

Introduction to The Tor Ecosystem:

Privacy, Anonymity, and Anti-censorship

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October 7, 2025



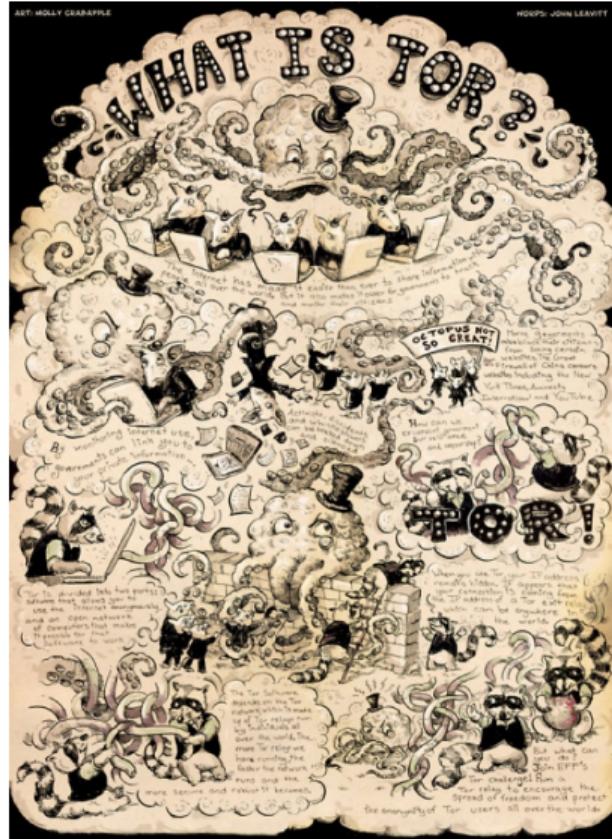
About Me

- Core Developer at The Tor Project since early 2017. Team Lead of the Network Team since late 2019.
- Free Software developer since 2006.
- Worked with distributed systems in the Erlang programming language, WebKit-based mobile browsers, embedded development, and software development consulting.

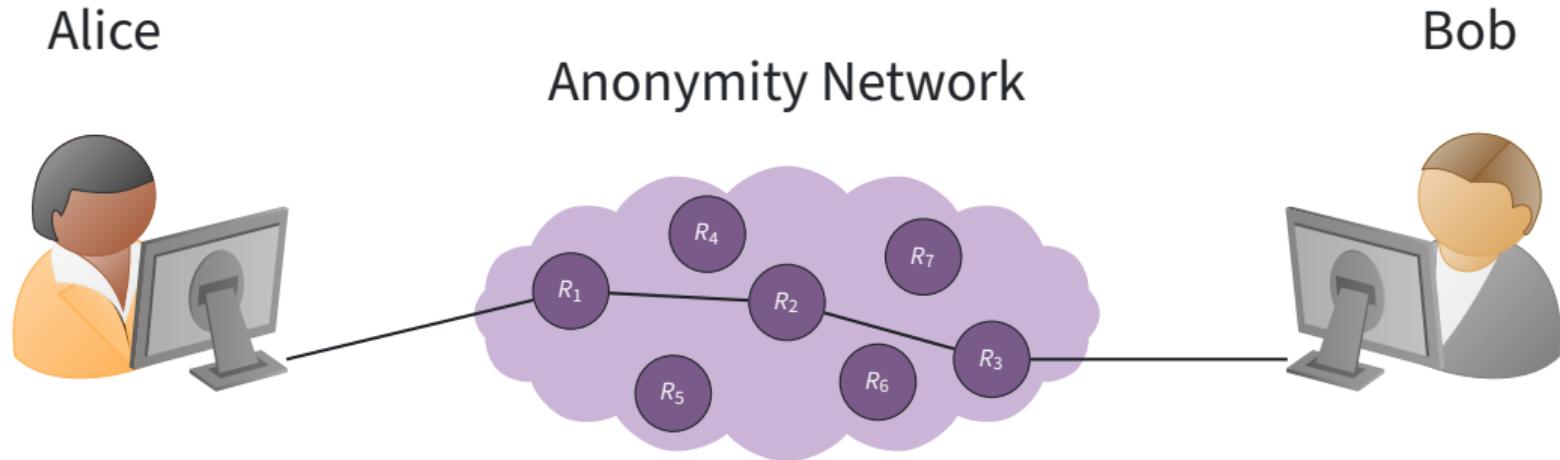


What is Tor?

- 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.

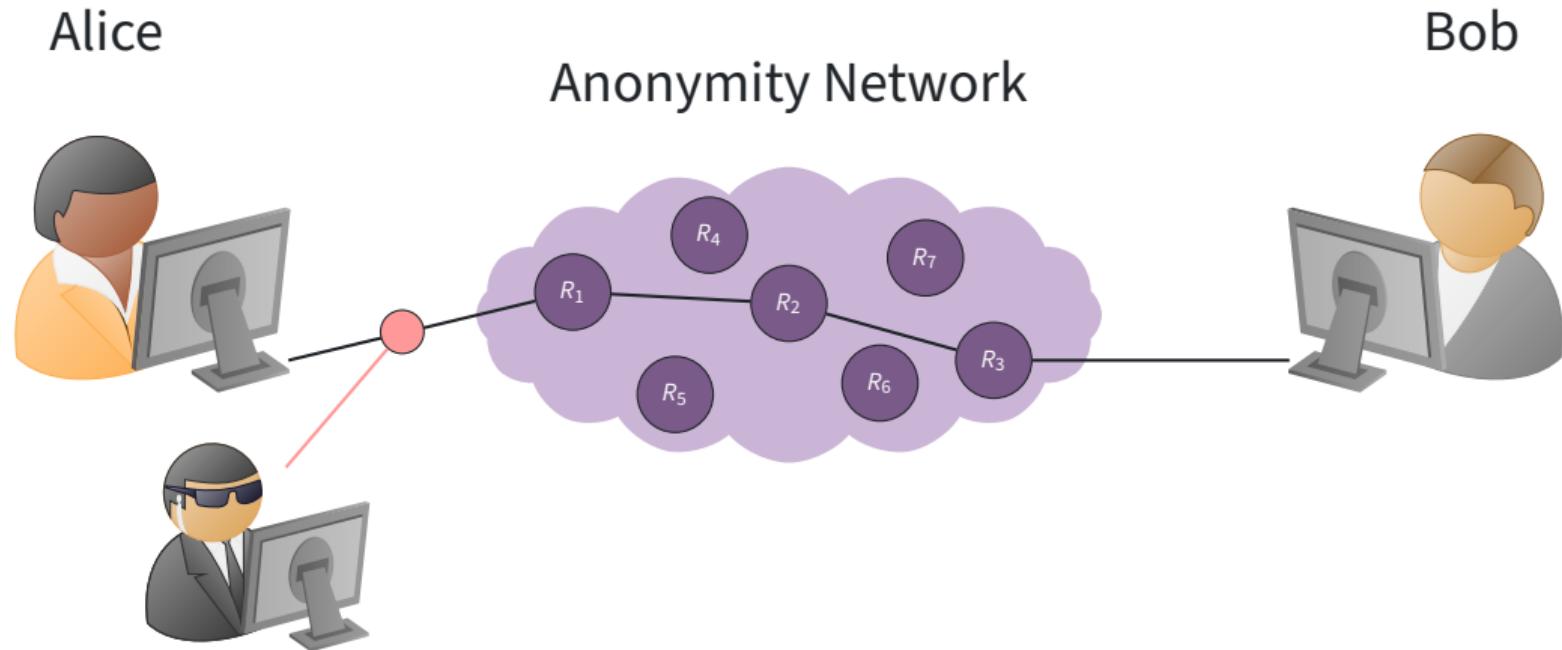


Threat Model

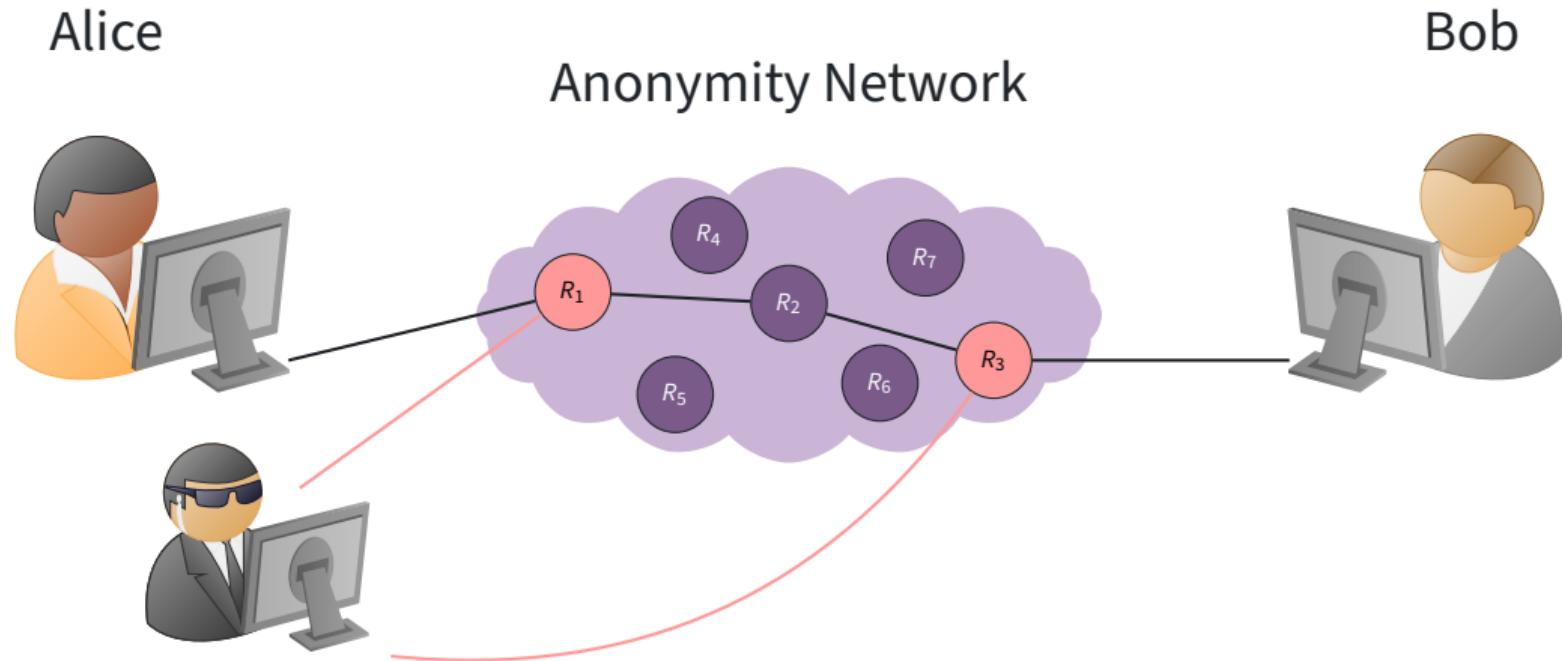


What can the attacker do?

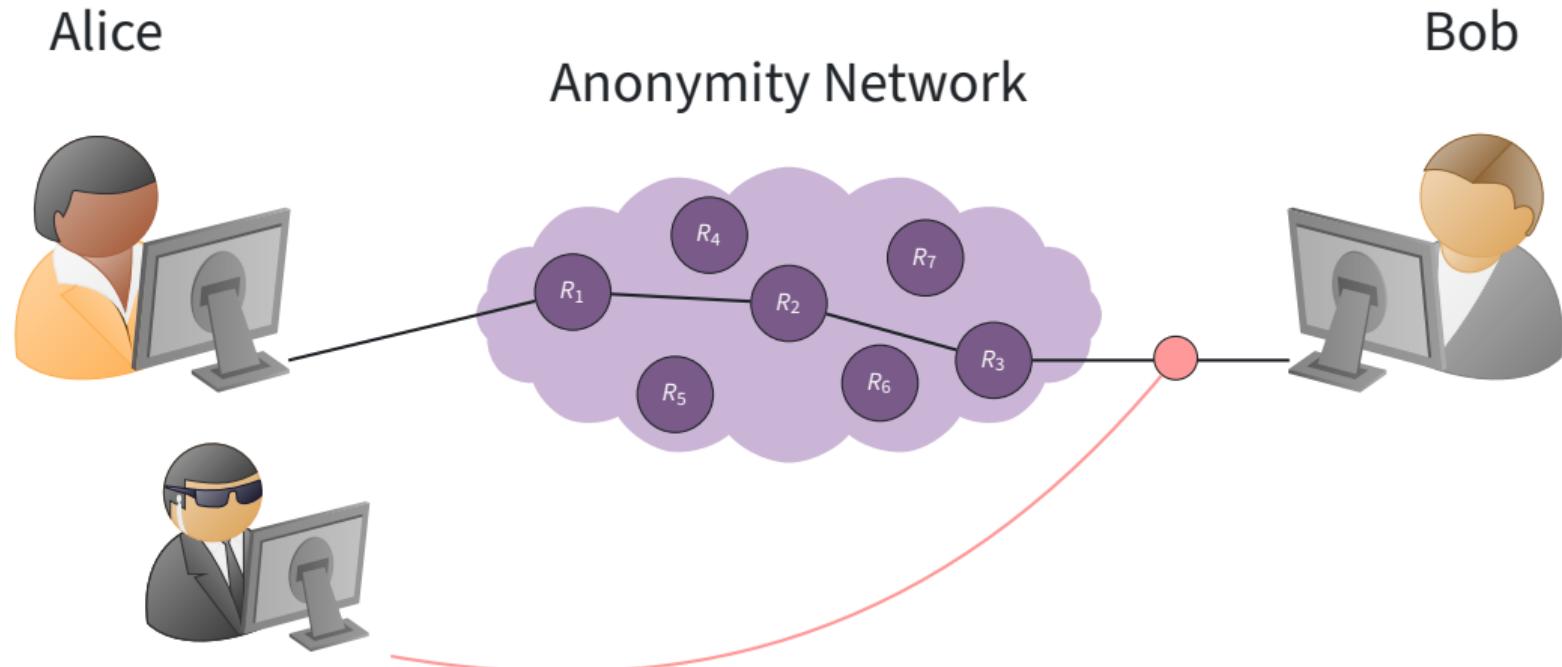
Threat Model



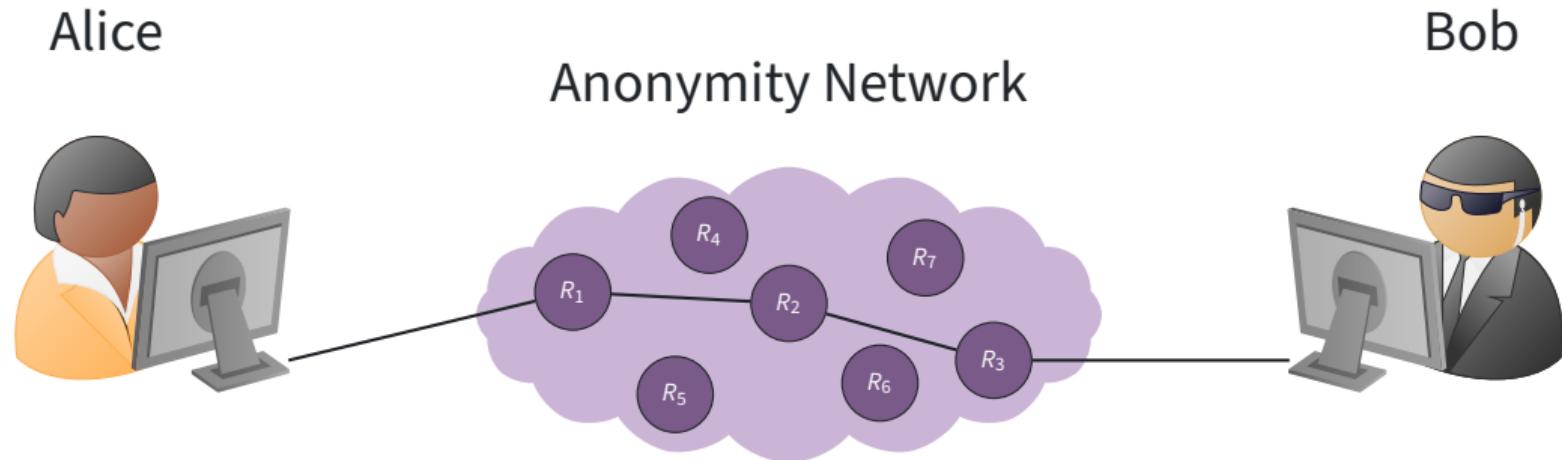
Threat Model



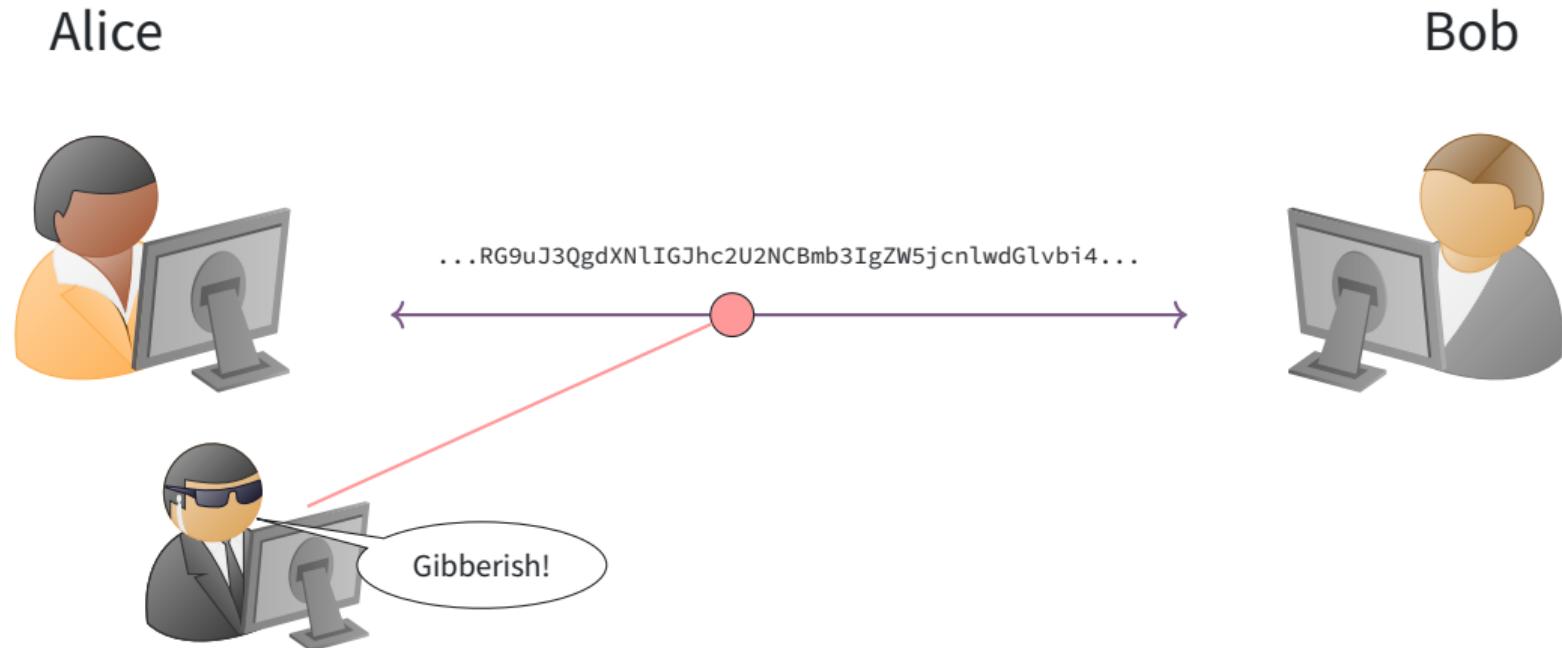
Threat Model



Threat Model



Anonymity isn't Encryption



Encryption just protects contents.

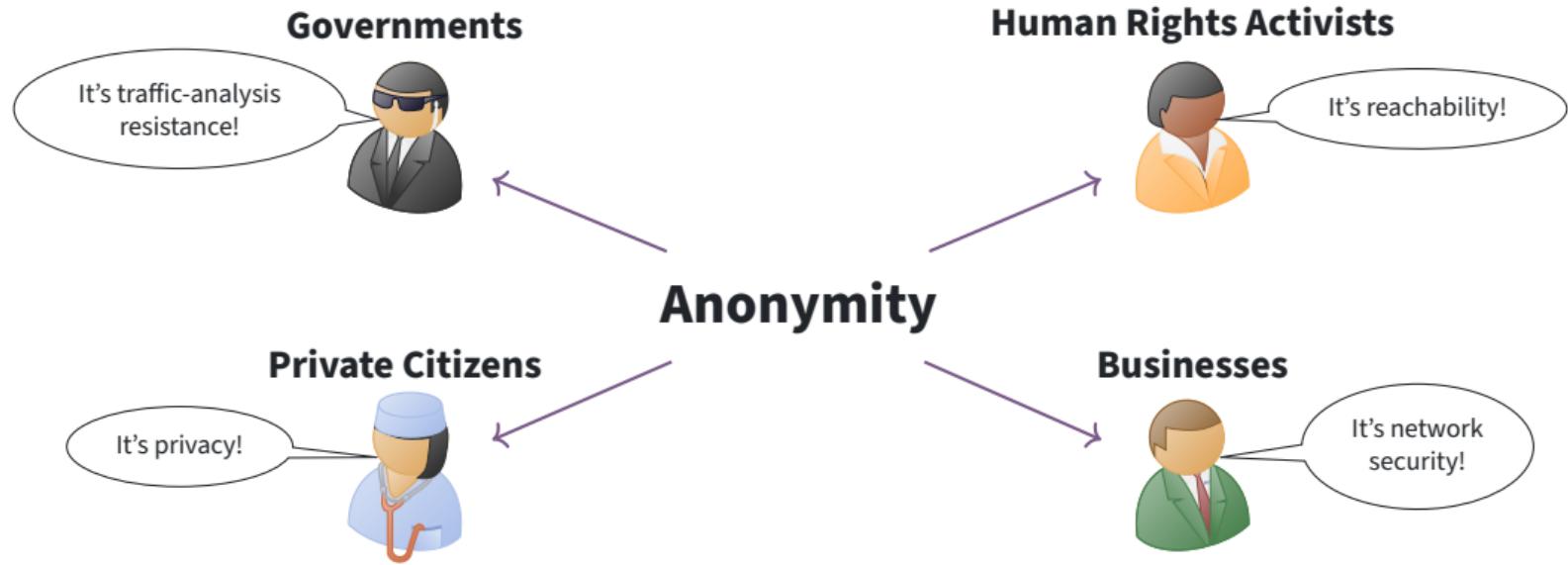
Metadata



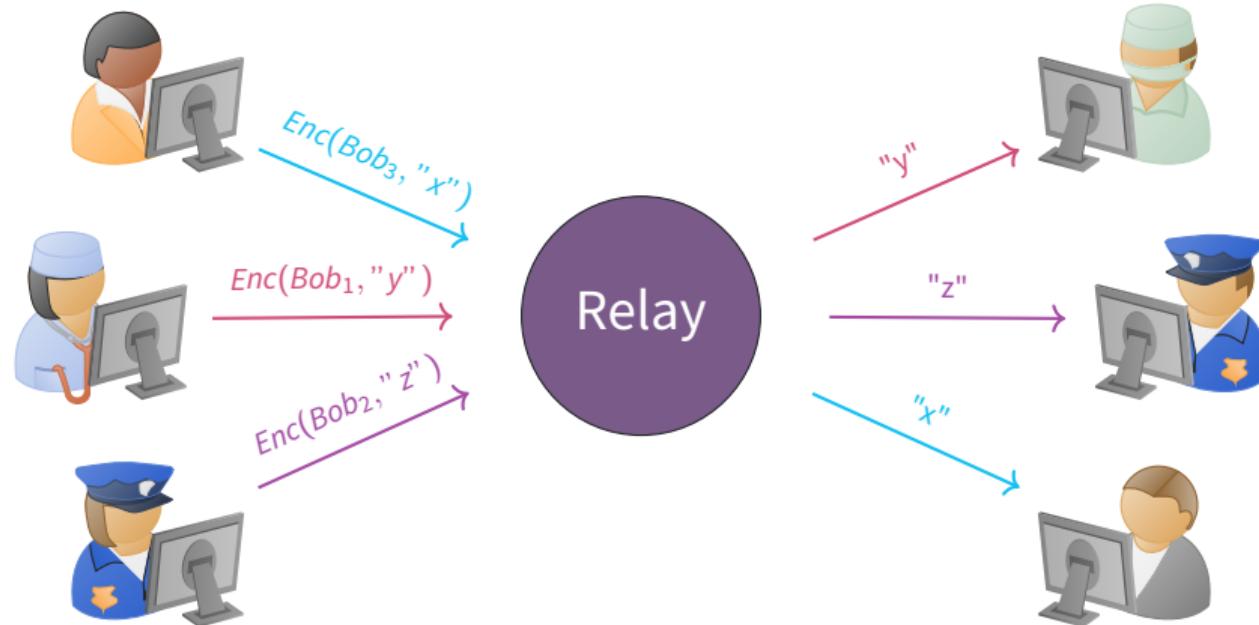
"We Kill People Based on Metadata."

—Michael Hayden, former director of the NSA.

Different Purposes of Anonymity

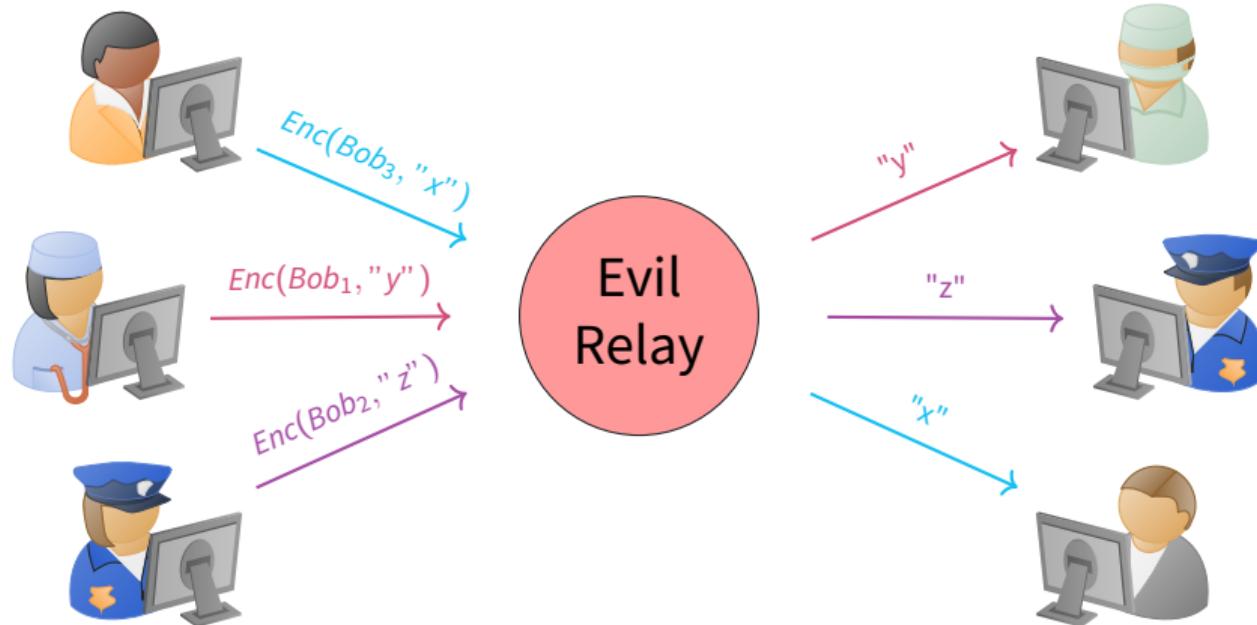


A Simple Design

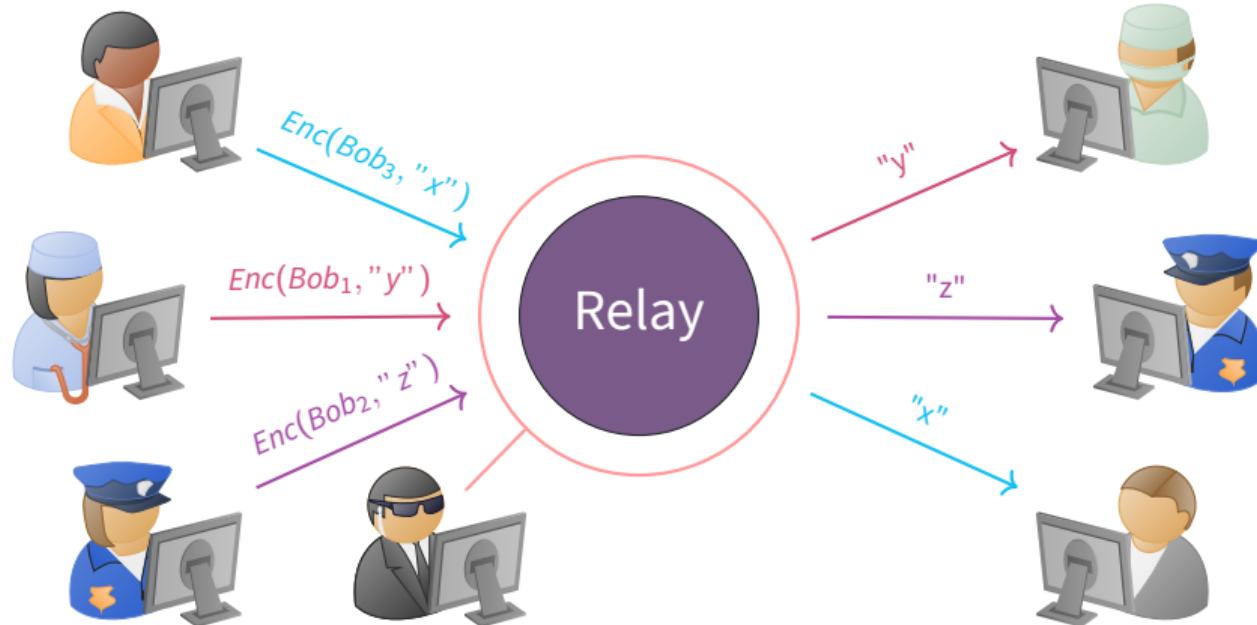


Equivalent to some commercial proxy providers.

A Simple Design

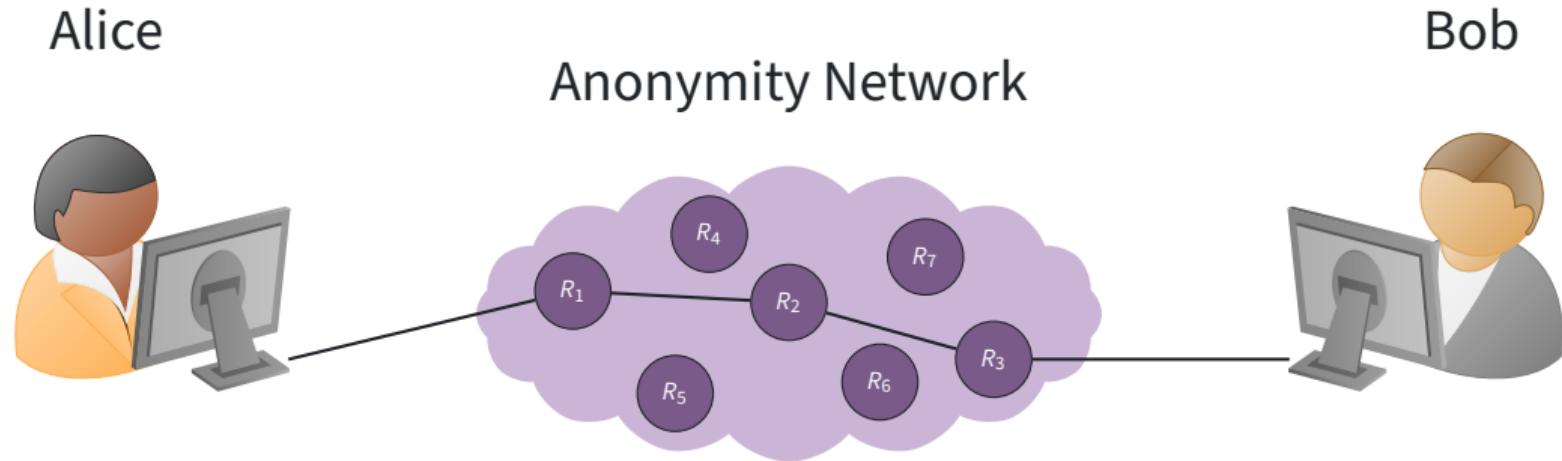


A Simple Design



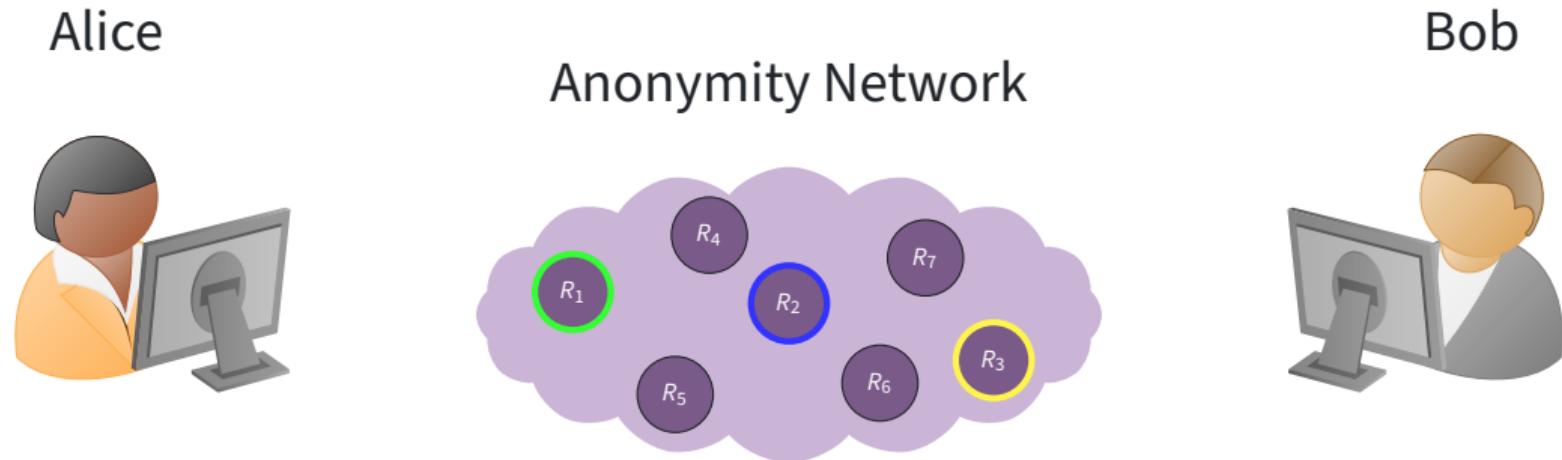
Timing analysis bridges all connections going through the relay.

The Tor Design



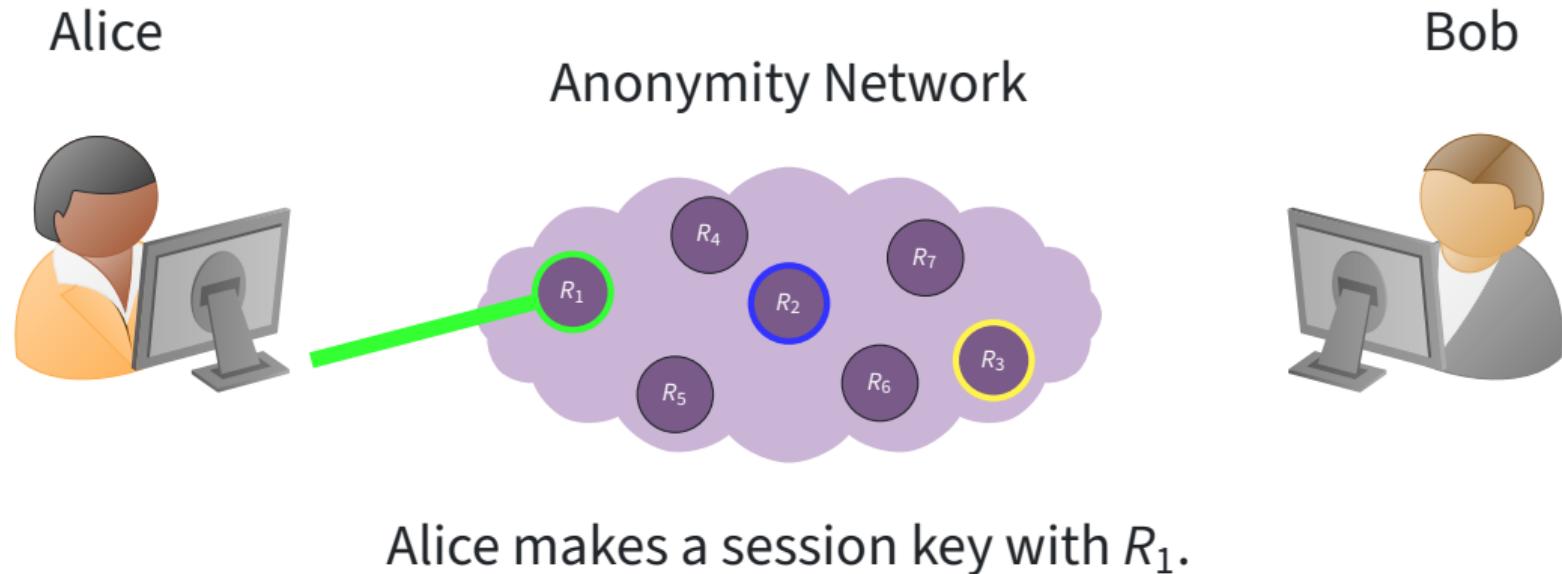
Add multiple relays so that no single relay can betray Alice.

The Tor Design

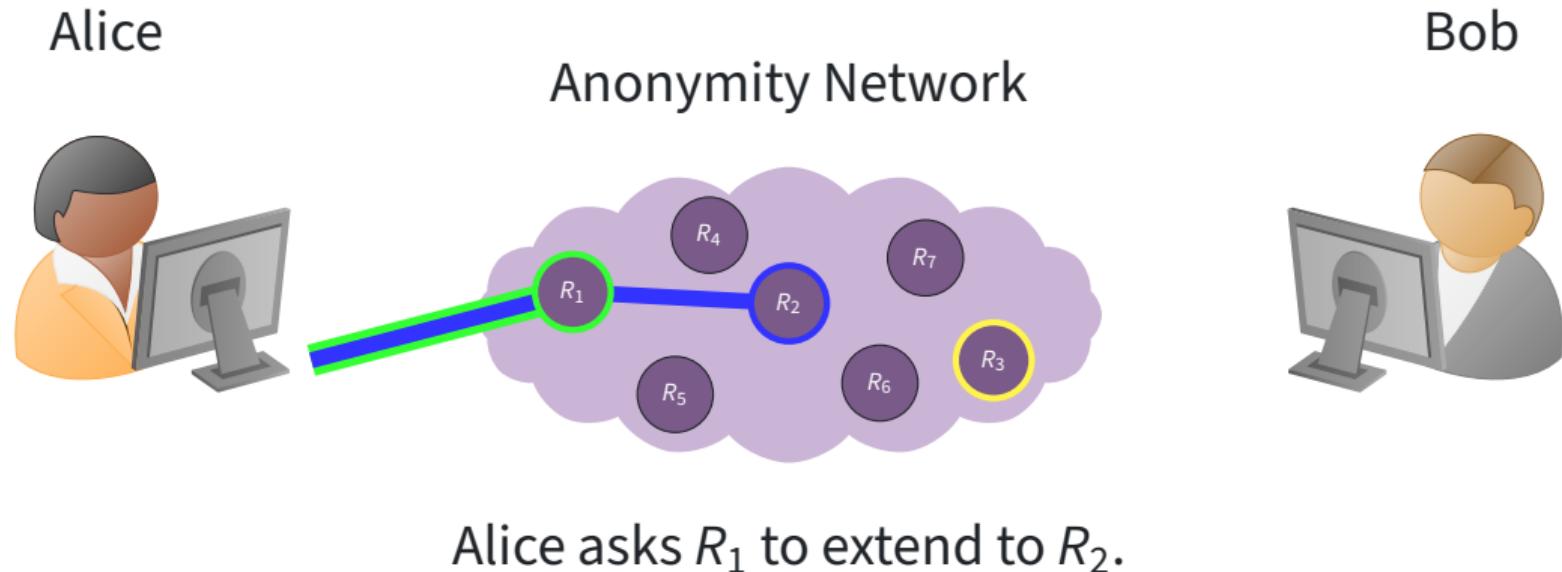


Alice picks a path through the network: R_1 , R_2 , and R_3 before finally reaching Bob.

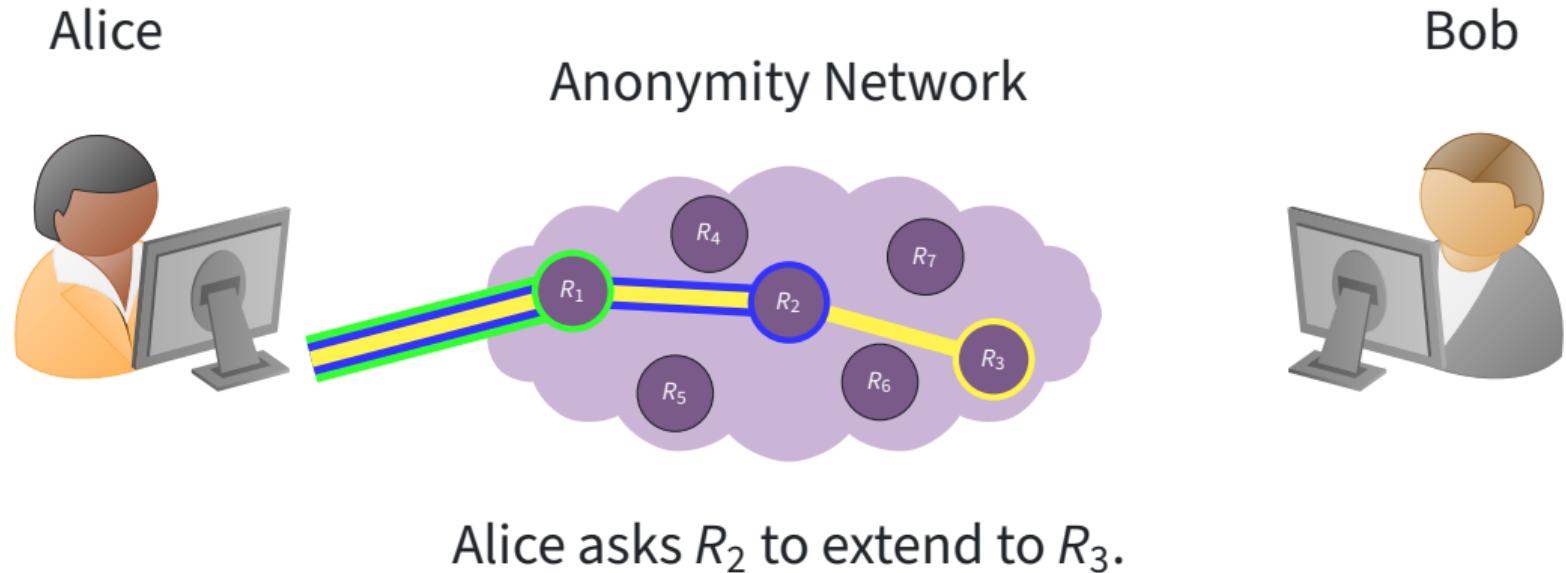
The Tor Design



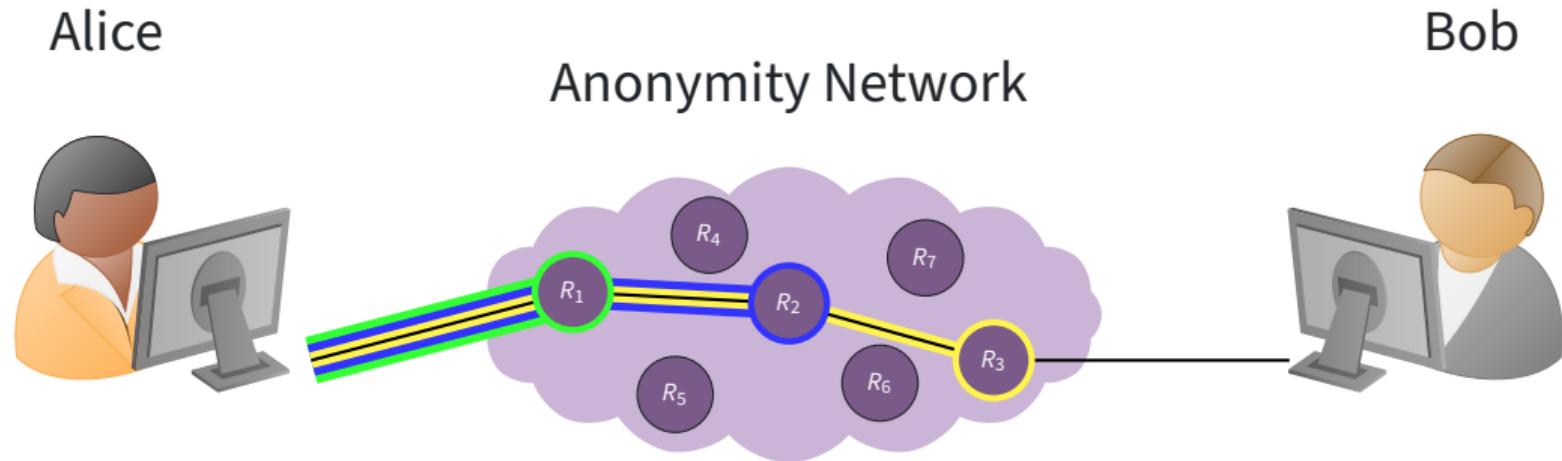
The Tor Design



The Tor Design



The Tor Design



Alice finally asks R_3 to connect to Bob.

The Tor Network

- An open network – everybody can join!
- Between 6000 and 8000 relay nodes.
- Kindly hosted by various individuals, companies, and non-profit organisations.
- 9 Directory Authority nodes and 1 Bridge Authority node.

I live in Iran and I have been using Tor for censorship circumvention. During political unrest while the government tightens grip on other censorship circumvention alternatives, **Tor with obfuscation plugins remains the only solution.**

Tor changed my personal life in many ways. **It made it possible to access information on Youtube, Twitter, Blogger and countless other sites.** I am grateful of Tor project, people working on it as well as people running Tor nodes.

—Anonymous Tor User.

بِاللَّهِ بِالسْتَّرِ !

تصفح بآمان!

عذرًا هذا الموقع غير متاح في دولة الإمارات العربية المتحدة.

شكراً شيكلاً لتقديركم وسيلة للتواصل والمعرفة وذمة مطالبات
عجلات المومية، وقد تم حجب الموقع الذي ترغب بدخوله لاشتماله
محتوى غير لائق تحت "التصنيف المخفي" بسبب تعلق
"التصنيف المخفي" بـ"التصنيف المخفي لـTorProject". لعلنا تتفهم المطالبات
بدعم دول الإمارات العربية المتحدة.

إذا كنت تدعي وجدة ذكر مخالفة، الرجاء [ال هنا](#)



Surf Safely!

This website is not accessible in the UAE.

The Internet is a powerful medium for communication, sharing and serving our daily learning needs. However, the site you are trying to access contains content that is prohibited under the 'Internet Access Management Policy' of the Telecommunications Regulatory Authority of the United Arab Emirates.

If you believe the website you are trying to access does not contain any such content, please [click here](#).



خطر!

تصفح بآمان!

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Access Denied

our request was denied because of its content categorization: "Computers/Internet;Proxy Avoida

عزيزي العميل: تم حجب هذا الموقع بناء على الوائح والقوانين

بأن هناك خطأ يرجح إرسال رسالة على البريد الإلكتروني unlock.kw@kw.zain.com مع ذكر عنوان الموقع الذي تم حجبه.

Dear Customer: This site has been
categorizing this site, please

9:28 AM
Site Block...
Blocked URL
Dear User, <http://torproject.org/>

Sorry, the requested page is
unavailable.

عفواً، الموقع المطلوب غير متاح.
If you believe the requested page should
not be blocked please [click here](#).

Site Blocked
This site has been blocked for violating
regulations and laws of Kingdom of Bahrain.

If you believe the requested page should
not be blocked please [click here](#).

http://torproject.org/

Dear User,

Sorry, the requested page is
unavailable.

If you believe the requested page should not be
blocked please [click here](#).

For more information about internet service in Saudi Arabia, please click
here: www.internet.gov.sa



Du var på vej ind på en ulovlig hjemmeside

Vi vil meget gerne hjælpe dig med at finde den film eller serie, du søger.

Søg med FilmFinder →

Hvis du er på udkig efter musik, bøger eller møbler

Gå til  SHARE WITH CARE →



SHARE
WITH
CARE

Hjemmesiden er blevet blokeret, fordi den er dømt ulovlig ved en dansk domstol. Brug Share With Care til at finde det, du leder efter, lovligt. På den måde passer du både på dig selv og på kulturen. [Læs mere om Share With Care](#)



RettighedsAlliancen



D



Digital

Introduction to Censorship

Censored Region

Alice



Bob



Alice is unable to reach Bob.

Introduction to Censorship

Censored Region



Alice can reach Bob, but their connection is throttled.

Introduction to Censorship

Censored Region

Alice



Bob



Alice can reach Bob because the censor thinks Bob is fine.

Anti-censorship Strategies

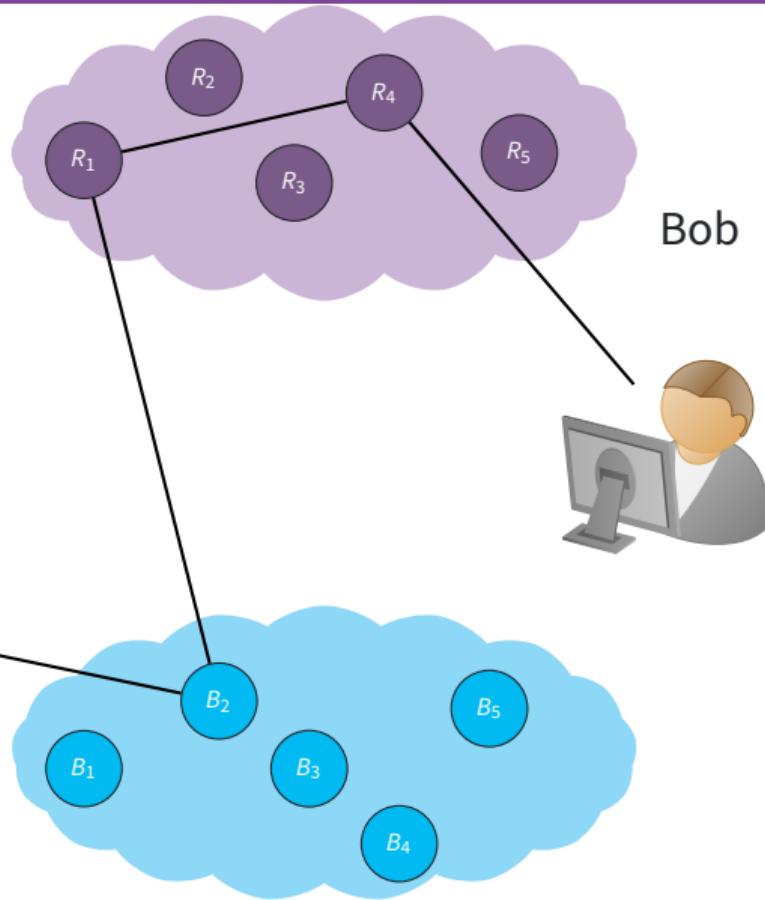
1. Censors will apply censorship to **all** relays in the network and effectively block access to the Tor network.
2. Censors will apply censorship to **known** bridges.

Solution: We make it difficult to find and block bridges and we make it difficult to learn if a given connection is between a Tor user and an entry-point into the Tor network.

Bridges

Censored Region

Alice



Bob



Bridges

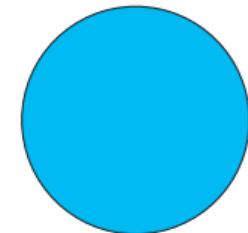
Censored Region

Alice

Bridge



Tor Protocol



Bridges and Pluggable Transports

Censored Region

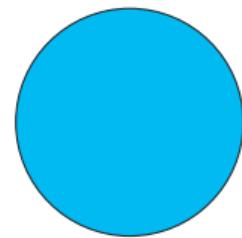
Alice



PT Client

Obfuscated Protocol

Bridge



PT Server

Pluggable Transports

- Allows people to easily build, experiment, and deploy their own obfuscation technology without having to modify the Tor source code itself.
- The specification for Pluggable Transports is open and allows other vendors to implement support for PTs in their own products.
- Allows people to experiment with different transports for Tor that might not be doing any anti-censorship related obfuscation.

Snowflake

Censored Region

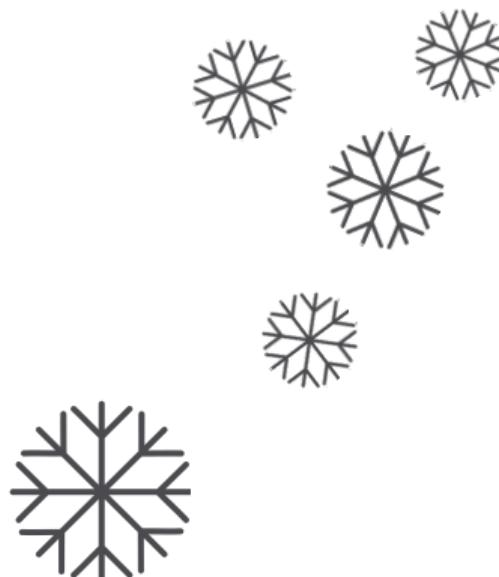
Alice



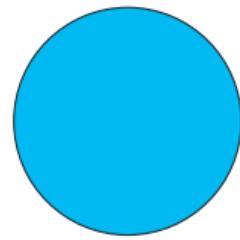
Snowflake PT Client

Snowflake Broker

Bridge



Snowflake PT Server



Snowflake

Censored Region

Alice

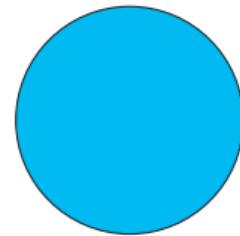


Snowflake PT Client

Snowflake Broker



Bridge



Snowflake PT Server



A vertical dashed red line separates the 'Censored Region' on the left from the 'Bridge' on the right.

Snowflake

Censored Region

Alice

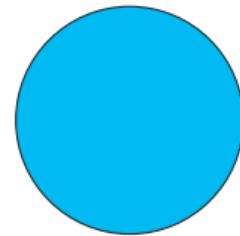


Snowflake PT Client

Snowflake Broker



Bridge



Snowflake PT Server



Snowflake

Censored Region

Alice



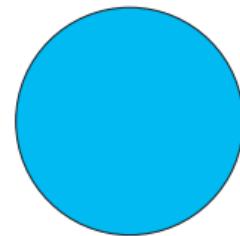
Snowflake PT Client



Snowflake Broker



Bridge



Snowflake PT Server



Snowflake

Censored Region

Alice



Snowflake PT Client

Snowflake Broker

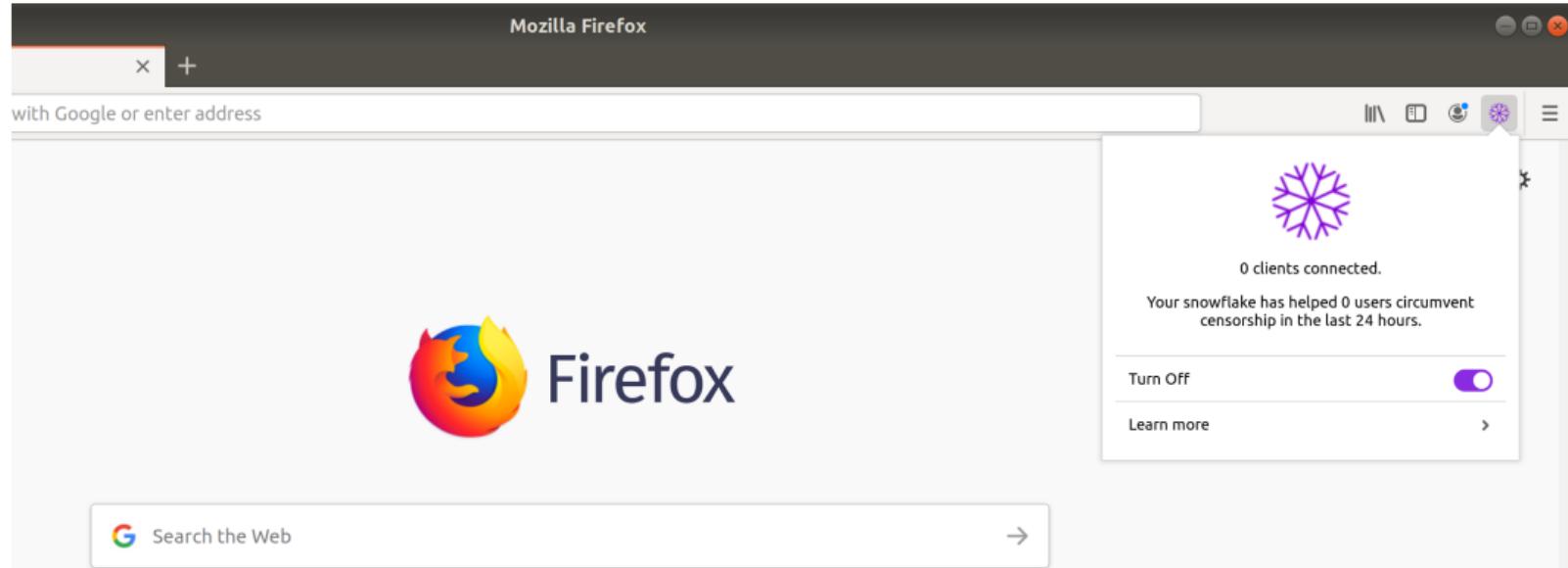
Bridge



Snowflake PT Server



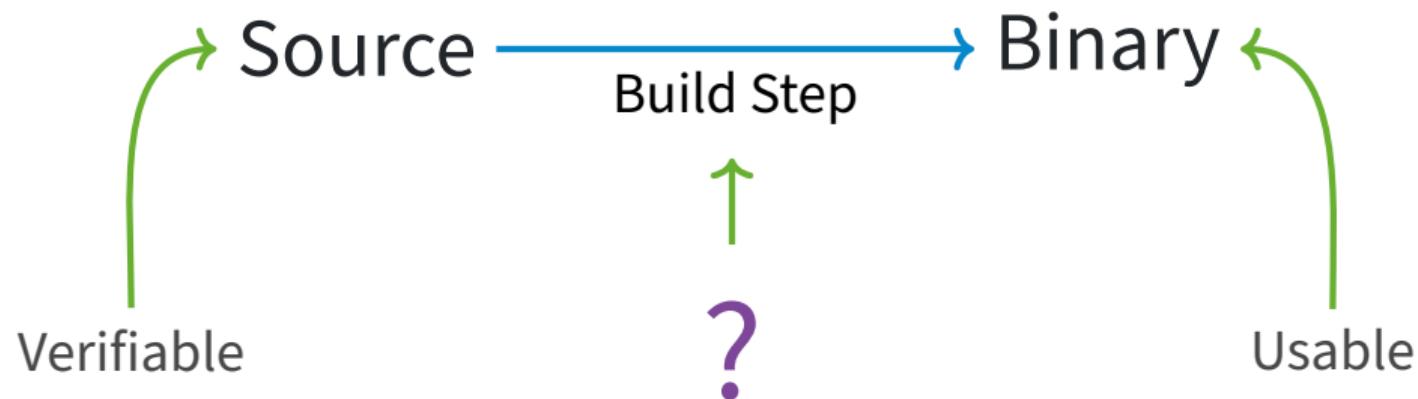
Snowflake



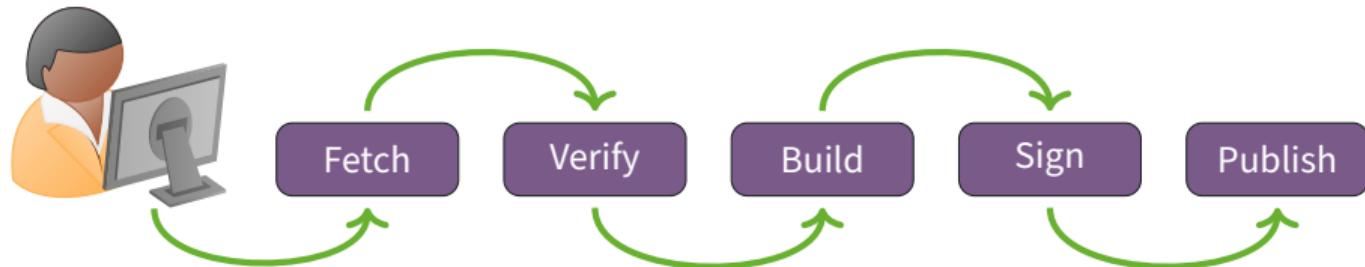
Reproducible Builds



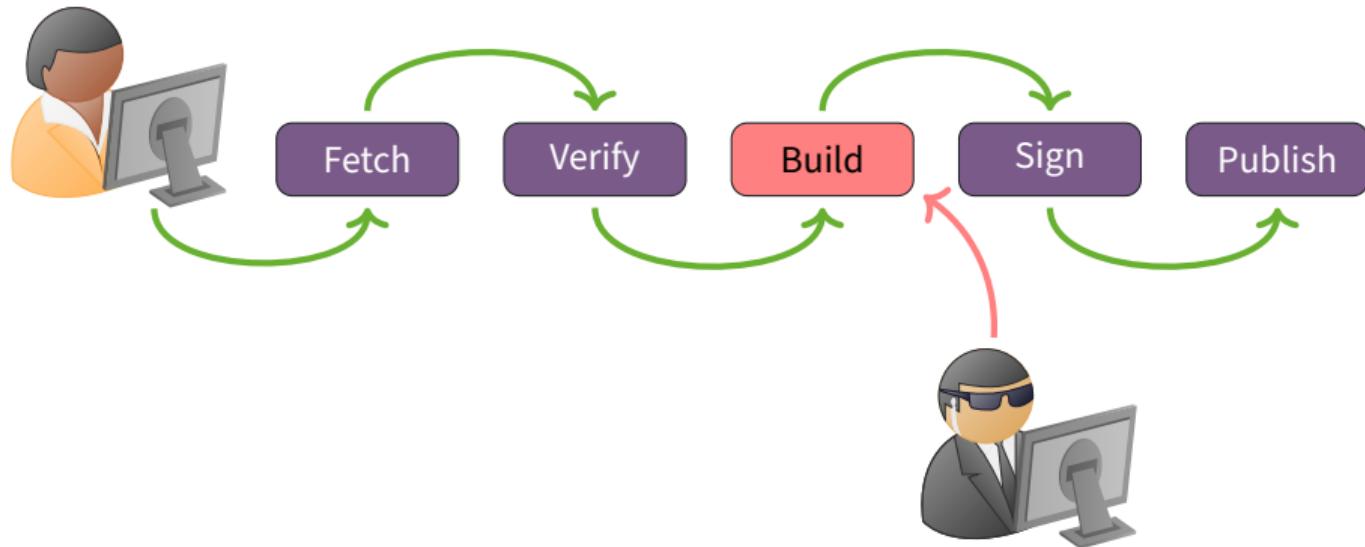
Reproducible Builds



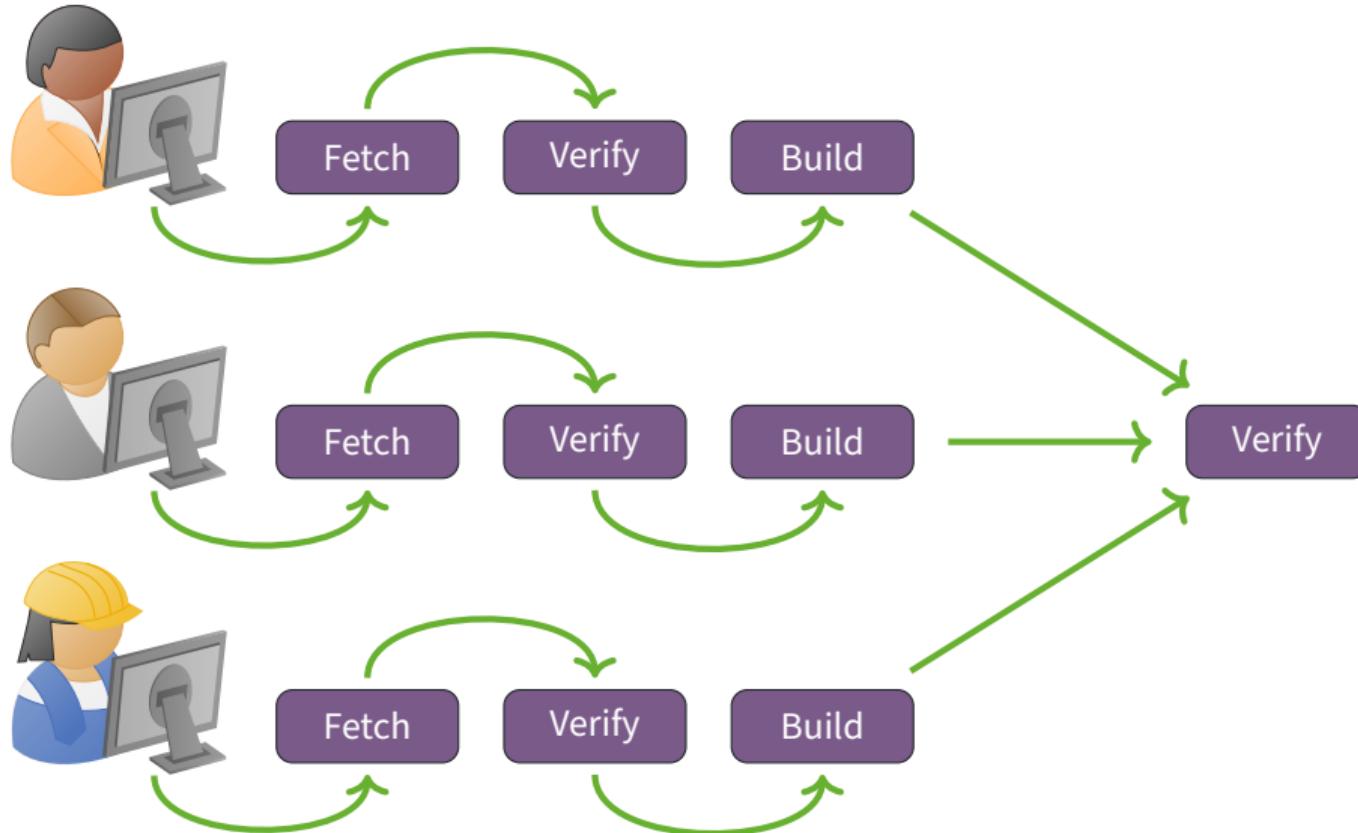
Build Process



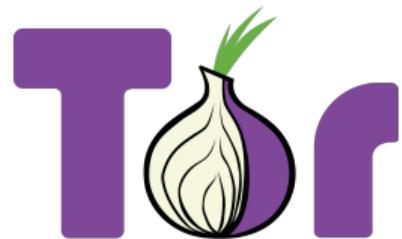
Build Process



Build Process



Reproducible Builds



Reproducible Builds Problems

Common problems includes:

- Timestamps as part of the build process.
- Usernames.
- Locale settings.
- Host settings (such as hostname and IP).

Tor is not foolproof

- Browser metadata fingerprinting.
- Browser exploits.
- Traffic analysis.
- Operational security mistakes.

How can you help?

- Find, and maybe fix, bugs in Arti.
- Run a Tor relay or a bridge!
- Teach others about Tor and privacy in general.
- Work on some of the many open research projects.



Questions?

✉ ahf@torproject.org

- ahf @ Funding the Commons
Discord

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

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