

Network Security

Traffic analysis and anonymization

Radboud University, The Netherlands



Spring 2018

A short recap

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- ▶ Most cipher suites in TLS have (or had) some problems

How much web traffic is encrypted?

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WIRED

GEAR SCIENCE ENTERTAINMENT BUSINESS SECURITY DESIGN OPINION MAG

ENTERPRISE

encryption

https

Encrypted Web Traffic More Than Doubles After NSA Revelations

BY KLINT FINLEY 05.16.14 | 5:14 PM | PERMALINK



No crypto

From the article:

“Early last year—before the Snowden revelations—encrypted traffic accounted for 2.29 percent of all peak hour traffic in North America, according to Sandvine’s report. Now, it spans 3.8 percent. But that’s a small jump compared to other parts of the world. In Europe, encrypted traffic went from 1.47 percent to 6.10 percent, and in Latin America, it increased from 1.8 percent to 10.37 percent.”

—Klint Finley on wired.com, May 16, 2014.

... update from 2015

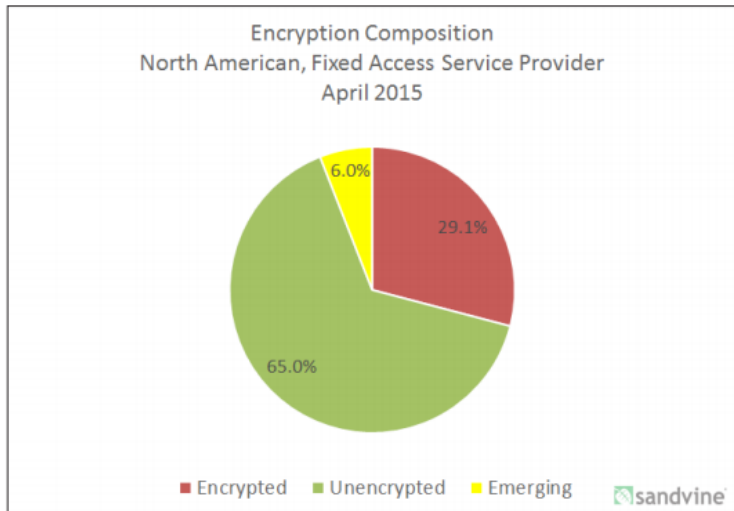


Figure 1 - Encryption Composition - North America, Fixed Access - April 2015

... estimated for 2016

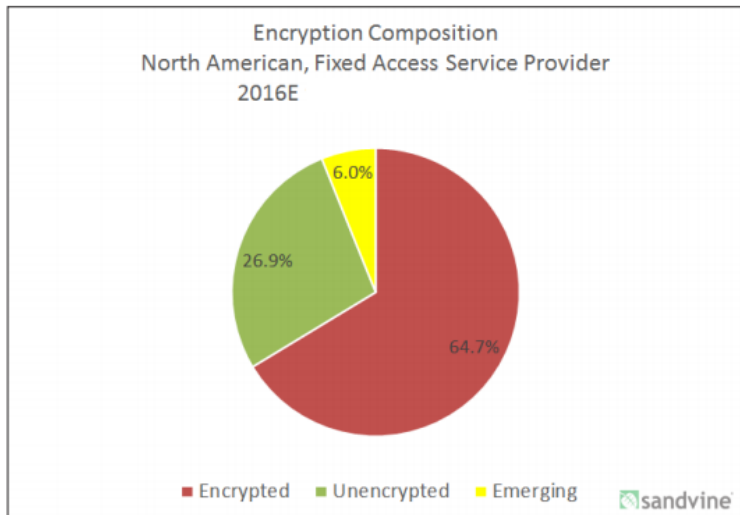


Figure 2 - Encryption Composition - North America, Fixed Access - 2016 Estimate

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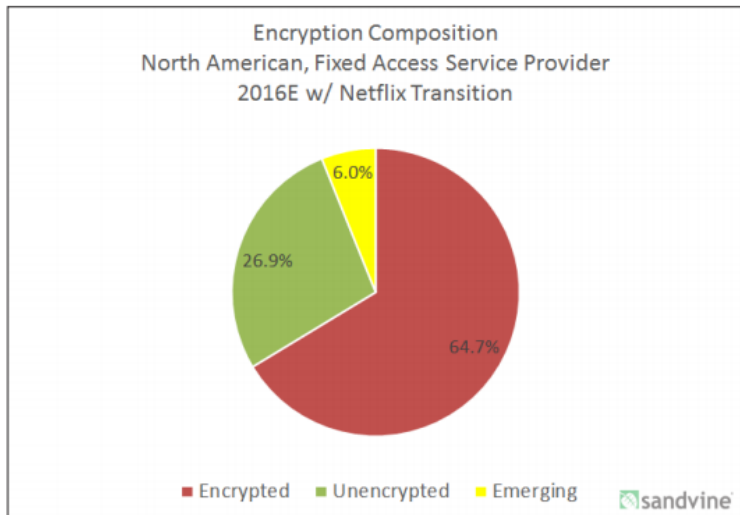
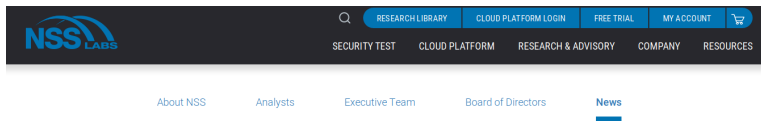


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... and for 2019



NSS Labs Predicts 75% of Web Traffic Will Be Encrypted by 2019

SSL/TLS encrypted internet traffic grew 90% year over year from July 2015 to July 2016.

AUSTIN, Texas – November 9, 2016 - NSS Labs, Inc., the world's leading cyber security product research, testing, and advisory company, today released new research examining the usage of Secure Socket Layer (SSL) and Transport Layer Security (TLS) encryption. SSL/TLS enables secure transmissions of private data over the internet, including credit card details, passwords and sensitive personal information. Enterprises use SSL/TLS to encrypt their traffic in order to address multiple issues including controlling access, confidentiality and reducing exposure to protocol-specific attacks (e.g. Heartbleed).

As part of on-going research and analysis, NSS Labs found that HTTPS (SSL/TLS encrypted) internet traffic grew over 90% year over year, with more than 40.5% of websites encrypting traffic by default in July 2016 vs. 21.3% in July 2015. Unsurprisingly, **97%** of surveyed enterprises are seeing an increase in encrypted web traffic. NSS predicts this trend to continue with 75% of all web traffic to be encrypted by 2019.

Key findings include:

- More non-enterprise traffic is encrypted than enterprise traffic, depending on region, type of content, etc.
- Over 40% of the most visited websites are encrypted by default; less than 10% have HTTPS properly applied (source: Trustworthy Internet Movement).
- Encryption does not protect us against all threats.

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- ▶ ... applied cryptographers have trouble finding a job.

What *does* an attacker see?

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Encrypting and authenticating content does not prevent any of this!

What can you do with “meta data”?

“Metadata absolutely tells you everything about somebody’s life. If you have enough metadata you don’t really need content. . . [It’s] sort of embarrassing how predictable we are as human beings.”

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“We kill people based on metadata.”

—Michael Hayden, former director of the NSA and the CIA

Is “metadata” all an attacker gets?

- ▶ Common assumption: an attacker sees only traffic data (“meta data”)
- ▶ Example, interview with Jimmy Wales (Wikipedia founder):

“You’ve said that you’re going to start encrypting communications on Wikipedia as a result. . .

We have done. It’s not completely finished yet but the only thing that GCHQ, hopefully, can see is that you’re looking at Wikipedia. They can’t see which article you’re reading. It’s not the government’s business to know what everybody is reading.”

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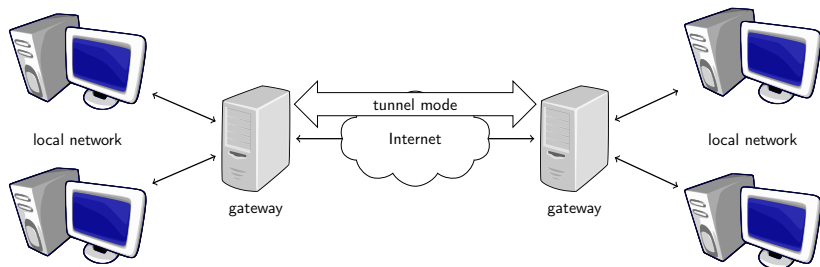
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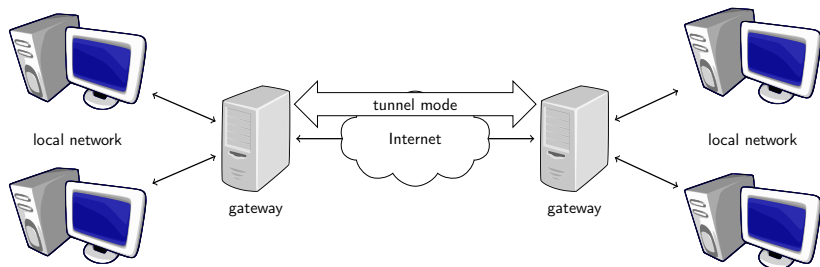
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 - ▶ This is not the only thing an attacker sees: number of requests, delays, same for replies. . .

IPsec ESP in tunnel mode



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- ▶ Nodes behind the gateways are indistinguishable
- ▶ [RFC 2406](#) calls this “limited traffic flow confidentiality”
- ▶ Problem 1: Does not help against state-level attacker who can request gateway's logfiles
- ▶ Problem 2: Potentially small *anonymity set*

Anonymizing proxies

- ▶ Somewhat similar idea (without crypto): use a proxy server
- ▶ Typically: application-specific proxies (e.g., HTTP proxies)
- ▶ Requests to websites come from proxy
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- ▶ Can add crypto to the proxy (e.g., OpenVPN Service)
- ▶ That still does not solve problems 1 and 2

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- ▶ Receiver Bob decrypts and obtains M
- ▶ Achieves anonymity if encrypted messages are indistinguishable
- ▶ Very important: never repeat input and output!
- ▶ Has high communication latency (wait for enough messages)

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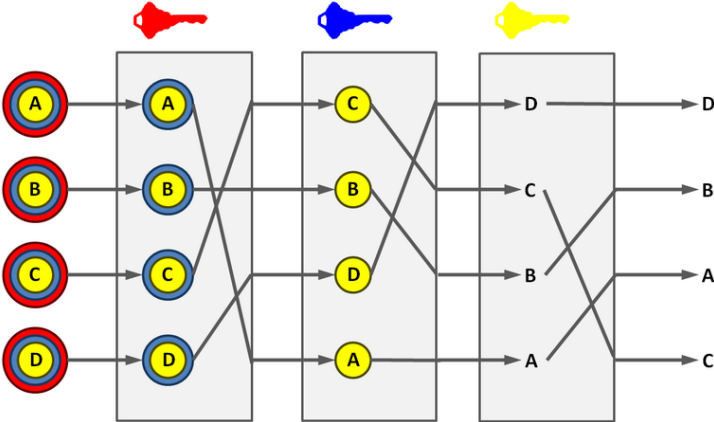
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- ▶ Only Alice can decrypt, because only she knows both K_X and R_1

Cascading Mixes



Mix Nets vs. Anonymizing proxies

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- + No single point of failure (with cascading)
- + Inbound/output-traffic analysis does not de-anonymize
- + Generally good anonymity

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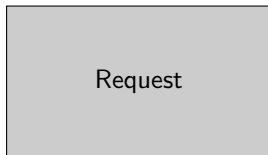
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Idea of Tor (The Onion Router): Combine advantages:

- ▶ Use cascade of “proxies”, called *Tor relays* or *Tor nodes*
- ▶ Use fast symmetric crypto instead of asymmetric crypto

Onion Routing and Tor

- ▶ Assume that user shares symmetric keys with three *relays*:
 - ▶ Entry relay R_1 (key K_{R_1})
 - ▶ Middle relay R_2 (key K_{R_2})
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- ▶ Wants to anonymously send request to `www.wikileaks.org`



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- ▶ Wants to anonymously send request to `www.wikileaks.org`
- ▶ Prepares packet as follows:
 - ▶ Write dest. `www.wikileaks.org`, encrypt with K_{R_3}

Onion Routing and Tor



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Onion Routing and Tor



- ▶ R_1 receives packet, removes encryption with K_{R_1}

Onion Routing and Tor



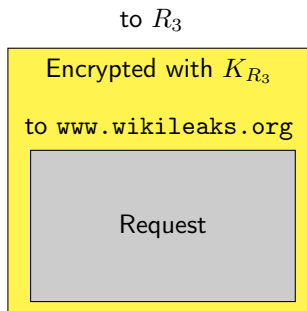
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Onion Routing and Tor



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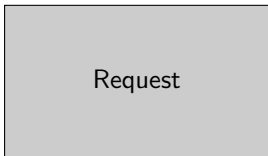
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Onion Routing and Tor

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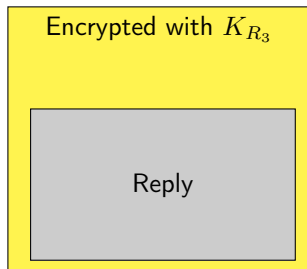
Reply from `www.wikileaks.org`

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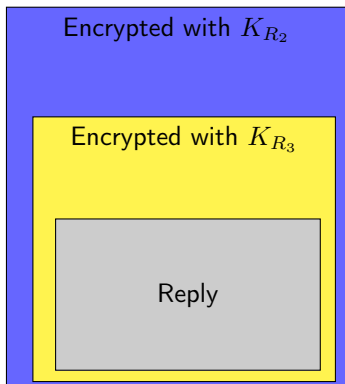


Reply from www.wikileaks.org

- ▶ R_3 receives reply from www.wikileaks.org
- ▶ R_3 encrypts with K_{R_3} , sends to R_2

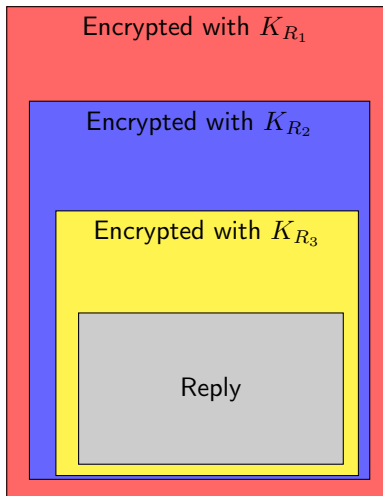


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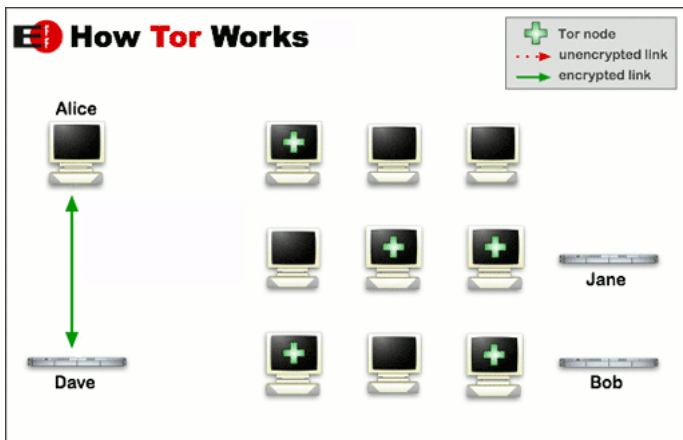
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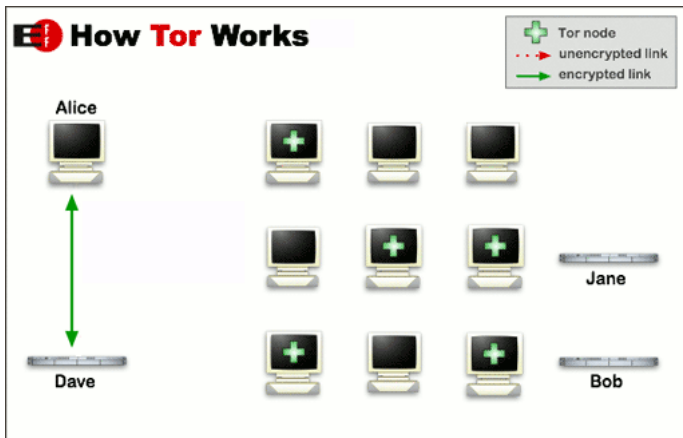
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Establishing a Circuit



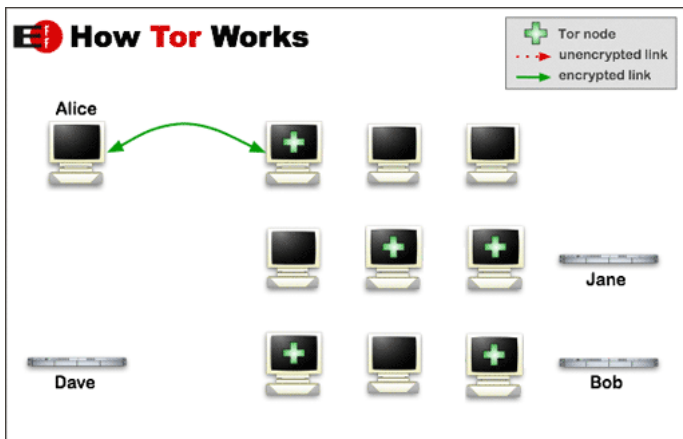
Request listing of Tor nodes from directory server (DS)

Establishing a Circuit



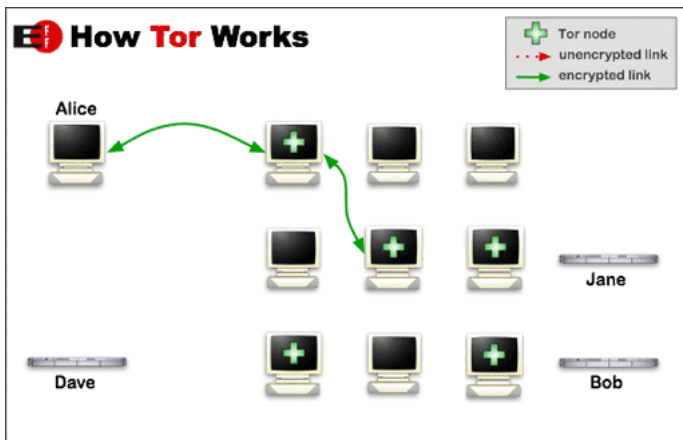
Pick entry, middle, and exit node; obtain their public keys from DS

Establishing a Circuit



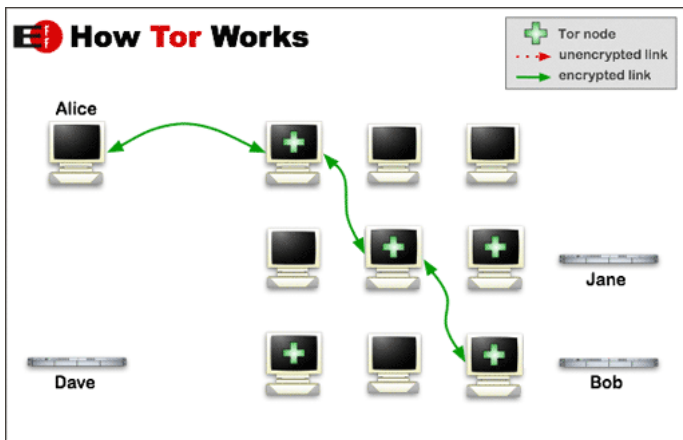
Exchange symmetric key with entry node (Diffie-Hellman)

Establishing a Circuit



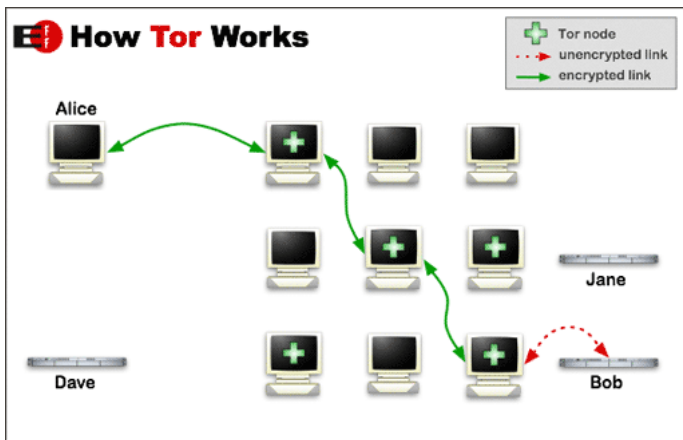
Exchange key with middle node (proxied by entry node!)

Establishing a Circuit



Exchange key with exit node (proxied by entry and middle node!)

Establishing a Circuit



Communicate with Bob (www.wikileaks.org)

Attacks against Tor, part I

- ▶ Tor offers anonymity up to the transport layer
- ▶ Tor cannot offer application-level anonymity
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- ▶ Tor re-uses an existing circuit for new TCP connections for 10 minutes
- ▶ Leaking your IP address to Bittorrent may also de-anonymize your browser session (bad apple attack)!

Attacks against Tor, part II

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- ▶ Very controversial discussion ensued... see <http://blog.fefe.de/?ts=af0134f5>

“Tor stinks”

- ▶ Snowden leaked NSA slides “Tor stinks” from 2007
- ▶ Quotes from these slides:

“We will never be able to de-anonymize all Tor users all the time.”

“With manual analysis we can de-anonymize a very small fraction of Tor users, however no success de-anonymizing a user in response to a TOPI request/on demand.”

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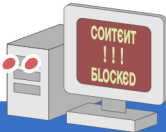
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- ▶ Solution: fully disguise Tor traffic as other traffic
- ▶ **Pluggable Transport API** allows communication between ofuscator and Tor client

★ YOU ★

Can Help Protect

Freedom Of Speech

Online...



Run a
TOR RELAY
Today!

★★ TorProject.org ★★