor Network

Bob

R_1 R_2 R_3 R_4 R_5 R_6 R_7

Conflux



Alice

The Tor Network

Bob

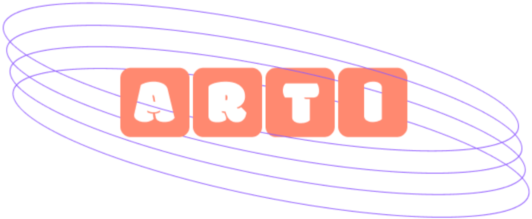
Proof of Work for Onion Services

Implement PoW for Onion Services that can dynamically enable, disable, and adjust the difficulty of the system if pathological situations appears.

Make the cost of attacking an Onion Service higher.

A big thanks to **tevador** for all the help here!

See Proposal #327.



Arti is our new Tor implementation in the Rust programming language.

Arti

Focus on building a library to work with the entire Tor ecosystem:

- Embed the Arti client into your own application.
- Parsing different Tor related network objects.
- Onion Services.

Arti

But, why rewrite Tor?

Writing "safe C" is costly, and prone to mistakes:

21 out of 34 of Tor’s TROVE’s was related to memory issues allowed by the C programming language.

Most of the Network Team at Tor is very excited about Rust, and was interested in spending more time writing software in it.

Arti Roadmap

0.1.0	API stability.
1.0.0	Usability, performance, and stability.
1.1.0	Anti-censorship.
1.2.0	Onion services.
2.0.0	Ready to replace the C client.
Future	Relay, bridge, directory authority, etc.

Arti and Legacy Tor

Currently, **3 out of 7 members of the Network Team are working full-time on Rust and Arti deliverables.** We aim to have the entire team work in this space as soon as possible.

We will **reduce feature additions in C Tor** drastically and will not be adding more Long-Term Support Tor releases.

We will **continue to support C Tor** until Arti can replace the currently used C Tor implementation.

UDP Support in the Tor Network

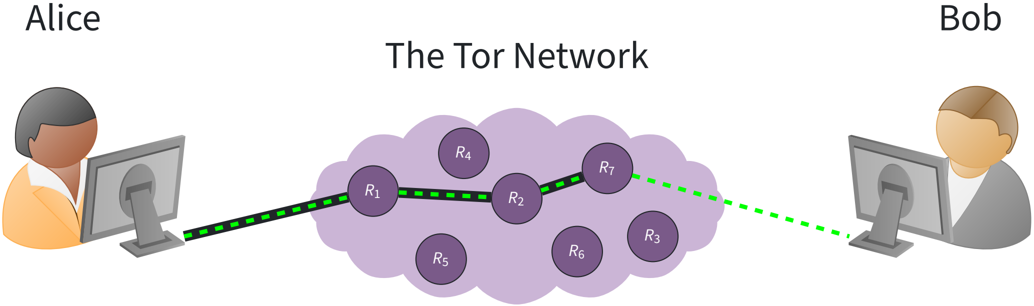
Support UDP for Tor clients and Exit nodes to allow support for modern internet applications such as: Crypto wallets, streaming, VoIP, and *hopefully* WebRTC-based applications.

Client and Exit nodes will require upgrades for deployment.

Use Tor’s Congestion Control system to decide when to drop packets at the edges.

Specification work being tracked in torspec#73 on Tor’s Gitlab.

UDP Support in the Tor Network



VPN using Tor

Allow users to use Tor with applications that are not necessarily Tor-aware.

The initial focus will be on the **Android** platform, but more platforms should become supported over time.

Our current **goal is to release the application in 2023.**

Onionmasq

Build a layer 3 packet engine library in Rust for handling:

- Read and write IP packets from TUN devices.
- Multiplexing between TCP/UDP flows and Arti’s TCP/UDP socket interface.
- Onion Service connectivity using cookie responses from DNS.
- Basic filtering mechanism for disallowing certain flows.

Onionmasq

We need to expand the usual IP 5-tuple with additional flow metadata for isolation purposes:

- Application UUID (Unix User ID on Android) and its name.
- Hostname (if any).
- DNS cookie (for looking up cookie IP to Onion Service identifier).

How can you help?

- Run a Tor relay or a bridge!
- Teach others about Tor and privacy in general.
- Find, and maybe fix, bugs in Tor software.
- Test Tor on your platform of choice.
- Work on some of the many open research projects.
- Donate at donate.torproject.org

Questions?

ahf@torproject.org

@ahf@mastodon.social

@ahfaeroey

OpenPGP:
1C1B C007 A9F6 07AA 8152
C040 BEA7 B180 B149 1921