

Anonymity & Censorship-free Communication

Remitters

- Simple enough to use
- Simple enough to use
- Simple enough to use
- Simple enough to use
- Simple enough to use

Sustainability

- Many users are unable to pay
- Many users are unable to pay
- Many users are unable to pay

Who needs anonymity?

Number of users ≈ 0

The Web

- High latency
- High variability
- Low tolerance for padding

Abuse



Censorship resistance



Steven J. Murdoch
VASCO & University College London

Who needs anonymity?

- Military personnel
- Law enforcement
- Bloggers
- Activists and whistle-blowers
- Ordinary people



Encryption doesn't work

TLS, PGP, S/MIME only hide what is being said

- Alice uploaded a gigabyte to CNN 6 hours before footage of human rights abuses were aired
- Bob, who just joined our criminal organization sent an encrypted email to the FBI a week before our boss got arrested
- Charlie keeps browsing our website of illegal material, maybe we should give him fake data?

BBC Horizon

Encryption doesn't work

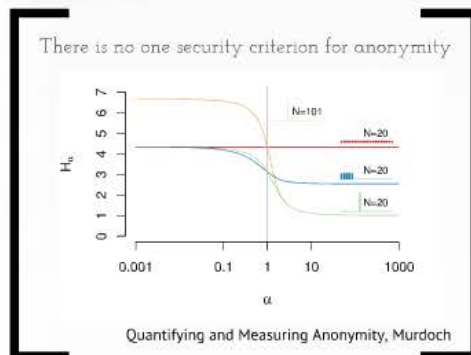
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Remailers

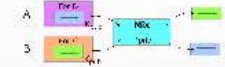
penet.fi (1993-1996)

- Simply stripped headers off emails sent via remailer
- Allowed replies to be sent
- Easy to use, but single point of compromise
- Shut down following compromise by CoS



Type-1 (Cypherpunk)

- Mix decrypts messages
- Uses PGP
- CAST5 & ElGamal



Mixmaster (1998-)

- Layered encryption
- Batching and re-ordering
- Based on Chaum Mix (1981)
- 3DES & RSA (PKCS #1 v1.5)



Mixminion (2002-)

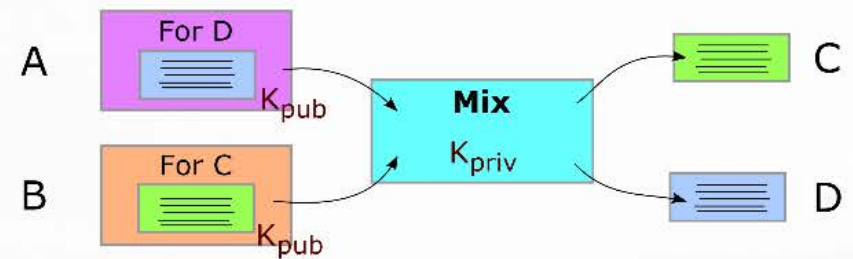
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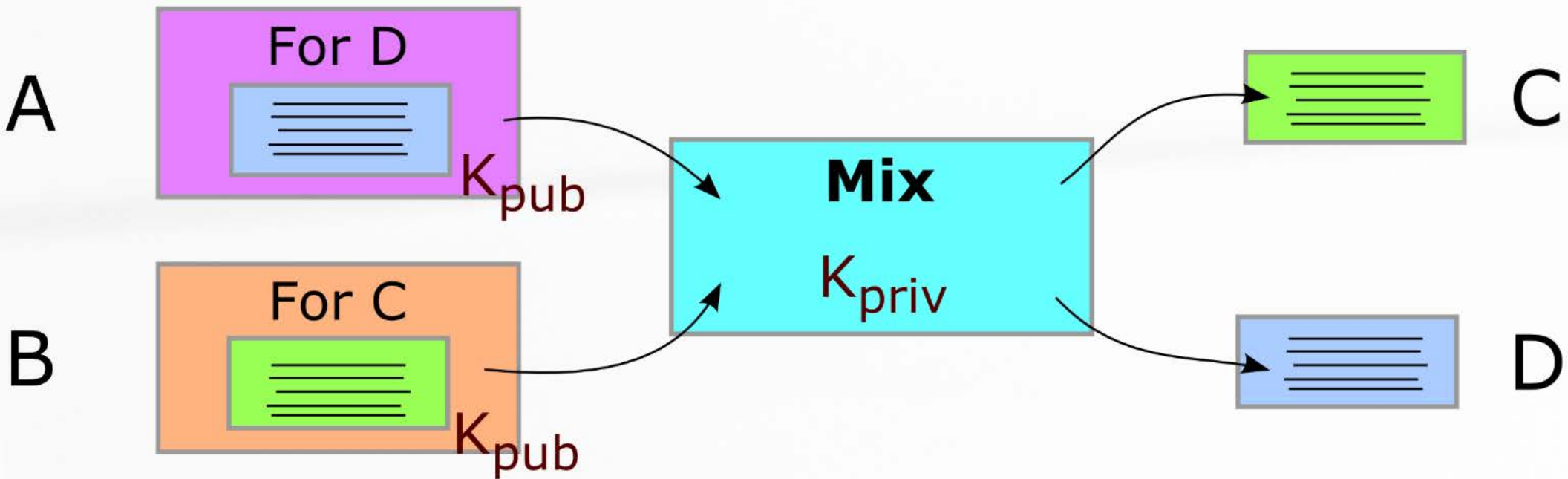
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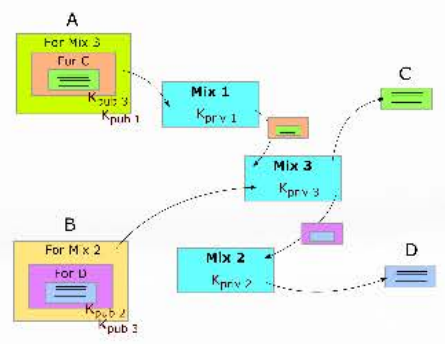


amal

CAST5 & ElGamal

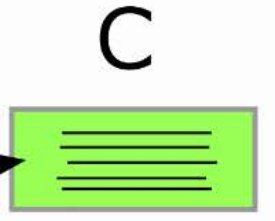
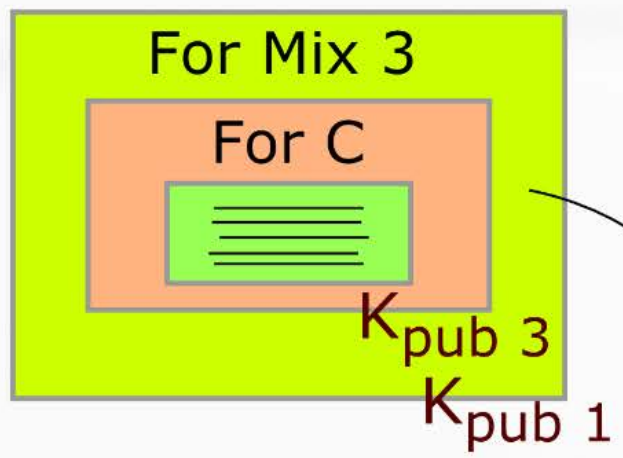
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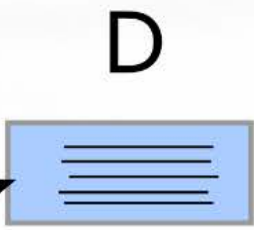
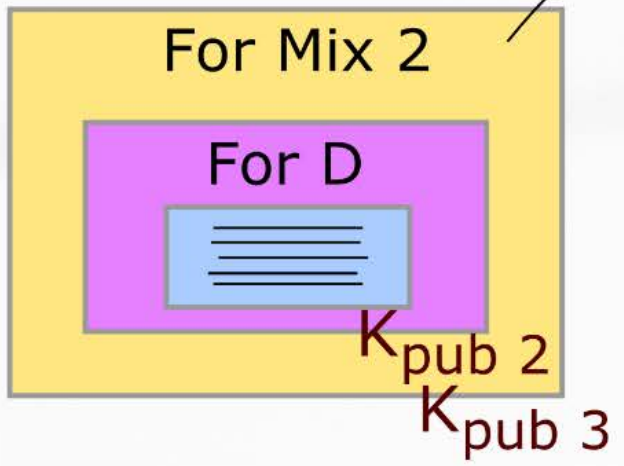


Mixminion (2002-)

A



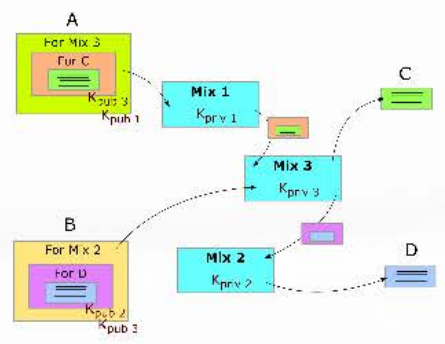
B



CAST5 & ElGamal

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Mixminion (2002-)

Senders



Receivers



- 3DES & RSA (PKCS #1 v1.5)

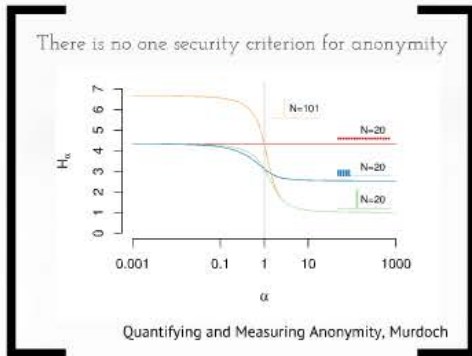
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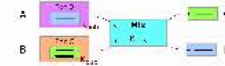
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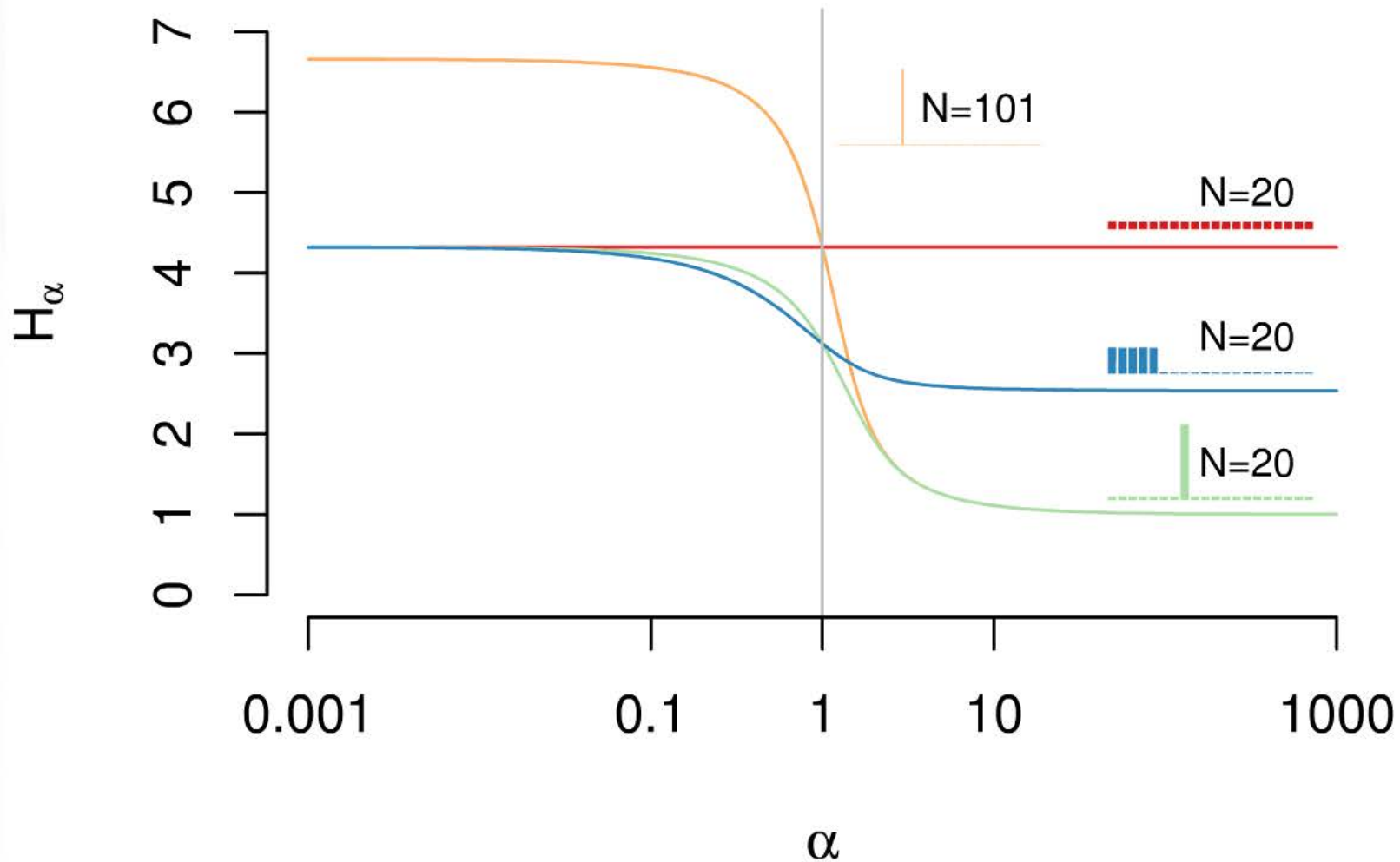
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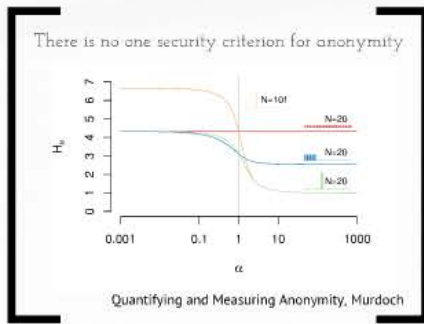
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There is no one security criterion for anonymity



Quantifying and Measuring Anonymity, Murdoch

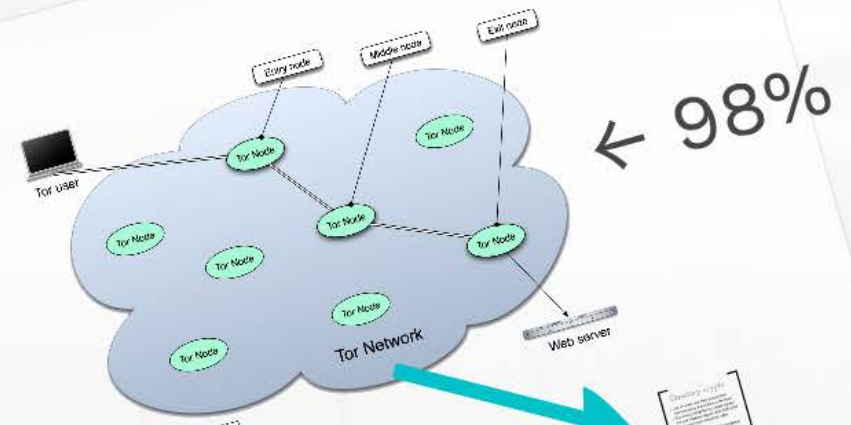


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Number of users ≈ 0

The Web

ard to secure



The Web

Web browsing is hard to secure

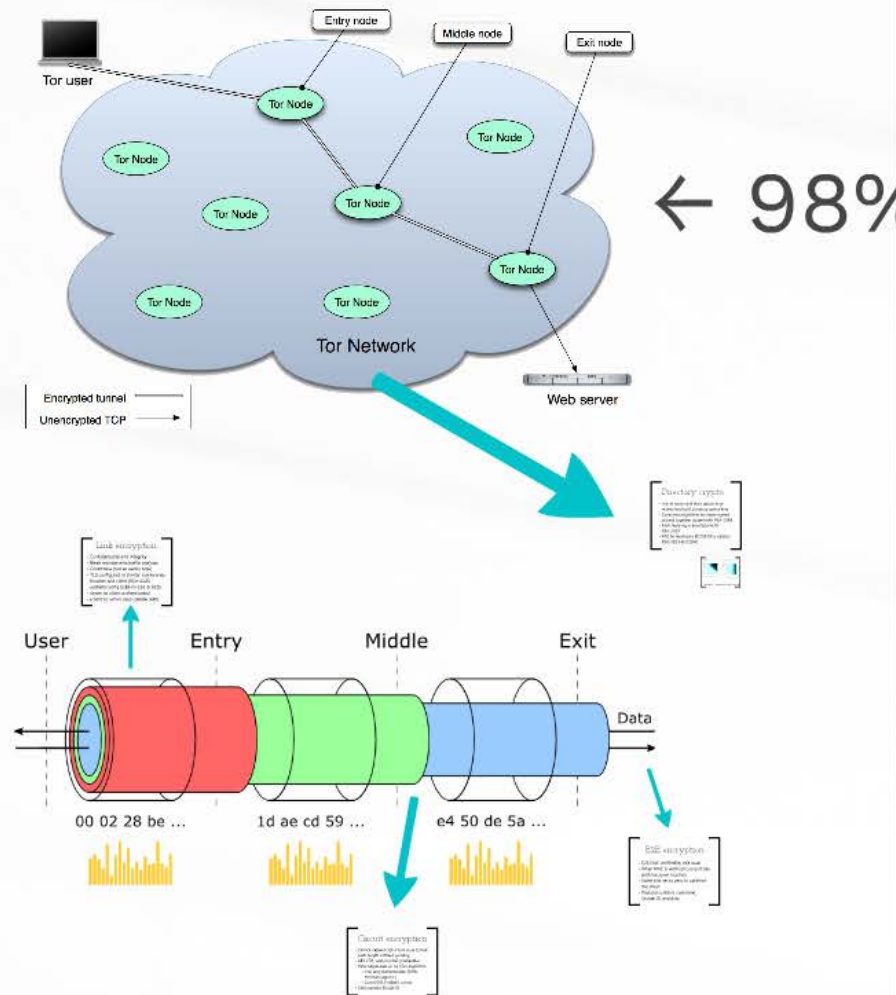
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- High variability
- Low tolerance to padding

Equivalent systems

Open proxies \approx penet.fi

VPN (IPSEC) \approx Type-0

MixMinion \approx Tor



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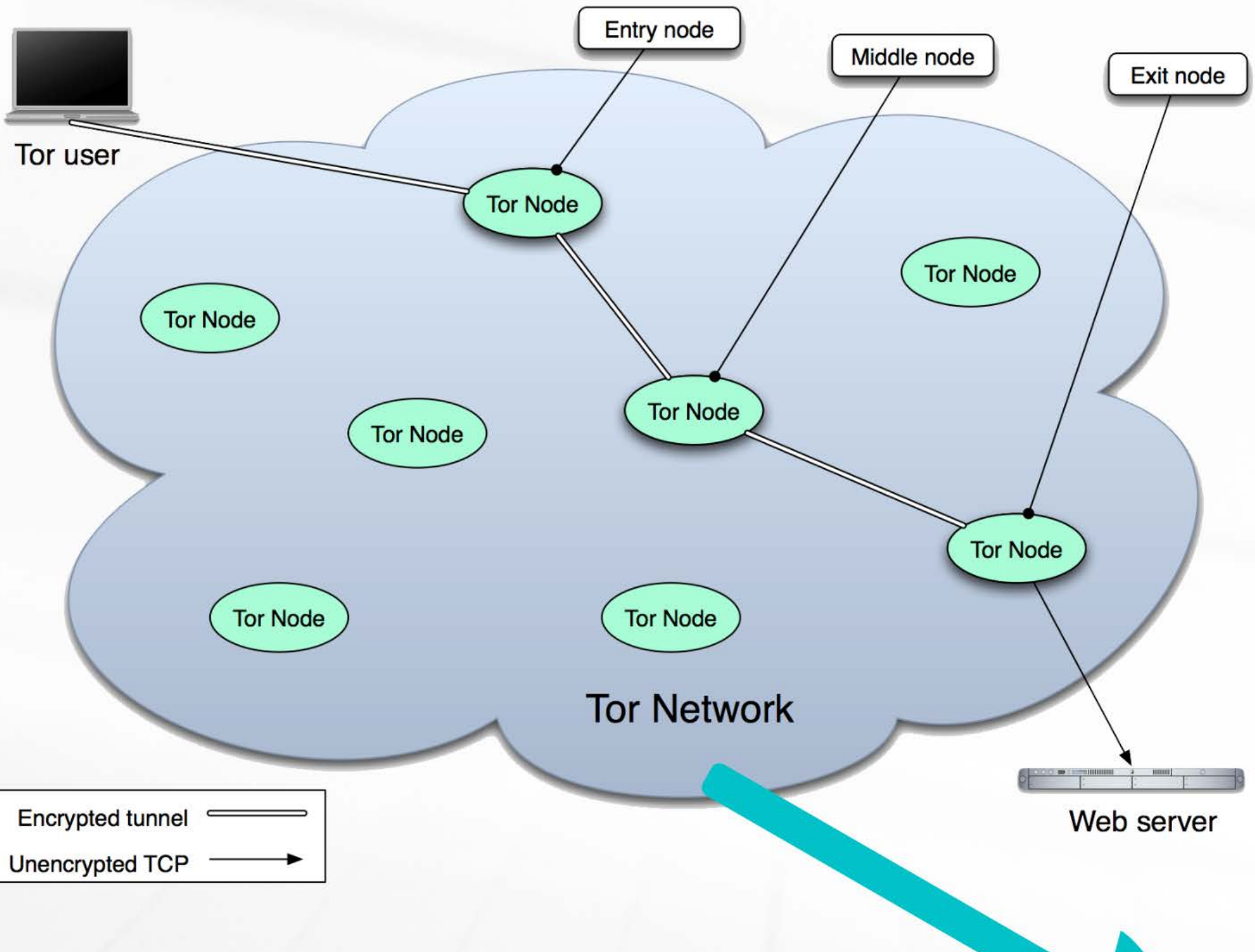
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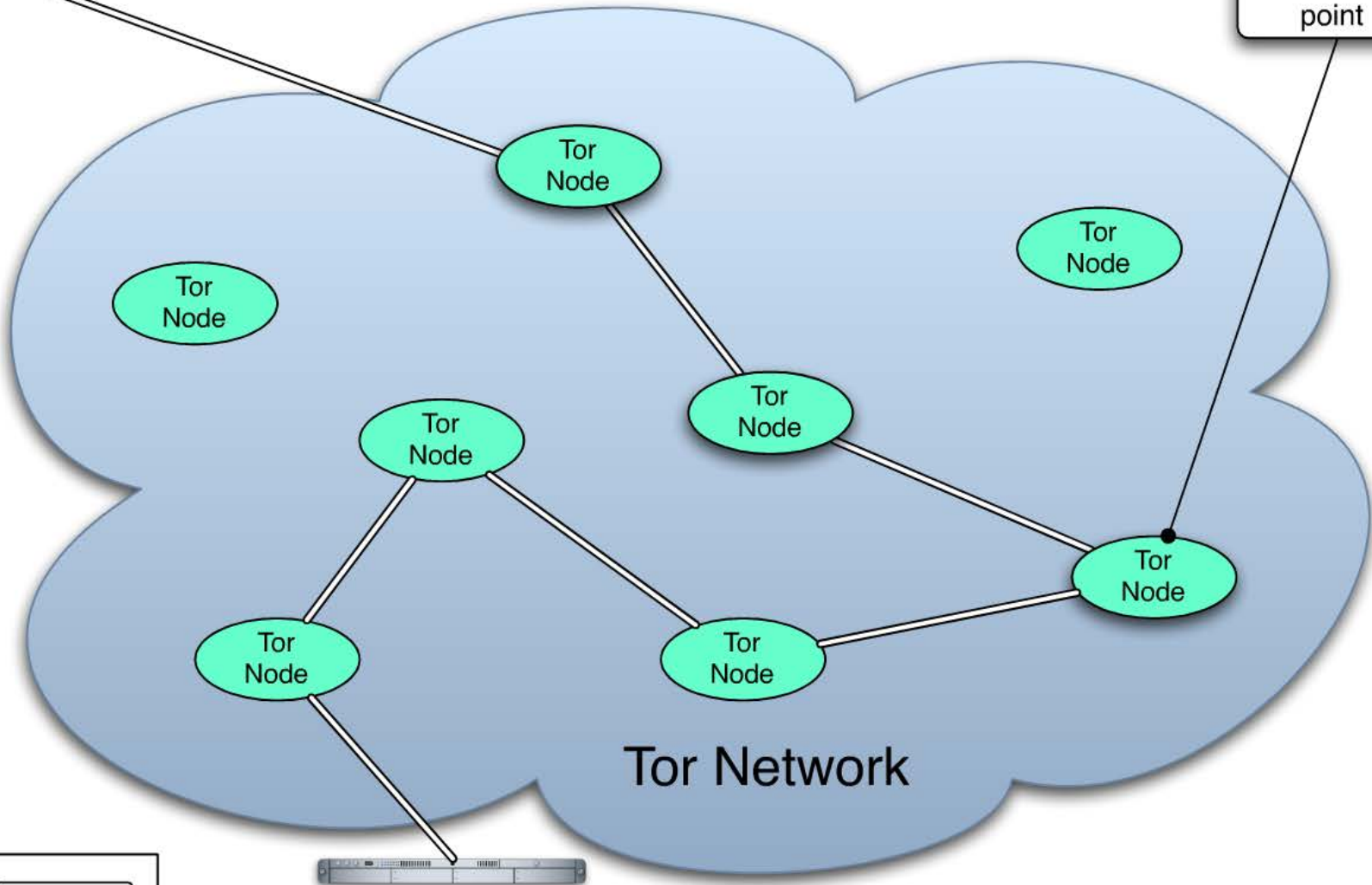
MixMinion \approx Tor



Tor user



Rendezvous point



Encrypted tunnel	
Unencrypted TCP	



Onion service

Link encryption

- Confidentiality and integrity
- Weak resistance to traffic analysis
- Covertness (not so useful now)
- TLS configured in similar way to web browser and client (RSA-1024 authenticating ECDH P-256 & AES)
- Server to client authenticated
- (client to server uses custom auth)

User

Entry

Middle

Exit

Data

00 02 28 be ...

1d ae cd 59 ...

e4 50 de 5a ...



Circuit encryption

- Cannot expand ciphertext so as to hide path length without padding
- AES CTR, with no MAC (malleable)
- Keys negotiated using nTor algorithm
 - One-way authenticated Diffie-Hellman (approx.)
 - Curve25519 elliptic curves
- Cells contain Circuit ID

E2E

- E2E M...
- When t...
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- Payload...
- Stream...

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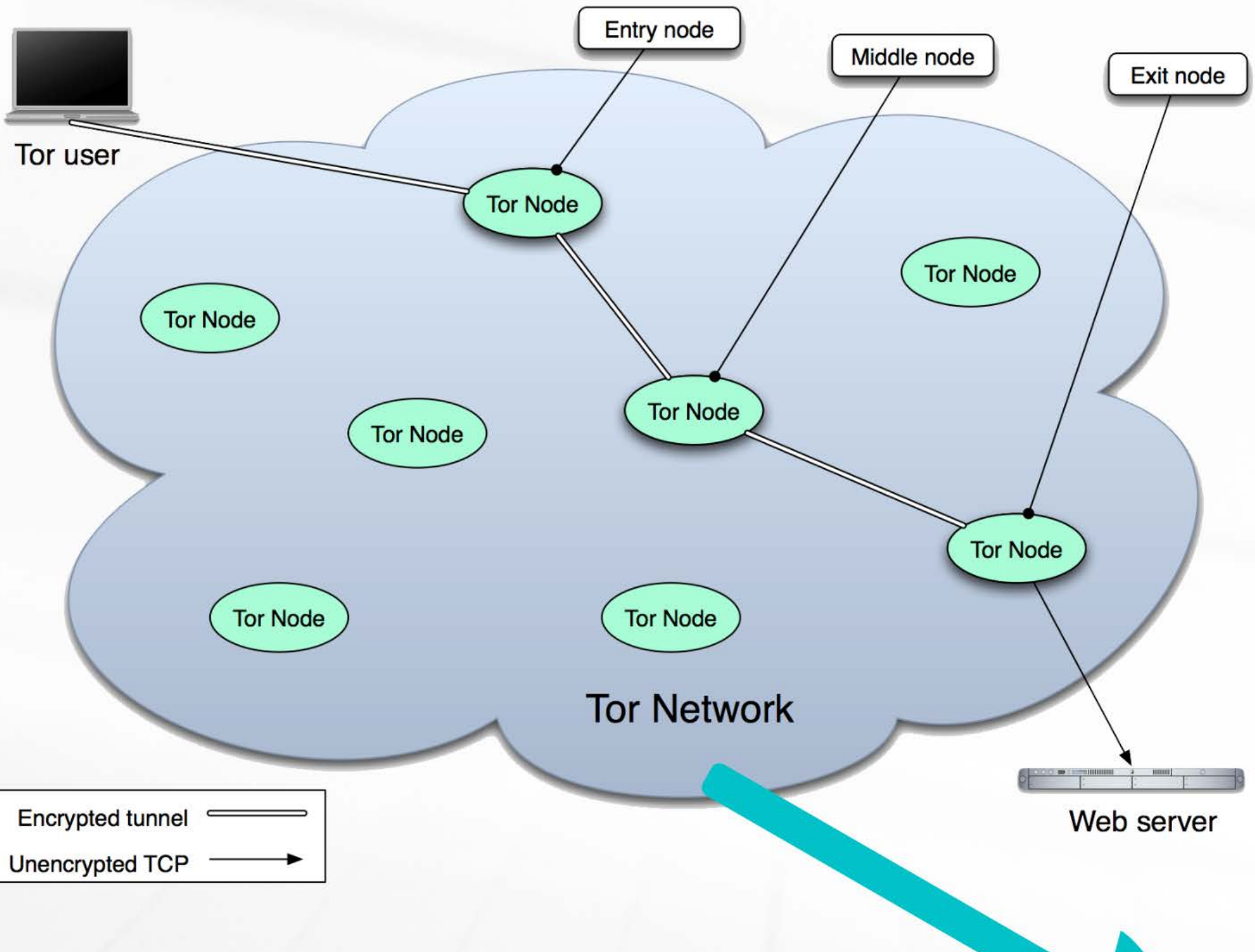
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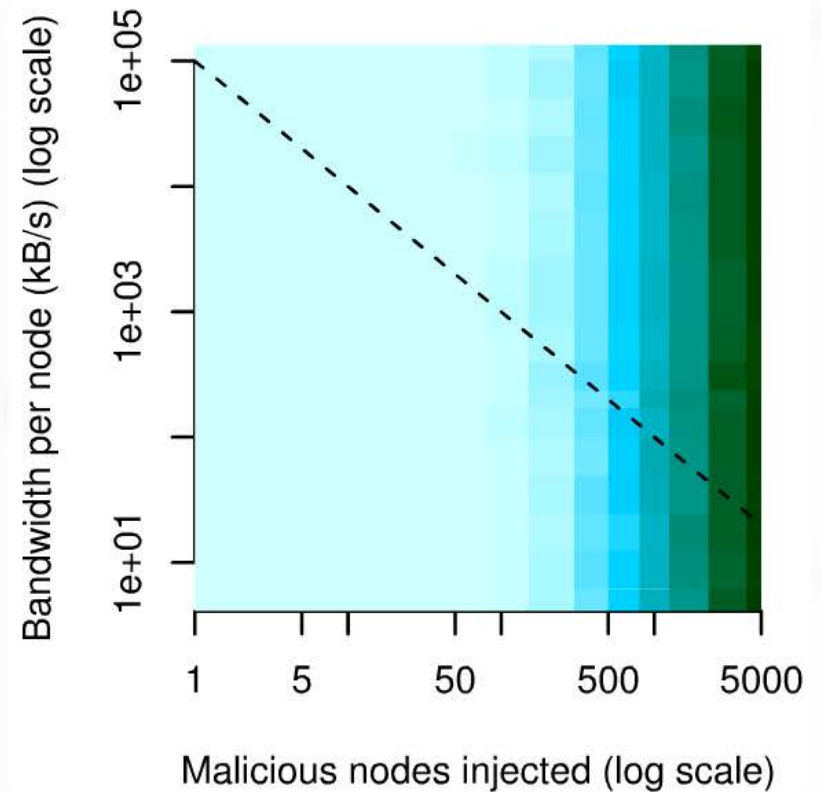
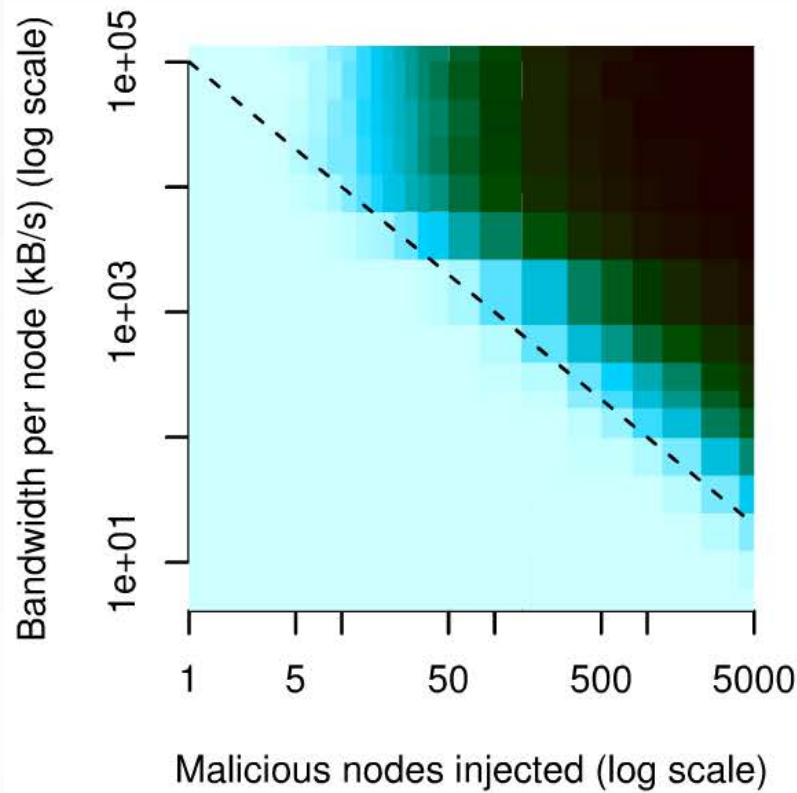
- E2E MAC verified by exit node
- When MAC is verified to end of the path has been reached
- Some bits set to zero to optimise the check
- Payload contains command, Stream ID and data



Directory crypto

- List of nodes and their public keys maintained by 8 directory authorities
- Consensus algorithm to create agreed set and together signed with RSA-2048
- Each node signs descriptor with RSA-1024
- Will be moving to ED25519 to replace RSA-1024 and 2048

Node selection for security and performance



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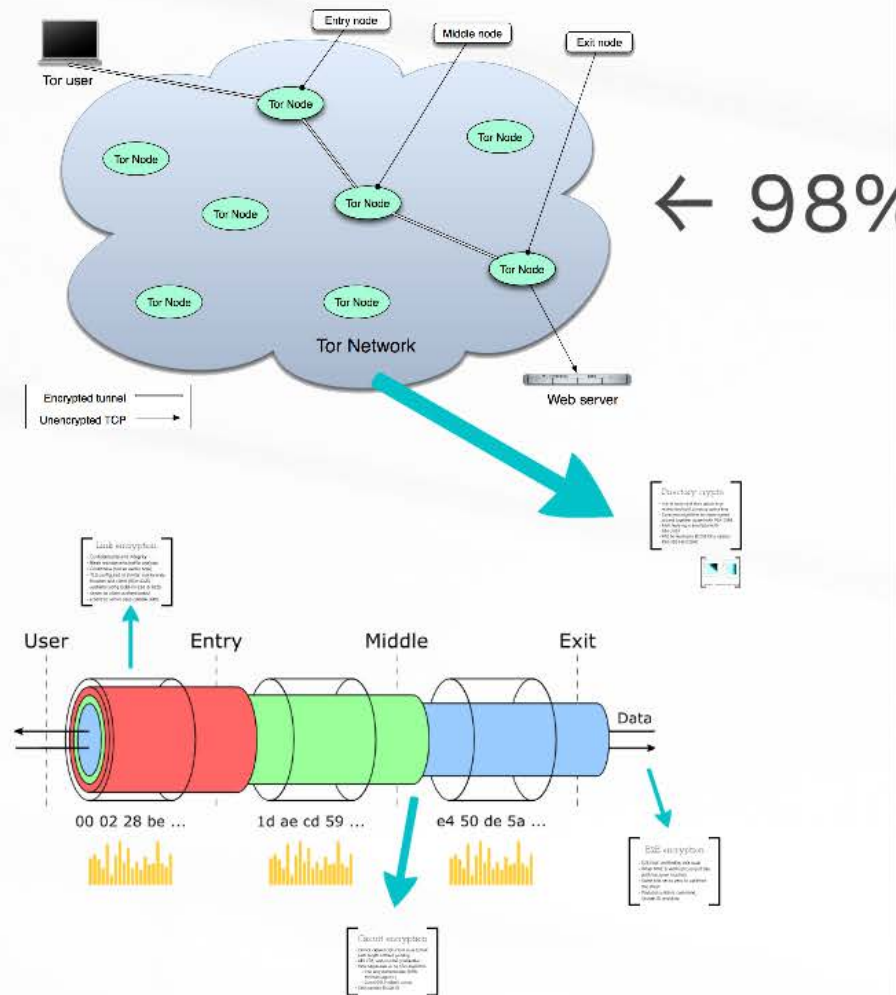
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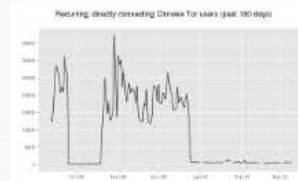
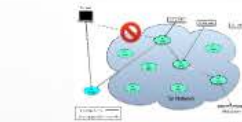
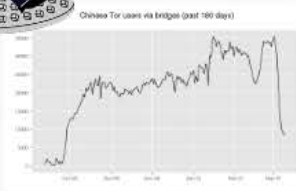
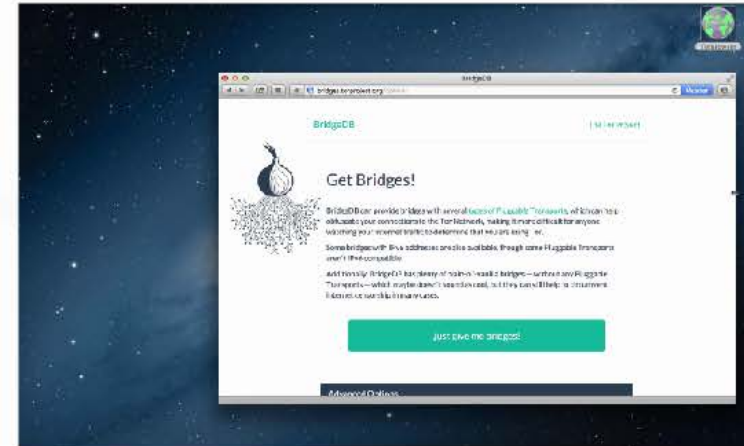
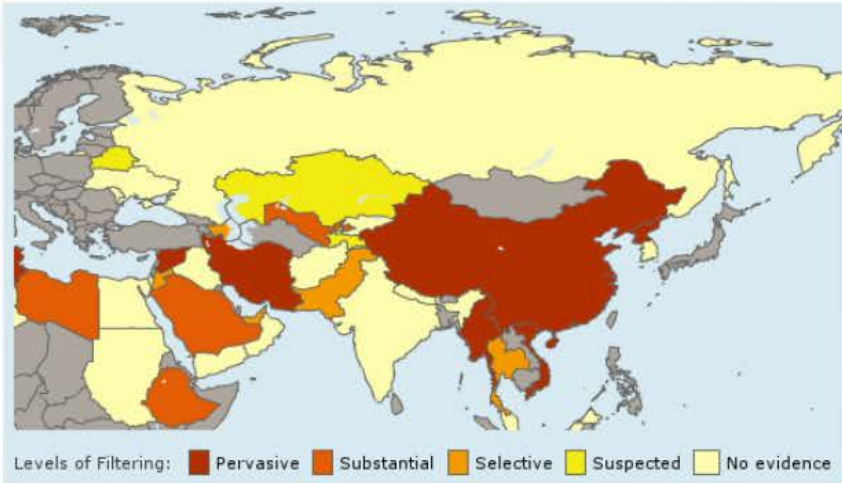
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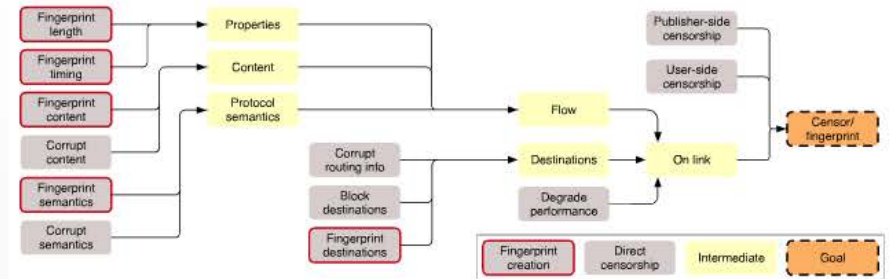
MixMinion \approx Tor



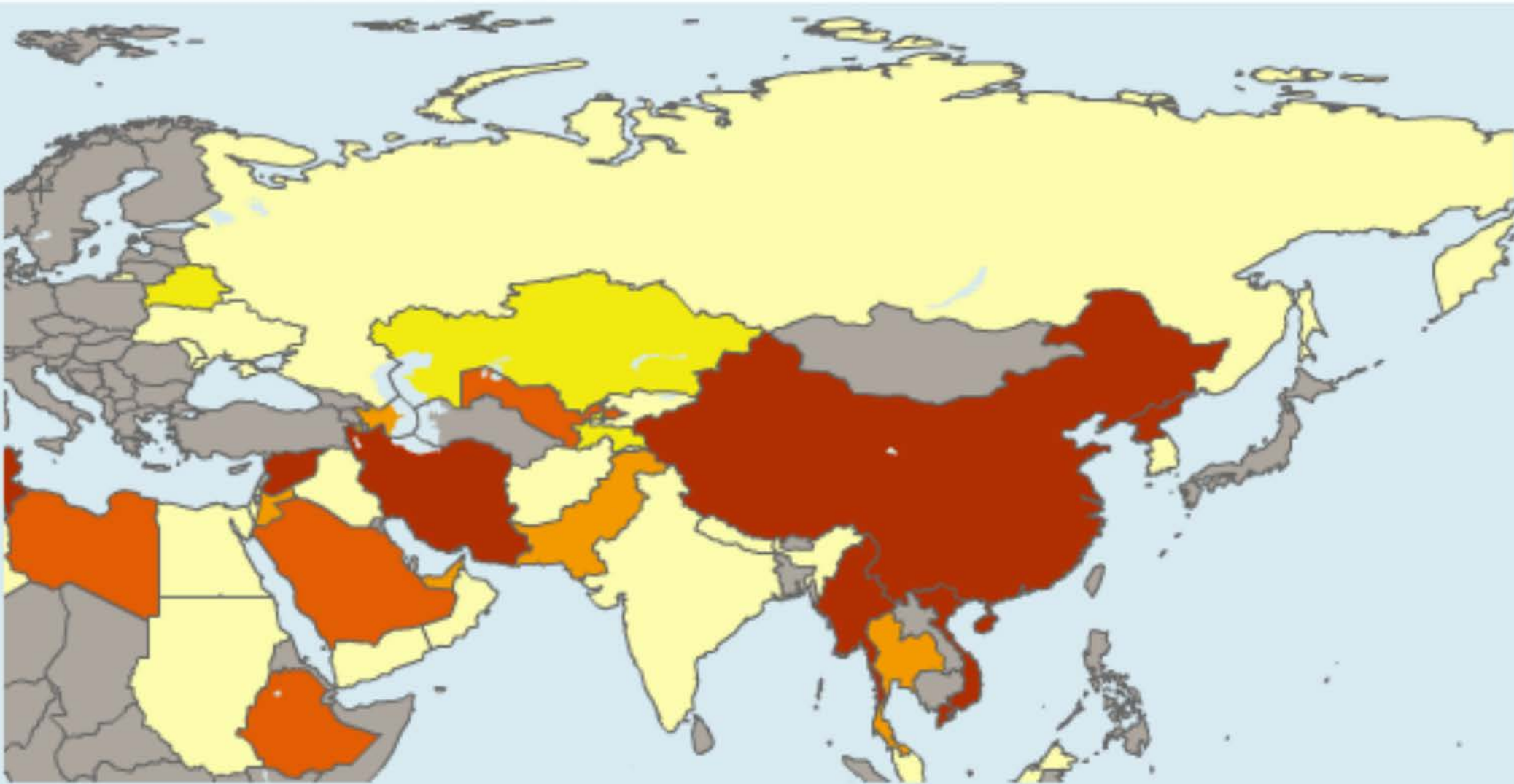
Censorship resistance



Fingerprinting and developing blocking rules



SoK: Making Sense of Censorship Resistance Systems, Khattak et al.



Levels of Filtering: ■ Pervasive ■ Substantial ■ Selective ■ Suspected ■ No evidence



Levels of Filtering:

■ Pervasive

■ Substantia

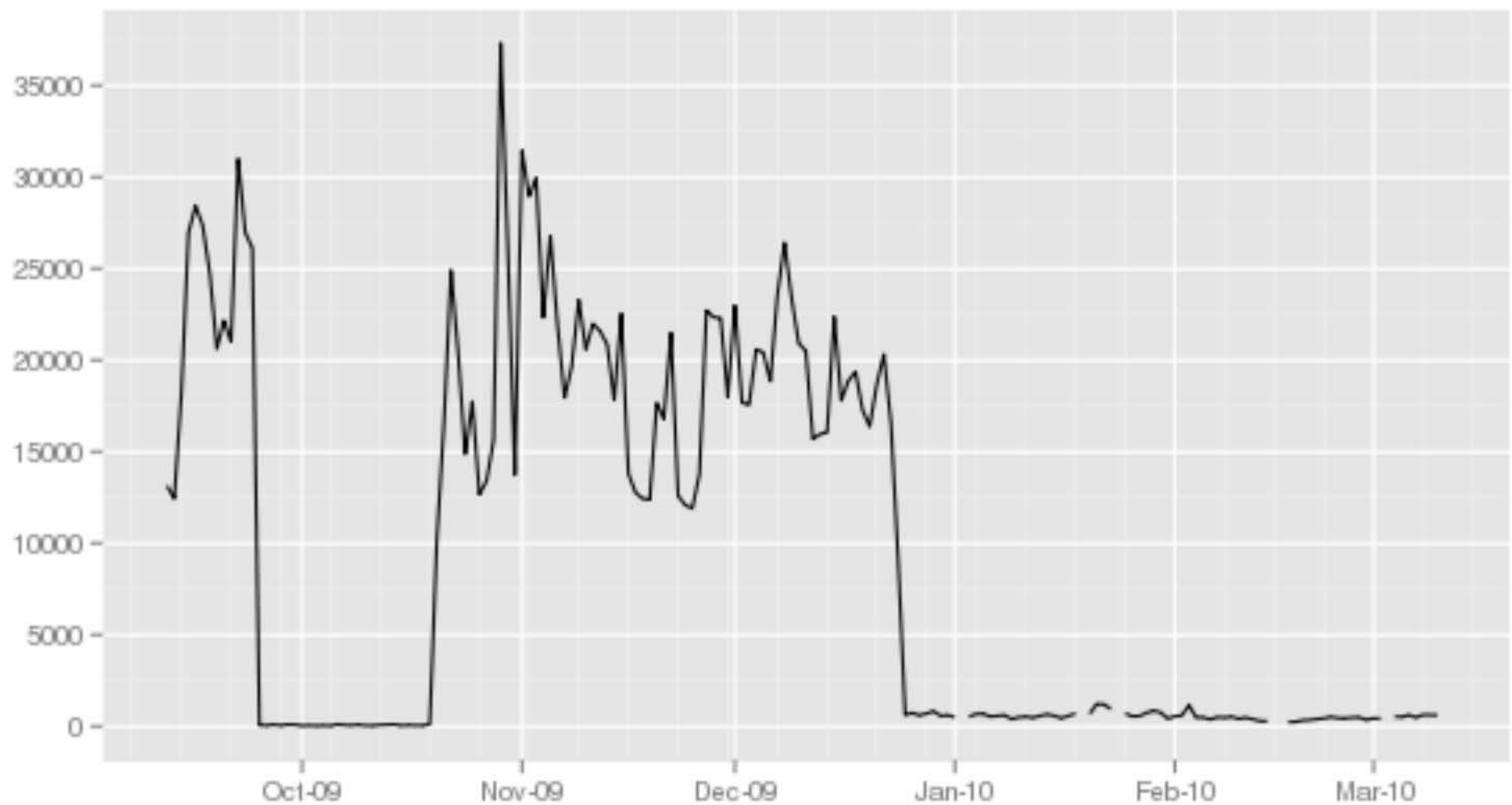


Chin

35000
30000
25000
20000



Recurring, directly connecting Chinese Tor users (past 180 days)



Tor user



Entry node

Middle node

Exit node



Tor Node

Tor Node

Tor Node

Tor Node

Tor Node

Tor Node

Tor Node

Tor Node

Tor Network

Tor Bridge

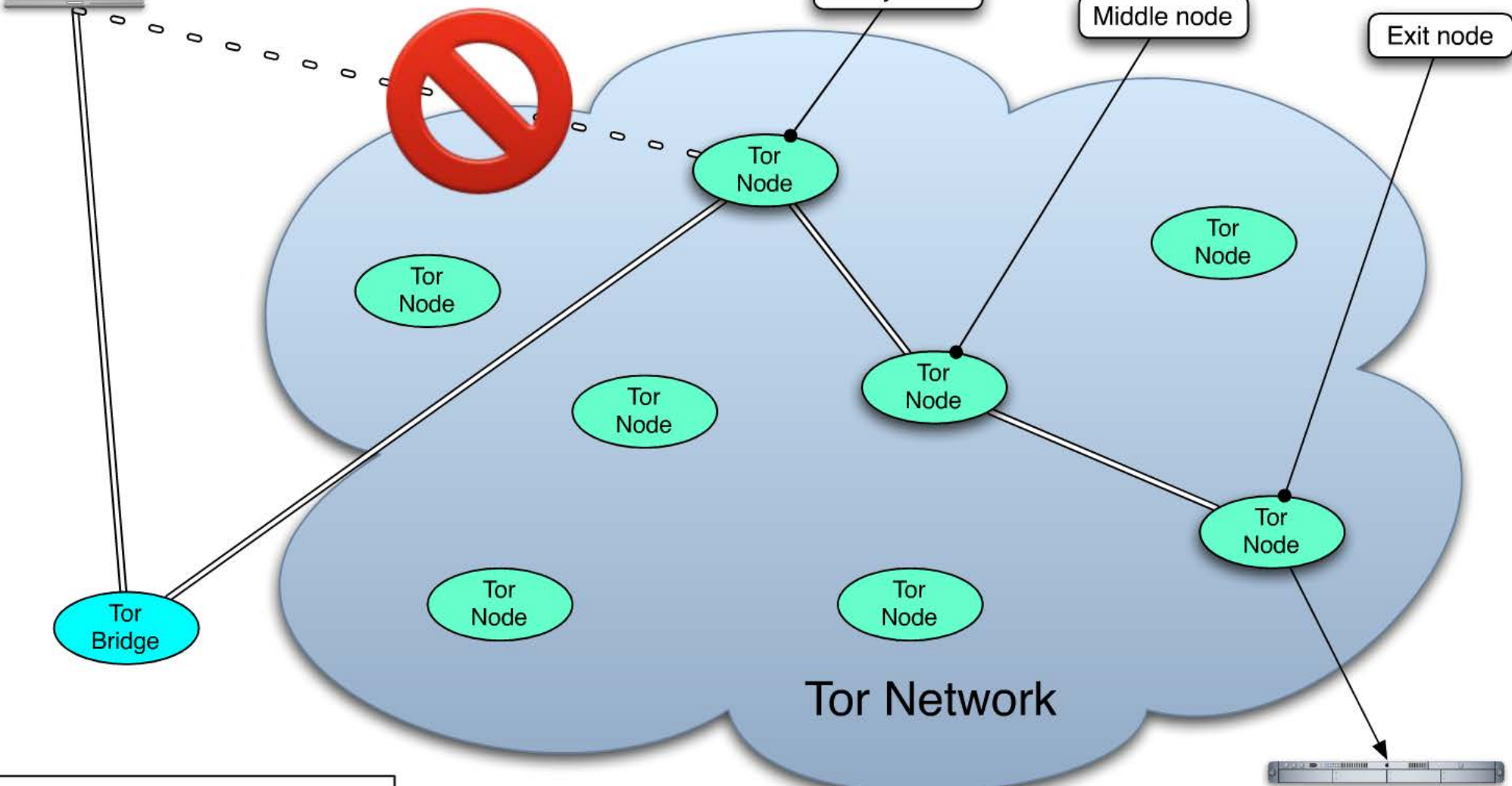


Web server

Encrypted tunnel



Unencrypted TCP






TorBrowser

BridgeDB

The Tor Project



Get Bridges!

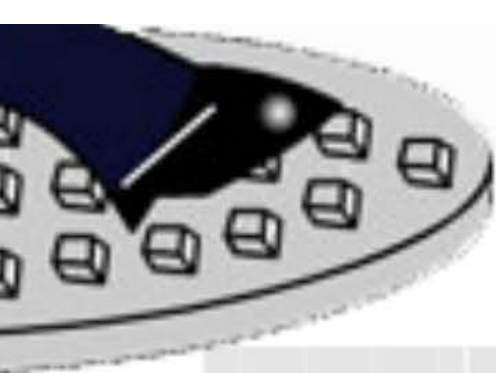
BridgeDB can provide bridges with several [types of Pluggable Transports](#), which can help obfuscate your connections to the Tor Network, making it more difficult for anyone watching your internet traffic to determine that you are using Tor.

Some bridges with IPv6 addresses are also available, though some Pluggable Transports aren't IPv6 compatible.

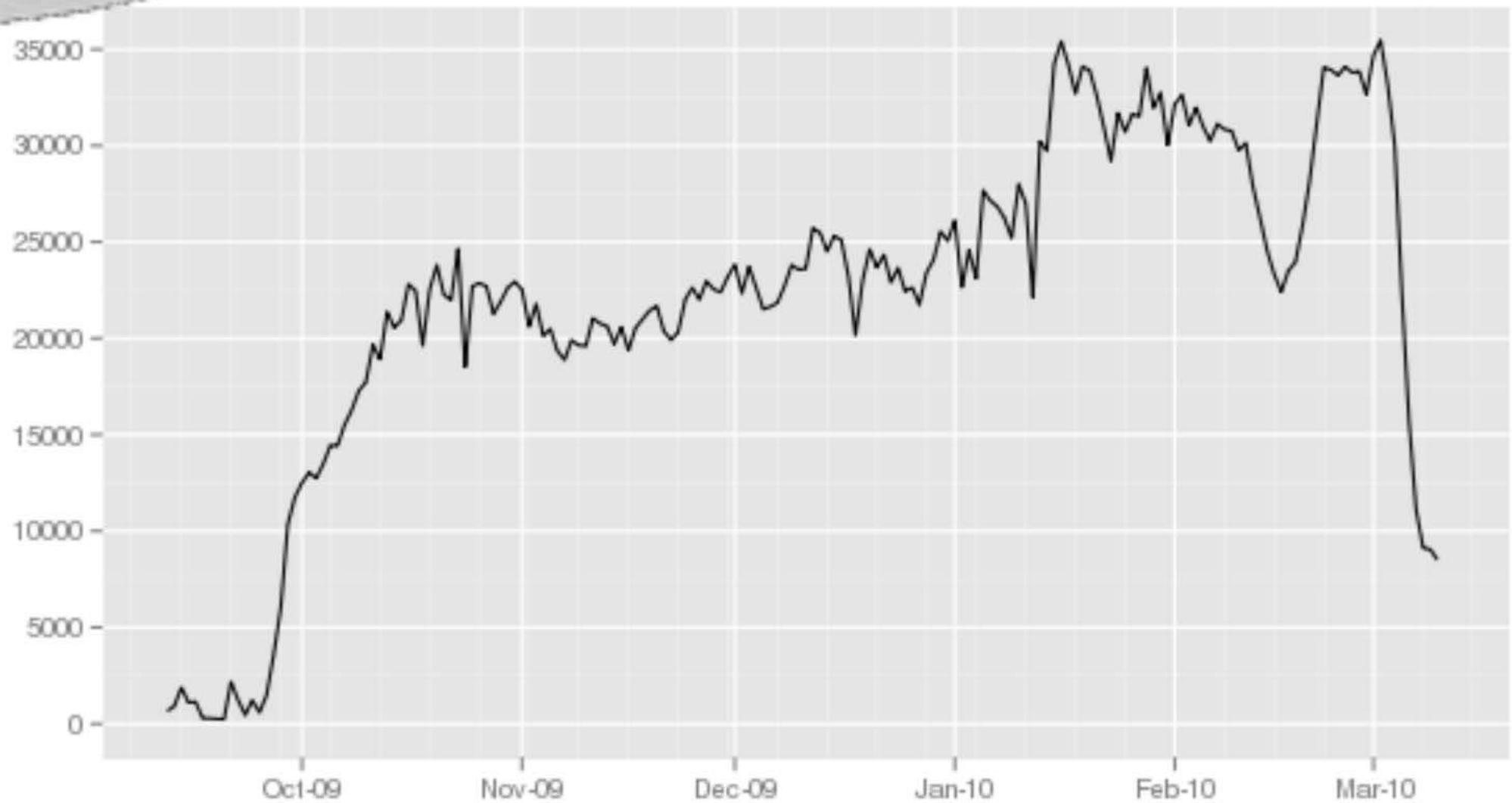
Additionally, BridgeDB has plenty of plain-ol'-vanilla bridges — without any Pluggable Transports — which maybe doesn't sound as cool, but they can still help to circumvent internet censorship in many cases.

[Just give me bridges!](#)

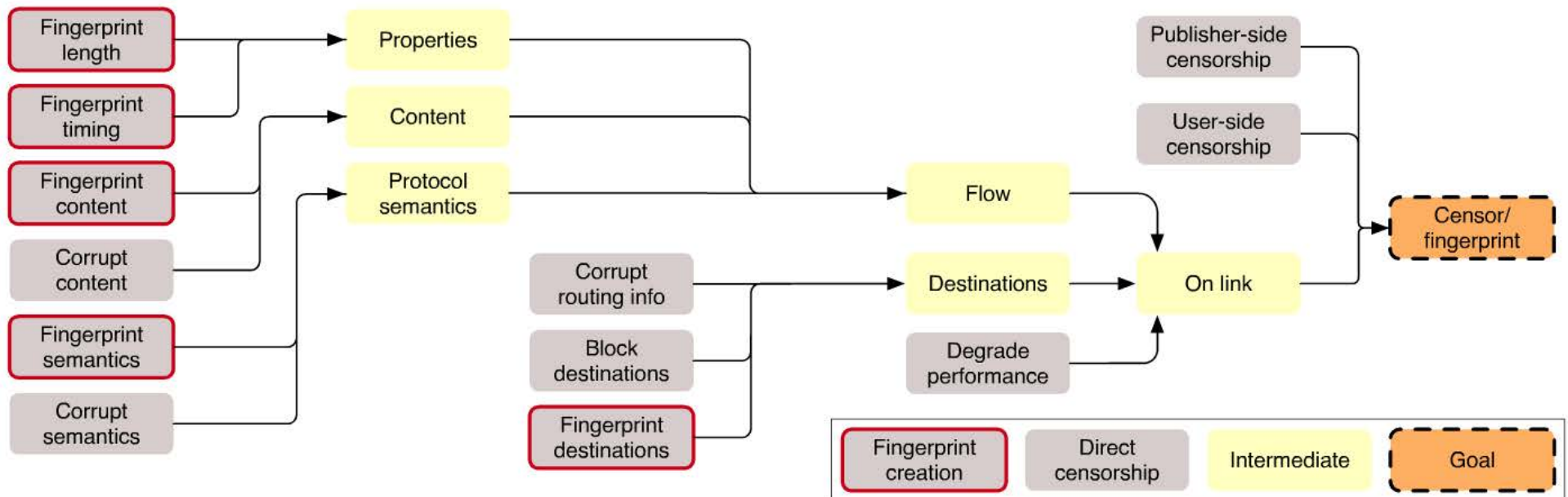
[Advanced Options](#)



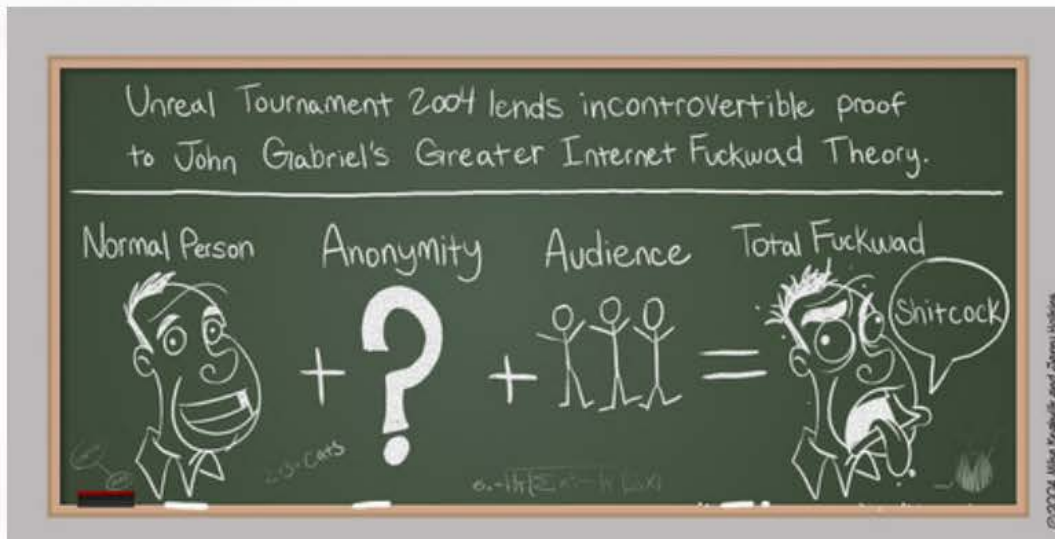
Chinese Tor users via bridges (past 180 days)



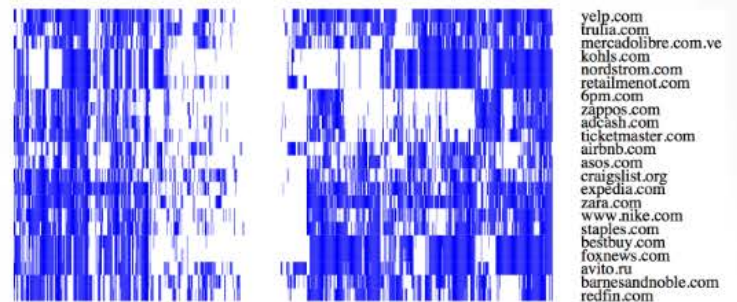
Fingerprinting and developing blocking rules



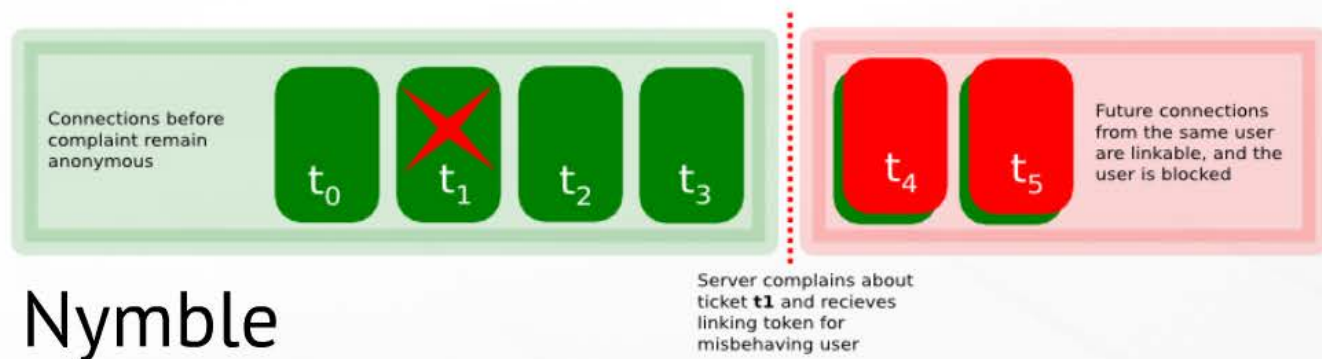
Abuse



3.67% of the most popular 1,000 websites block Tor



Do You See What I See? Differential Treatment of Anonymous Users, Khattak et al.



Unreal Tournament 2004 lends incontrovertible proof to John Gabriel's Greater Internet Fuckwad Theory.

Normal Person



Anonymity



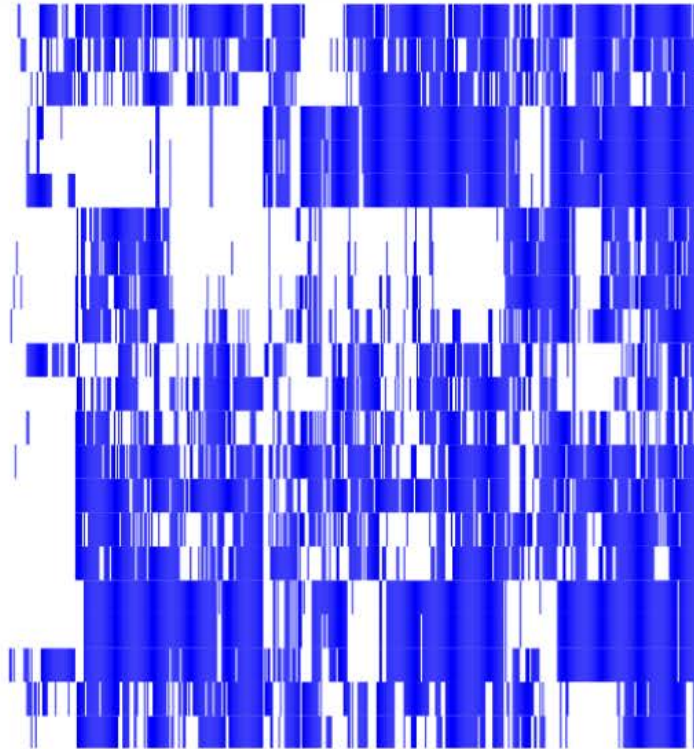
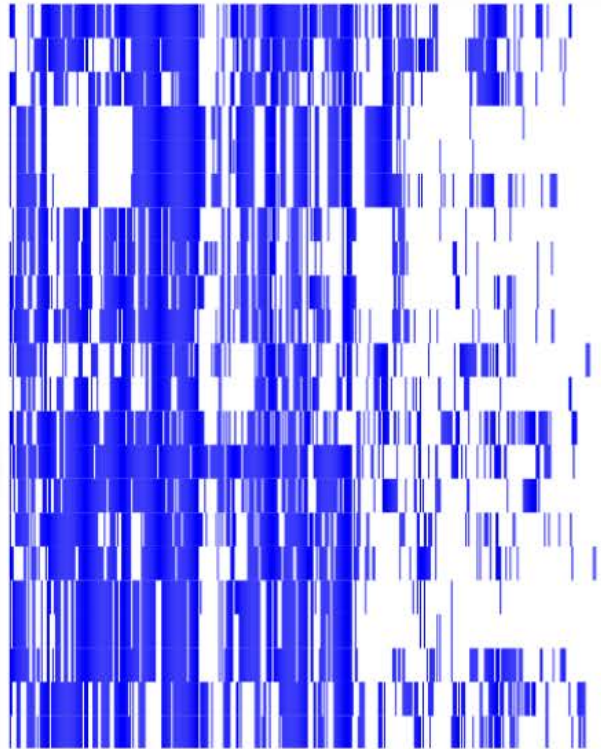
Audience



Total Fuckwad

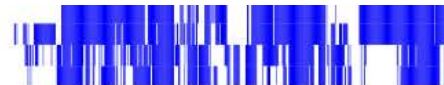
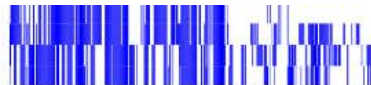


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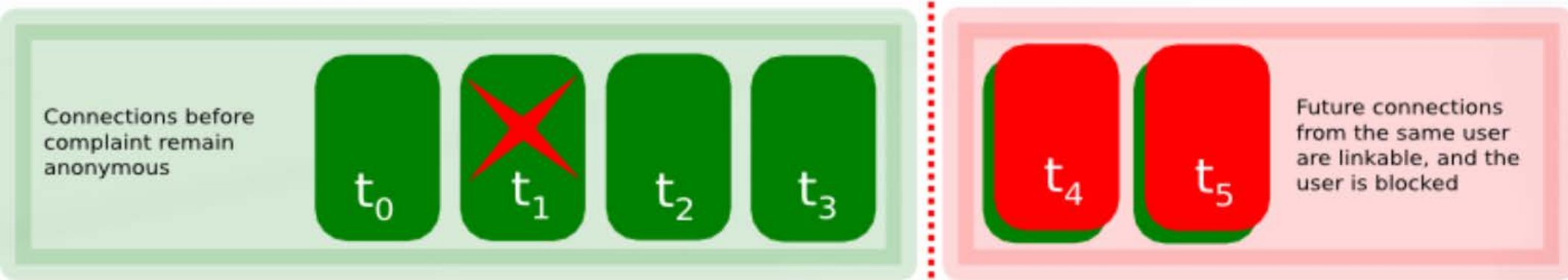
yelp.com
trulia.com
mercadolibre.com.ve
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adcash.com
ticketmaster.com
airbnb.com
asos.com
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Do You See What I See? Differential Treatment of Anonymous Users, Khattak et al.



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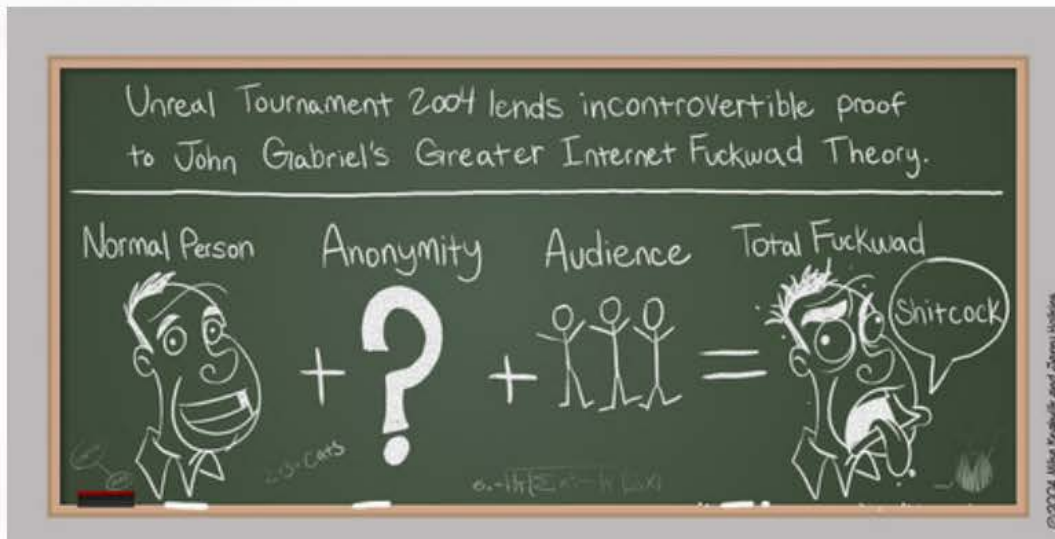
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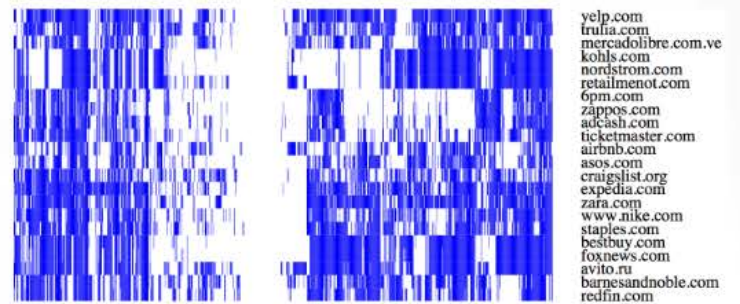
Server complains about ticket **t1** and receives linking token for misbehaving user

Nymble

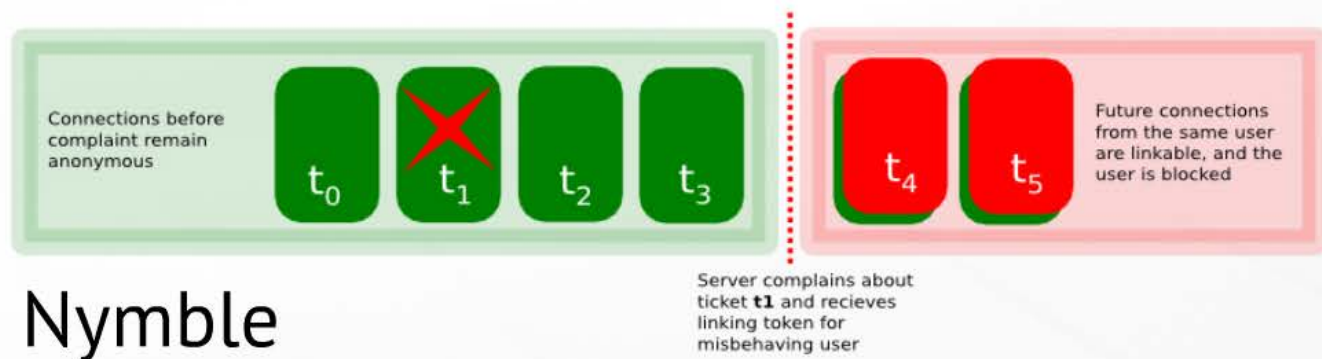
Abuse



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Sustainability

Financial Review

Tor's Fiscal 2012 marked a year of financial improvement and stability. The Tor Project has seen steady revenue growth since its inception. Since meeting the revenue milestones of \$1.2M in 2009, \$1,574,119 in 2010 and \$1,681,101 in 2011, Tor has reached new heights in 2012 with over \$2 million in revenue (unaudited).

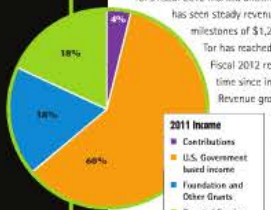
Fiscal 2012 results also provided a new financial achievement, for the first time since inception: The Tor Project, Inc. had net operating income. Tor's Revenue growth was driven by diversity in funding sources which include U.S. government federal funding, Knight Foundation, SRI International, Google, the Swedish International Development Co-operative Agency, and private donations, among others.

Financial responsibility is important to The Tor Project, Inc. In order to maintain financial stability, Tor maintains cash reserves sufficient to maintain operations for a minimum of 90 days. Tor is proud to report that, since 2009, over 80% of its revenue has been directed towards spending on programs.

As plans for 2013 commence, Tor will continue to improve and expand revenues to expand research and development efforts.

The accounts and financial statements of The Tor Project are maintained in accordance with generally accepted principles in the United States. Our audits are performed in accordance with government auditing standards and in accordance with OMB A133 which requires a higher level of assurance with respect to compliance and internal controls. Tor is proud to report that in both fiscal 2010 and 2011, we obtained an unmodified audit opinion and had no compliance or internal control findings.

To view Tor's audited financial reports visit www.torproject.org/about/financials.

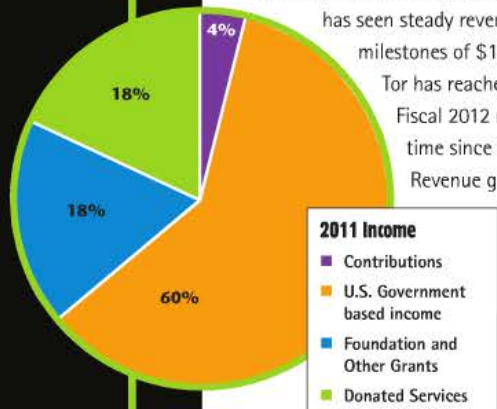


Incentives

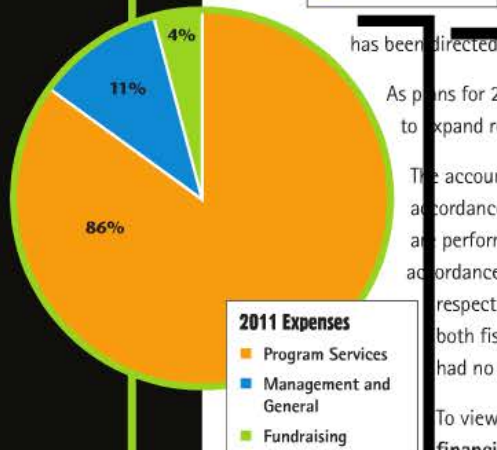
- Many users are unable to pay (tragedy of the commons)
- Giving better performance to users who contribute could reduce anonymity
- If money is changing hands, volunteers may give up

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The accounts and financial statements of The Tor Project are maintained in accordance with generally accepted principles in the United States. Our audits are performed in accordance with government auditing standards and in accordance with OMB A133 which requires a higher level of assurance with respect to compliance and internal controls. Tor is proud to report that in both fiscal 2010 and 2011, we obtained an unmodified audit opinion and had no compliance or internal control findings.

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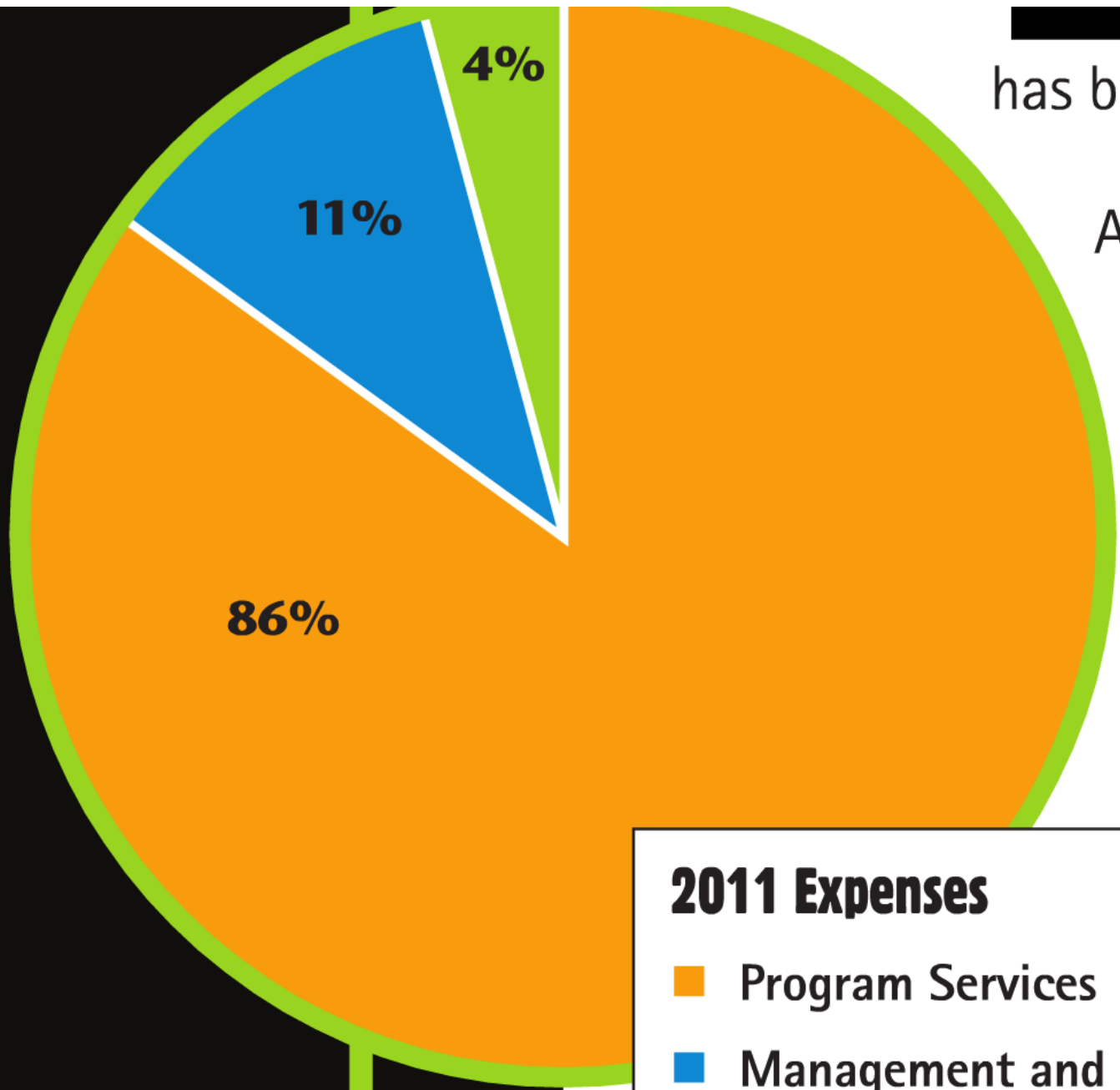
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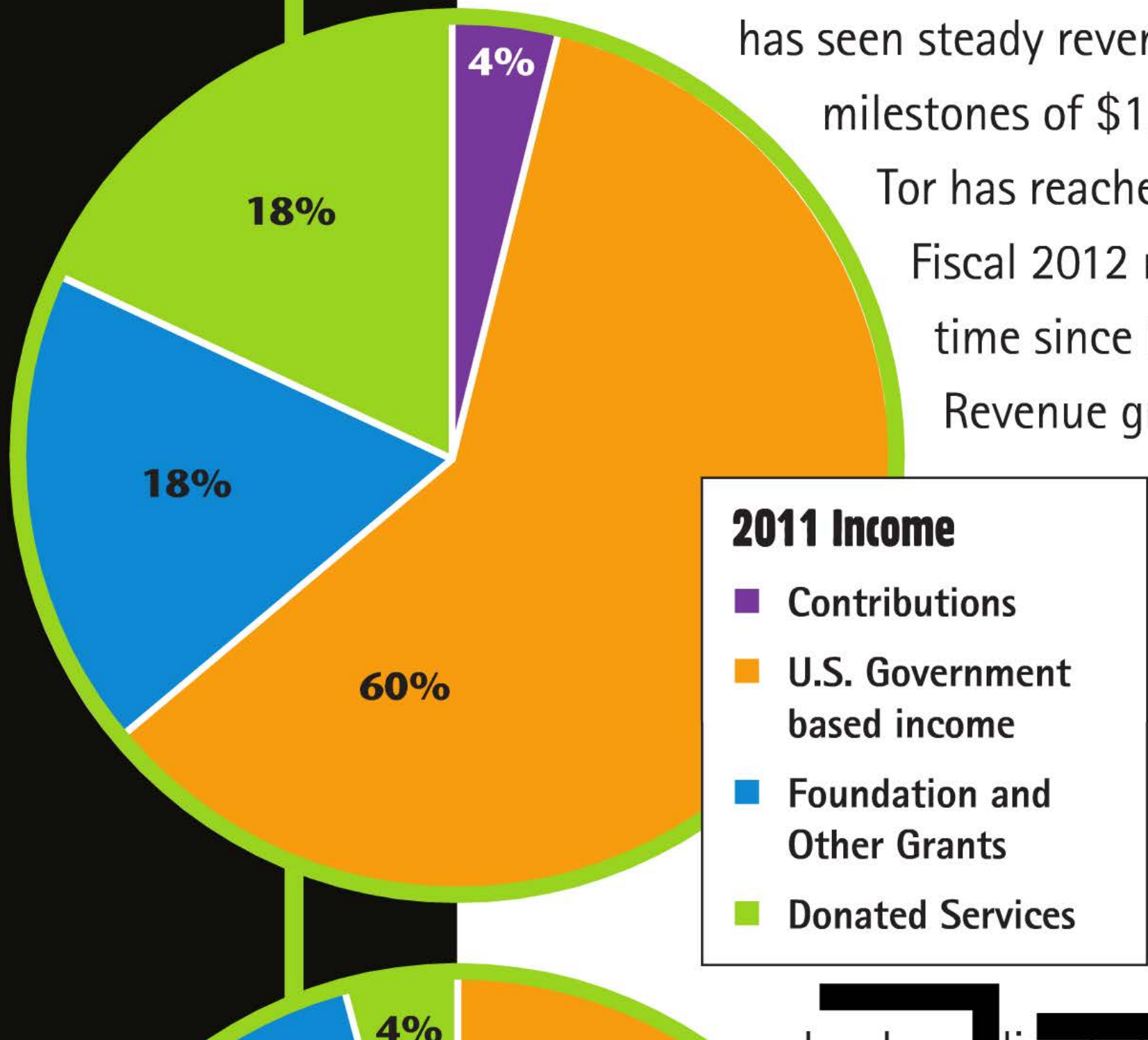
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2011 Expenses

- Program Services
- Management and General
- Fundraising

Tor's fiscal 2012 marked another milestone as the organization has seen steady revenue growth, reaching milestones of \$1,250 million. Tor has reached this milestone in Fiscal 2012, the first time since inception. Revenue growth



Incentives

- Many users are unable to pay (tragedy of the commons)
- Giving better performance to users who contribute could reduce anonymity
- If money is changing hands, volunteers may give up

Juice Media Rap News
September 2012

THIS IS WHAT A
Tor



DAN ELLSBERG AND PATRICIA MARX ELLSBERG, PRIVACY ACTIVISTS

**SUPPORTER
LOOKS LIKE**

#SUPPORT**Tor**

Sustainability

Financial Review

Tor's Fiscal 2012 marked a year of financial improvement and stability. The Tor Project has seen steady revenue growth since its inception. Since meeting the revenue milestones of \$1.2M in 2009, \$1,574,119 in 2010 and \$1,681,101 in 2011, Tor has reached new heights in 2012 with over \$2 million in revenue (unaudited).

Fiscal 2012 results also provided a new financial achievement, for the first time since inception: The Tor Project, Inc. had net operating income. Tor's Revenue growth was driven by diversity in funding sources which include U.S. government federal funding, Knight Foundation, SRI International, Google, the Swedish International Development Co-operative Agency, and private donations, among others.

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