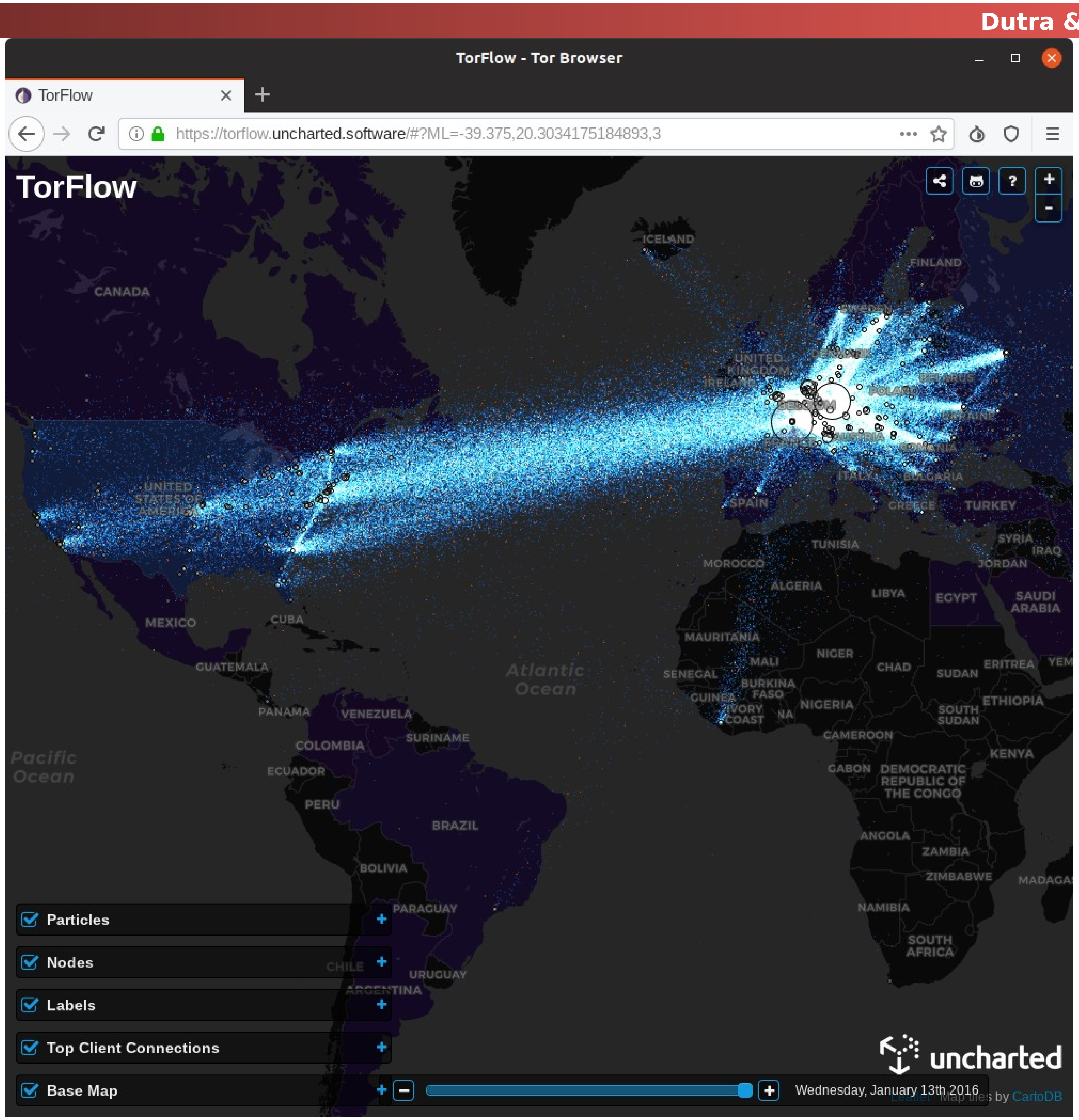
Tor, The Onion Router



TorFlow - Tor Browser

https://torflow.uncharted.software/#?ML=-39.375,20.3034175184893,3

TorFlow

☑ Particles

☑ Nodes

☑ Labels

☑ Top Client Connections

☑ Base Map

Wednesday, January 13th 2016

Announcements

- Office Hours changing locations
- MT2 review session
  - Friday 5-7pm, Soda 310
- HW2 due Friday
- MT2 Monday
- Project 3 is up

Tor: The Onion Router
Anonymous Websurfing

- Tor actually encompasses many different components
- The Tor network:
  - Provides a means for anonymous Internet connections with low(ish) latency by relaying connections through multiple Onion Router systems
- The Tor Browser:
  - A copy of Firefox extended release with privacy optimizations, configured to only use the Tor network
- Tor Onion Services (formerly called hidden services):
  - Services only reachable though the Tor network
- Tor bridges with pluggable transports:
  - Systems to reach the Tor network using encapsulation to evade censorship
- Tor provides three separate capabilities in one package:
  - Client anonymity, censorship resistance, server anonymity

The Tor Threat Model:
Anonymity of content against ***local*** adversaries

- The goal is to enable users to connect to other systems "anonymously" but with low latency
  - The remote system should have no way of knowing the IP address originating traffic
  - The local network should have no way of knowing the remote IP address the local user is contacting
- Important what is excluded:
  The ***global*** adversary
  - Tor does not even attempt to counter someone who can see ***all*** network traffic:
    It is probably ***impossible*** to do so and be low latency & efficient

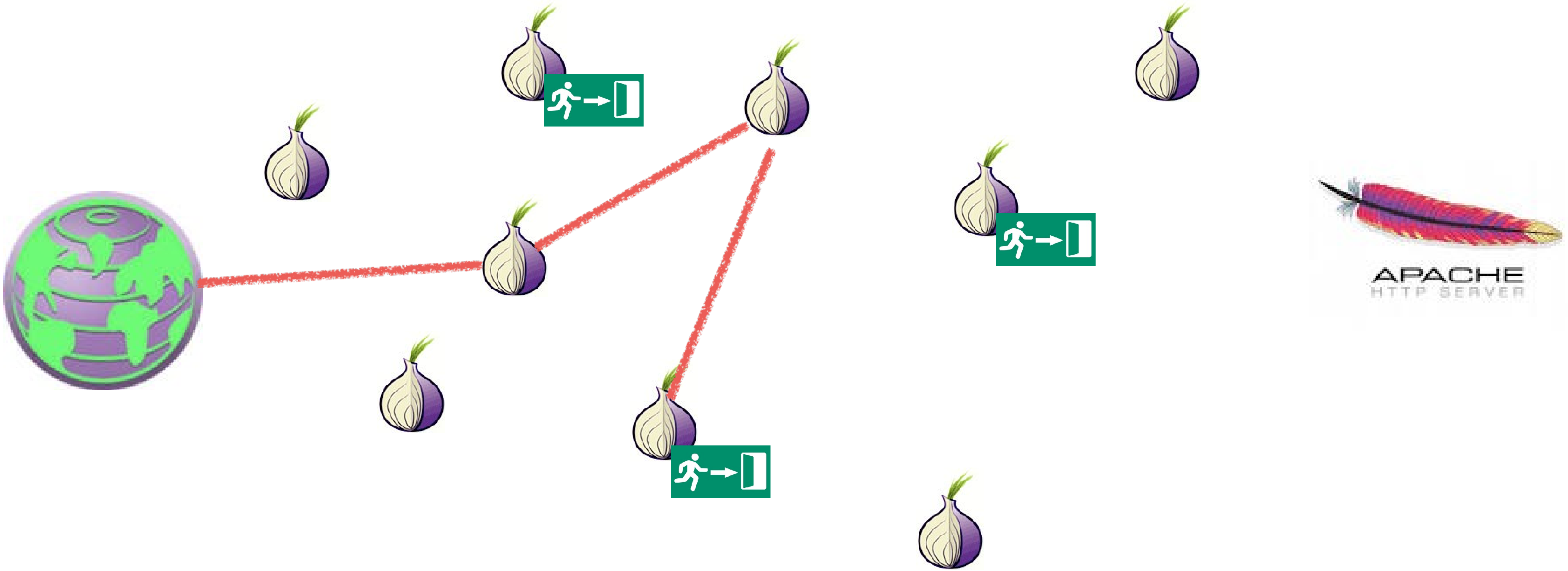
Low Latency & Efficiency...

- Tor is designed to be low latency...
  - Which means if you send a message in, it should appear on the other side ASAP
- Tor is designed to be efficient...
  - Which means that if you send a lot of messages in, they should all appear on the other side ASAP
  - And the network can't send a whole bunch of additional garbage to confuse things
- This is ***why*** Tor doesn't work against a global adversary
  - Those requirement directly imply that if someone can see where a target's traffic both enters and leaves the network they can break the anonymity

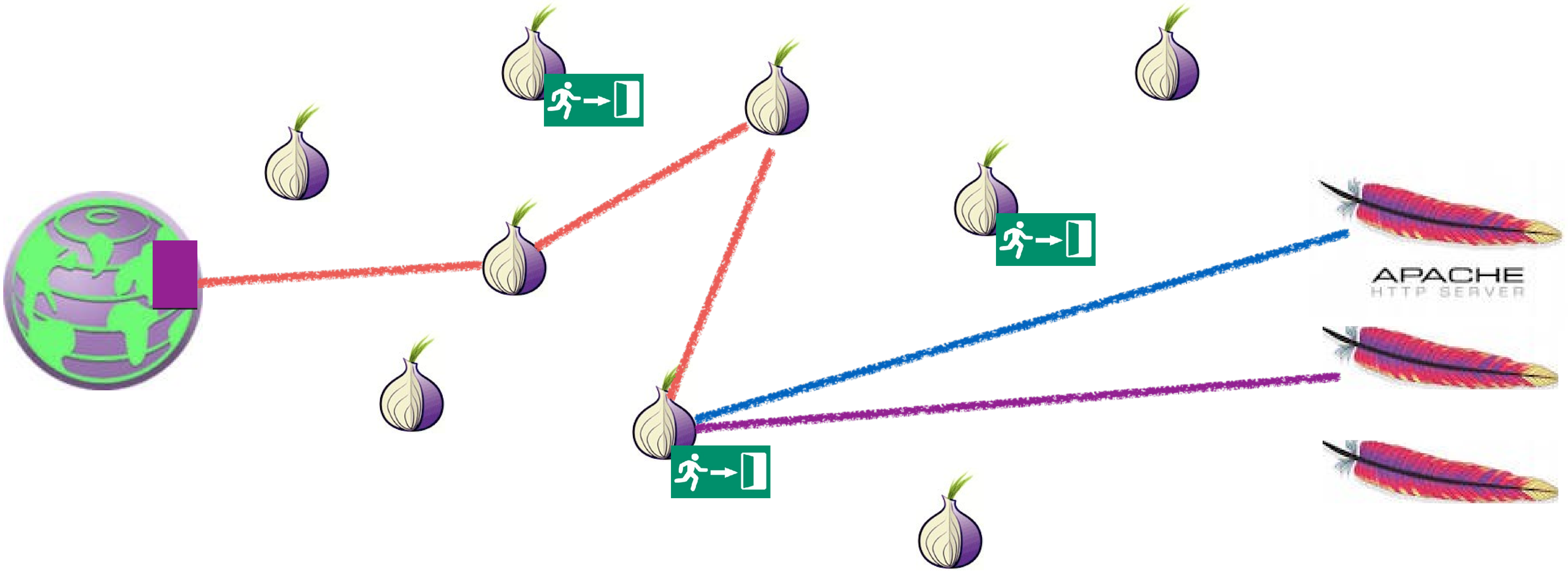
The High Level Approach: Onion Routing

- The Tor network consists of thousands of independent Tor nodes, or "Onion Routers"
  - Each node has a distinct public key and communicates with other nodes over TLS connections
- A Tor circuit encrypts the data in a series of layers
  - Each hop away from the client removes a layer of encryption
  - Each hop towards the client adds a layer of encryption
- During circuit establishment, the client establishes a session key with the first hop...
  - And then with the second hop through the first hop
- The client has a ***global*** view of the Tor Network:
  The directory servers provide a list of all Tor relays and their public keys

Tor Routing
In Action



Tor Routing In Action



Creating the Circuit Layers...

- The client starts out by using an authenticated DHE key exchange with the first node...
  - So conceptually like DHE in TLS:
    OR1 creates $\boldsymbol{g^a}$, signs it with public key in the directory, sends to client
    Client creates $\boldsymbol{g^b}$, sends it to OR1
  - Creating a session key to talk to OR1
    - This first hop is commonly referred to as the “guard node”
- It then tells OR1 to extend this circuit to OR2
  - Through that, creating a session key for the client to talk to OR2 that OR1 ***does not know***
  - And OR2 doesn't know what the client is, just that it is somebody talking to OR1 requesting to extend the connection...
- It then tells OR2 to extend to OR3...
  - And OR1 won’t know where the client is extending the circuit to, only OR2 will

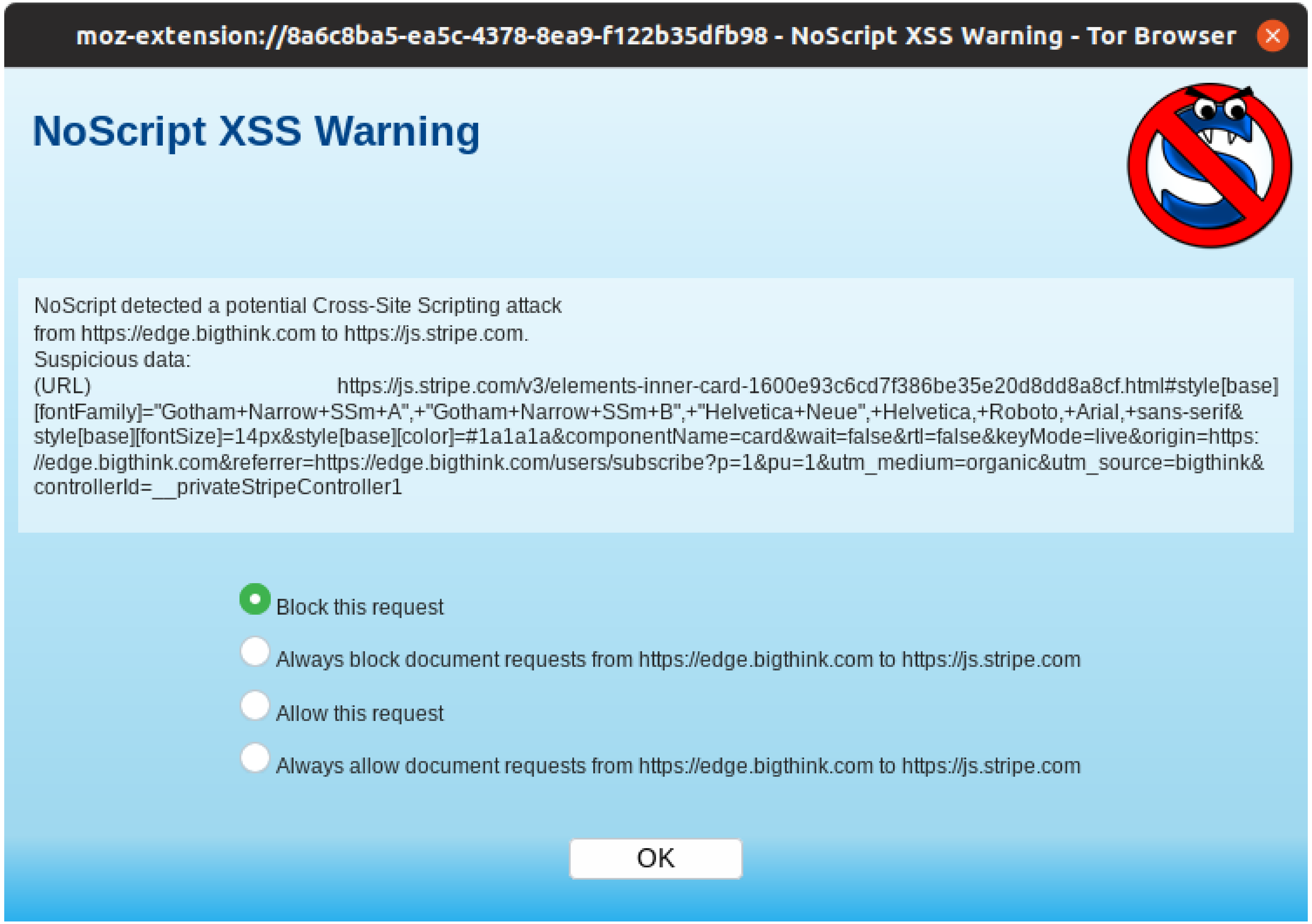
Unwrapping the Onion

- Now the client sends some data…
  - $E(K_{or1},E(K_{or2},E(K_{or3}, Data)))$
- OR1 decrypts it and passes on to OR2
  - $E(K_{or2}, E(K_{or3}, Data))$
- OR2 then passes it on…
- Generally go through at least 3 hops…
  - Why 3? So that OR1 can’t call up OR2 and link everything trivially
- Messages are a fixed-sized payload

The Tor Browser…

- Surfing “anonymously” doesn’t simply depend on hiding your connection…
- But also configuring the browser to make sure it resists tracking
  - No persistent cookies or other data stores
  - ***No deviations from other people*** running the same browser
- Anonymity ***only works in a crowd***…
  - So it really tries to make it all the same
- But by default it makes it easy to say “this person is using Tor”

The Tor Browser...
NoScript



moz-extension://8a6c8ba5-ea5c-4378-8ea9-f122b35dfb98 - NoScript XSS Warning - Tor Browser

NoScript XSS Warning

NoScript detected a potential Cross-Site Scripting attack
from https://edge.bigthink.com to https://js.stripe.com.
Suspicious data:
(URL) https://js.stripe.com/v3/elements-inner-card-1600e93c6cd7f386be35e20d8dd8a8cf.html#style[base][fontFamily]="Gotham+Narrow+SSm+A",+"Gotham+Narrow+SSm+B",+"Helvetica+Neue",+Helvetica,+Roboto,+Arial,+sans-serif&style[base][fontSize]=14px&style[base][color]=#1a1a1a&componentName=card&wait=false&rtl=false&keyMode=live&origin=https://edge.bigthink.com&referrer=https://edge.bigthink.com/users/subscribe?p=1&pu=1&utm_medium=organic&utm_source=bigthink&controllerId=__privateStripeController1

● Block this request

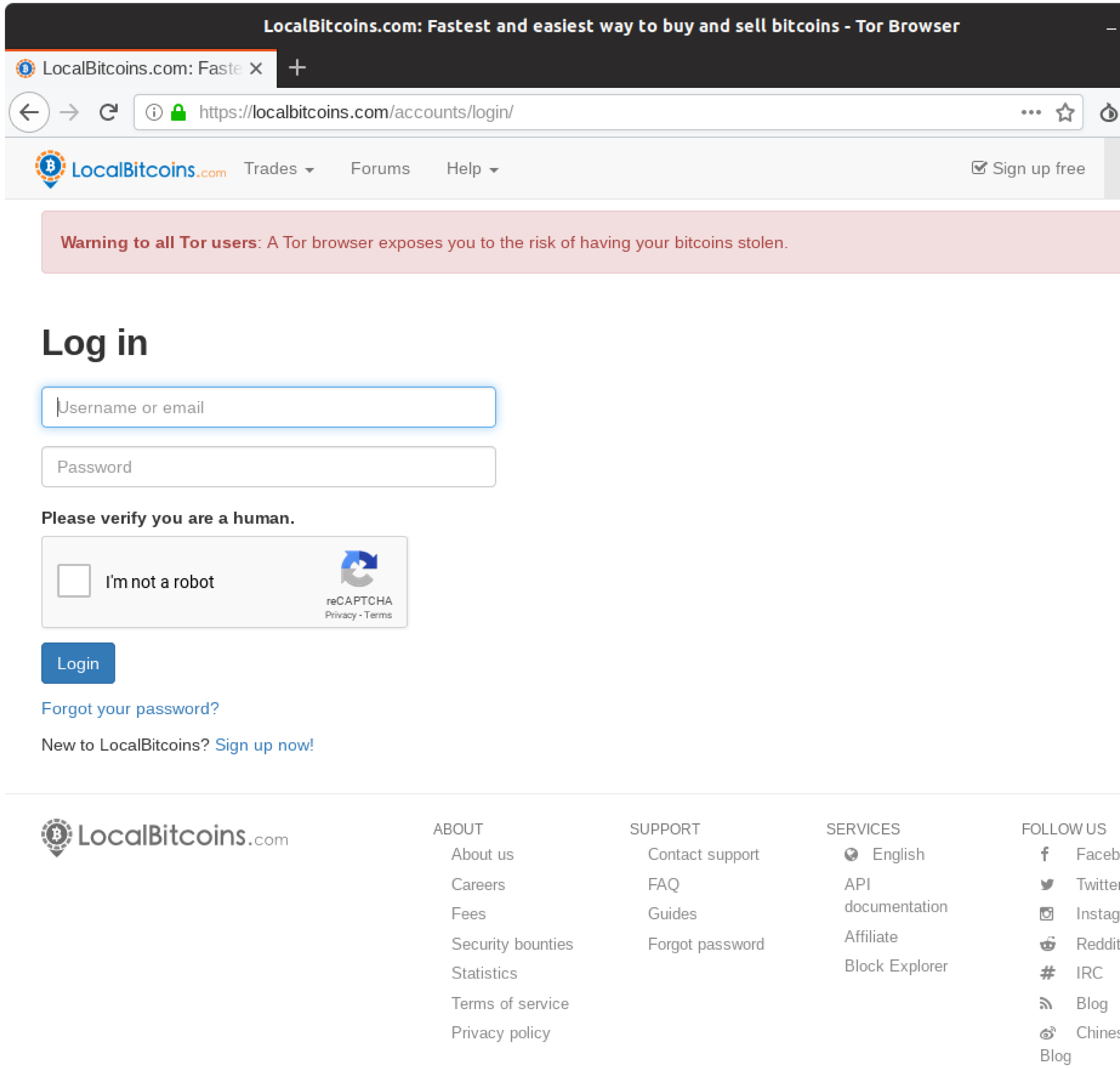
○ Always block document requests from https://edge.bigthink.com to https://js.stripe.com

○ Allow this request

○ Always allow document requests from https://edge.bigthink.com to https://js.stripe.com

But You Are Relying On Honest Exit Nodes...

- The exit node, where your traffic goes to the general Internet, is a man-in-the-middle...
  - Who can see and modify all non-encrypted traffic
  - The exit node also does the DNS lookups
- Exit nodes have not always been honest...



LocalBitcoins.com: Fastest and easiest way to buy and sell bitcoins - Tor Browser

LocalBitcoins.com: Faste

https://localbitcoins.com/accounts/login/

LocalBitcoins.com Trades Forums Help Sign up free

Warning to all Tor users: A Tor browser exposes you to the risk of having your bitcoins stolen.

Log in

Username or email

Password

Please verify you are a human.

□ I'm not a robot reCAPTCHA Privacy - Terms

Login

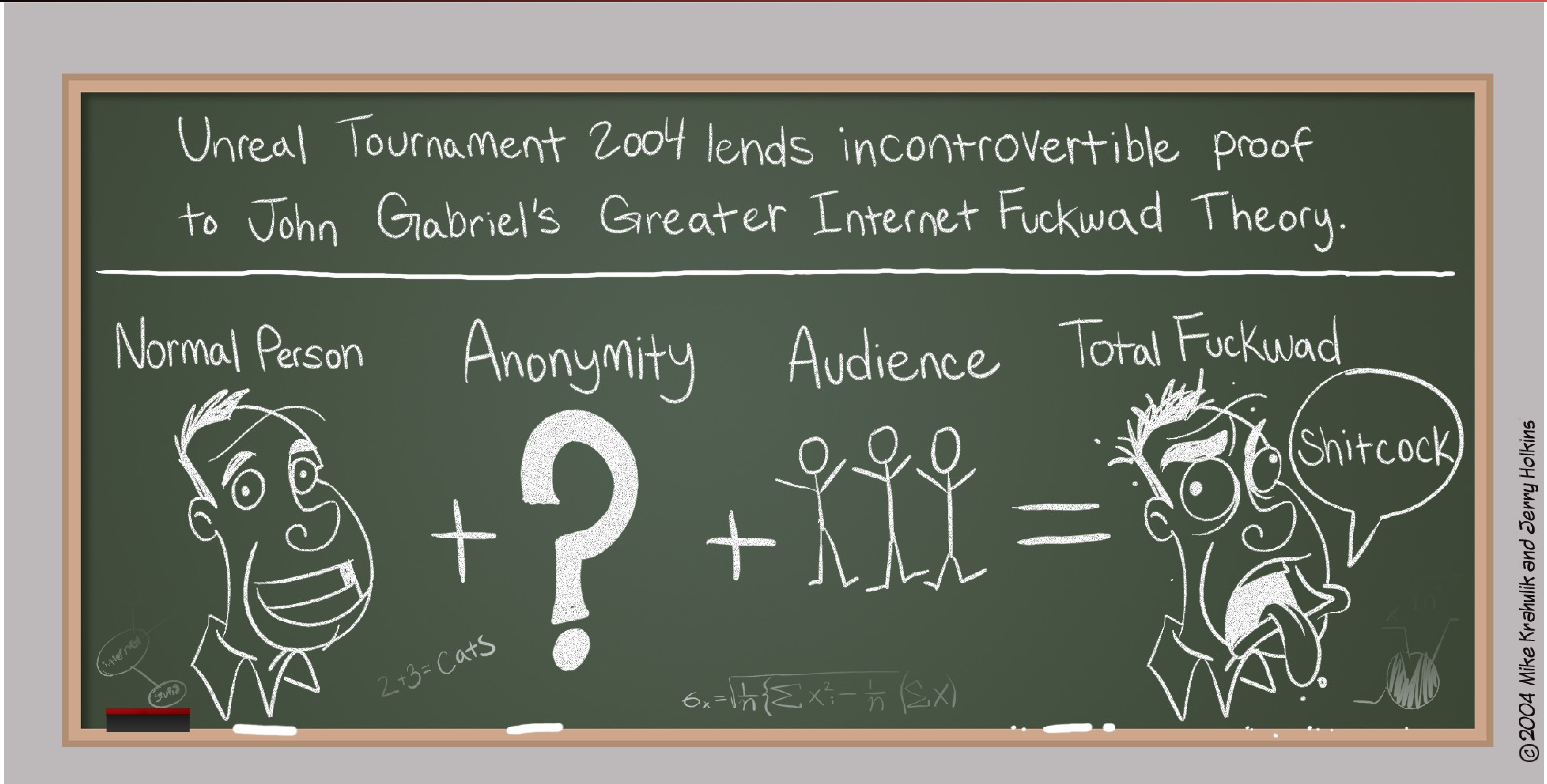
Forgot your password?

New to LocalBitcoins? Sign up now!

LocalBitcoins.com

ABOUT	SUPPORT	SERVICES	FOLLOW US
About us	Contact support	English	Faceb
Careers	FAQ	API documentation	Twitte
Fees	Guides	Affiliate	Instag
Security bounties	Forgot password	Block Explorer	Reddi
Statistics			IRC
Terms of service			Blog
Privacy policy			Chines Blog

Anonymity Invites Abuse...
(Stolen from Penny Arcade)


Unreal Tournament 2004 lends incontrovertible proof to John Gabriel's Greater Internet Fuckwad Theory.
Normal Person
Anonymity
Audience
Total Fuckwad
+
?
+
=
Shitcock
2+3=Cats
©2004 Mike Krahulik and Jerry Holkins

This Makes Using Tor Browser Painful…

And Also Makes Running Exit Nodes Painful...

- Tor Relay operators may receive abuse complaints...
  - If they run a Tor Exit Node
- ISPs may not be friendly to Tor
- Serves as a large limit on Tor in practice:
  - Internal bandwidth is plentiful, but exit node bandwidth is restricted
- Know a colleague who ran an exit node for research...
  - And got a ***visit from the FBI***!

One Example of Abuse: The Harvard Bomb Threat...

- On December 16th, 2013, a Harvard student didn't want to take his final in "Politics of American Education"...
  - So he emailed a bomb threat using Guerrilla Mail
  - But he was "smart" and used Tor and Tor Browser to access Guerrilla Mail
- Proved easy to track
  - "Hmm, this bomb threat was sent through Tor..."
  - "So who was using Tor on the Harvard campus..." (look in Netflow logs..)
  - "So who is this person..." (look in authentication logs)
  - "Hey FBI agent, wanna go knock on this guy's door?!"
- There is no magic Operational Security (OPSEC) sauce...
  - And again, anonymity only works if there is a crowd

Break
Random fact about me...

- I use Tor for everything
  - Web browsing
  - SSH with .onion services
  - OS updates
  - Tor on Android
    - Route traffic of all apps through Tor
- I run a few Tor relays in Brazil and US

Censorship Resistance: Pluggable Transports

- Tor is really used by two separate communities
  - Anonymity types who want anonymity in their communication
  - Censorship-resistant types who want to communicate despite government action
    - The price for "free" censorship evasion is that your traffic acts to hide other anonymous users
- Direct connection to Tor fails the latter ***completely***
- So there is a framework to deploy bridges that encapsulate Tor over some other protocol
  - So if you are in a hostile network...
  - Lots of these, e.g. OBS3 (Obfuscating Protocol 3), OBS4, Meek...

OBS3 Blocking: China Style

- Its pretty easy to recognize something is ***probably*** the Tor obs3 obfuscation protocol
  - But there may be false positives...
    - And if you are scanning ***all internet traffic in China*** the base rate problem is going to get you
- So they scan all Internet traffic looking for obs3...
  - And then try to connect to any server that looks like obs3...
  - Do a handshake and if successful...
- If it is verified as an obs3 proxy...
  - China then blocks that IP/port for 24 hours

Meek: Collateral Freedom

- Meek is another pluggable transport
  - It uses Google App engine and other cloud services
- Does a TLS connection to the cloud service
  - And then encapsulates the Tor frames in requests laundered through the cloud service
- Goal is "Too important to block"
  - The TLS handshake is to a legitimate, should not be blocked service
  - And traffic analysis to tell the difference between Meek and the TLS service is going to be hard/have false positives

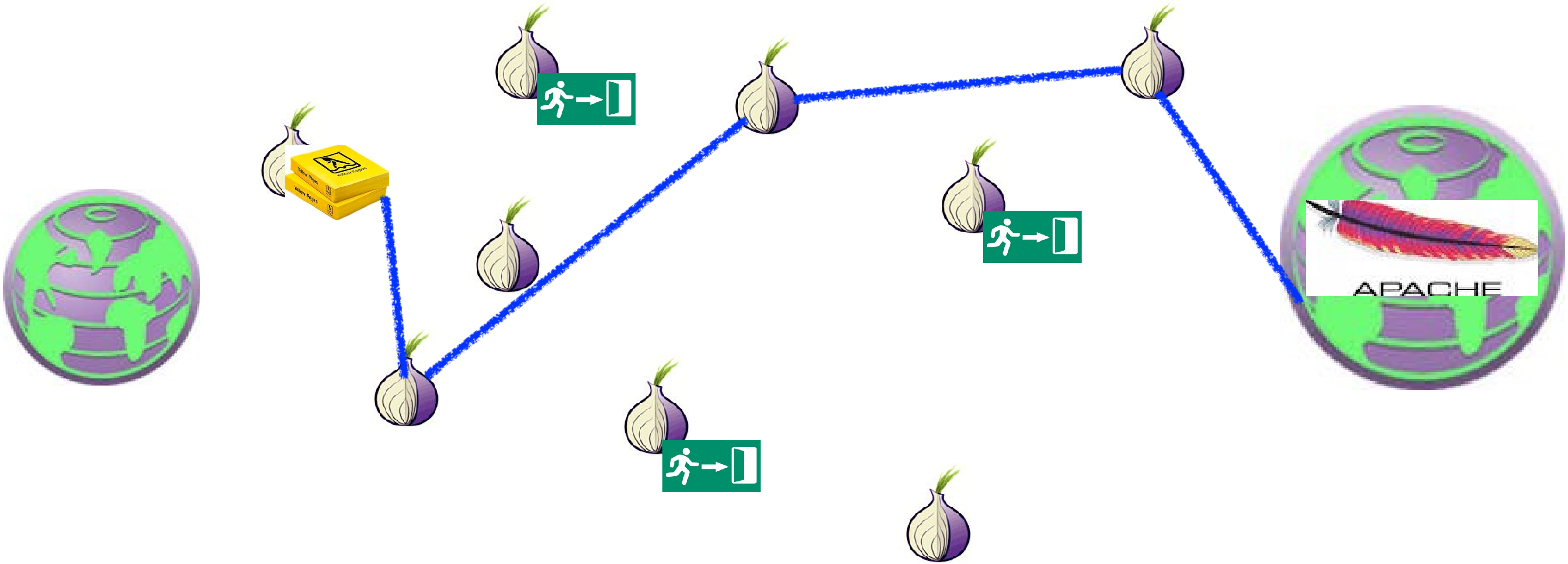
The End Of Collateral Freedom...

- Meek relied on "Domain fronting"
  - A "bug"/"feature" of TLS/HTTPS:
    You tell TLS what host you want to talk to
    You tell the HTTP server what host you want to talk to...
- So you tell TLS one thing
  - Which the censor can see
- And the web server something else
  - Because its a Google server, or a Cloudflare CDN server or...
    Which supports a large number of different hosts
- Recently all the major CDNs stopped supporting it
  - After all, it ***is*** a bug!

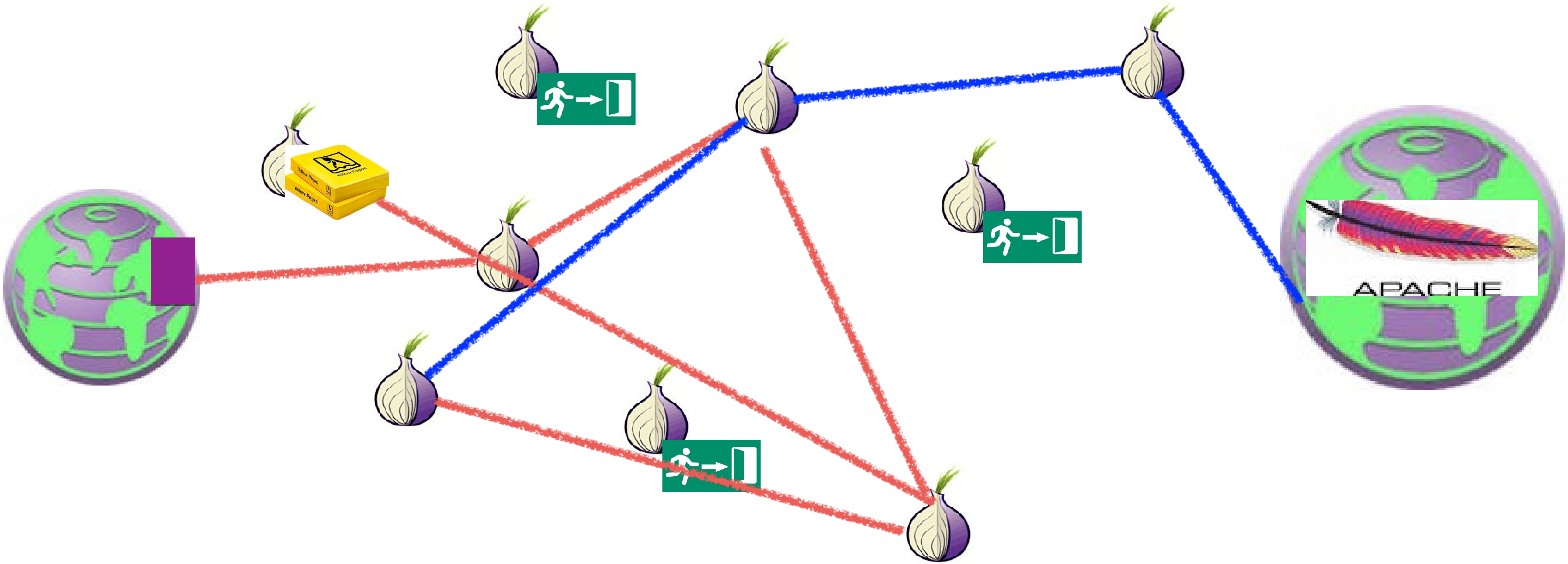
Tor Browser is also used to access Tor Hidden Services aka .onion sites

- Services that ***only*** exist in the Tor network
  - So the service, not just the client, has possible anonymity protection
  - The “Dark Web”
- A ***hash*** of the hidden service's public key
  - http://pwoah7foa6au2pul.onion
    - AlphaBay, one of many dark markets
  - https://facebookcorewwwi.onion
    - In this case, Facebook spent a lot of CPU time to create something distinctive
- Using this key hash, can query to set up a circuit to create a hidden service at a rendezvous point

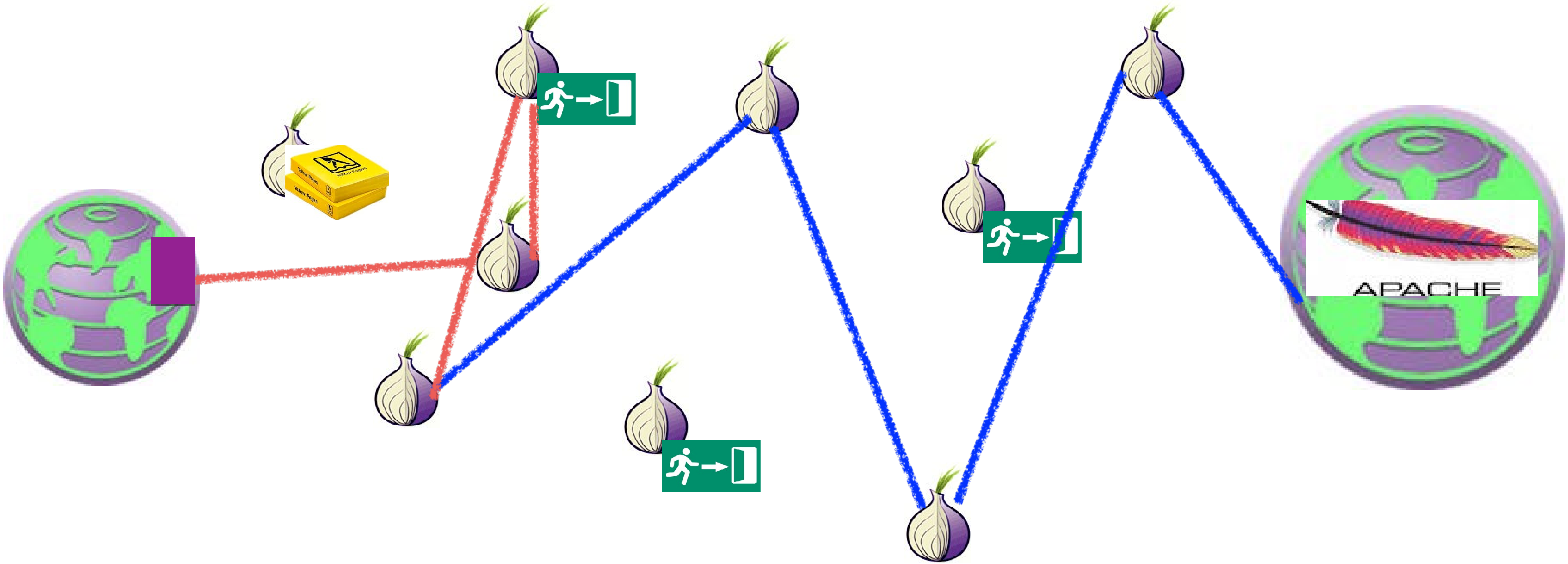
Tor Hidden Service:
Setting Up Introduction Point

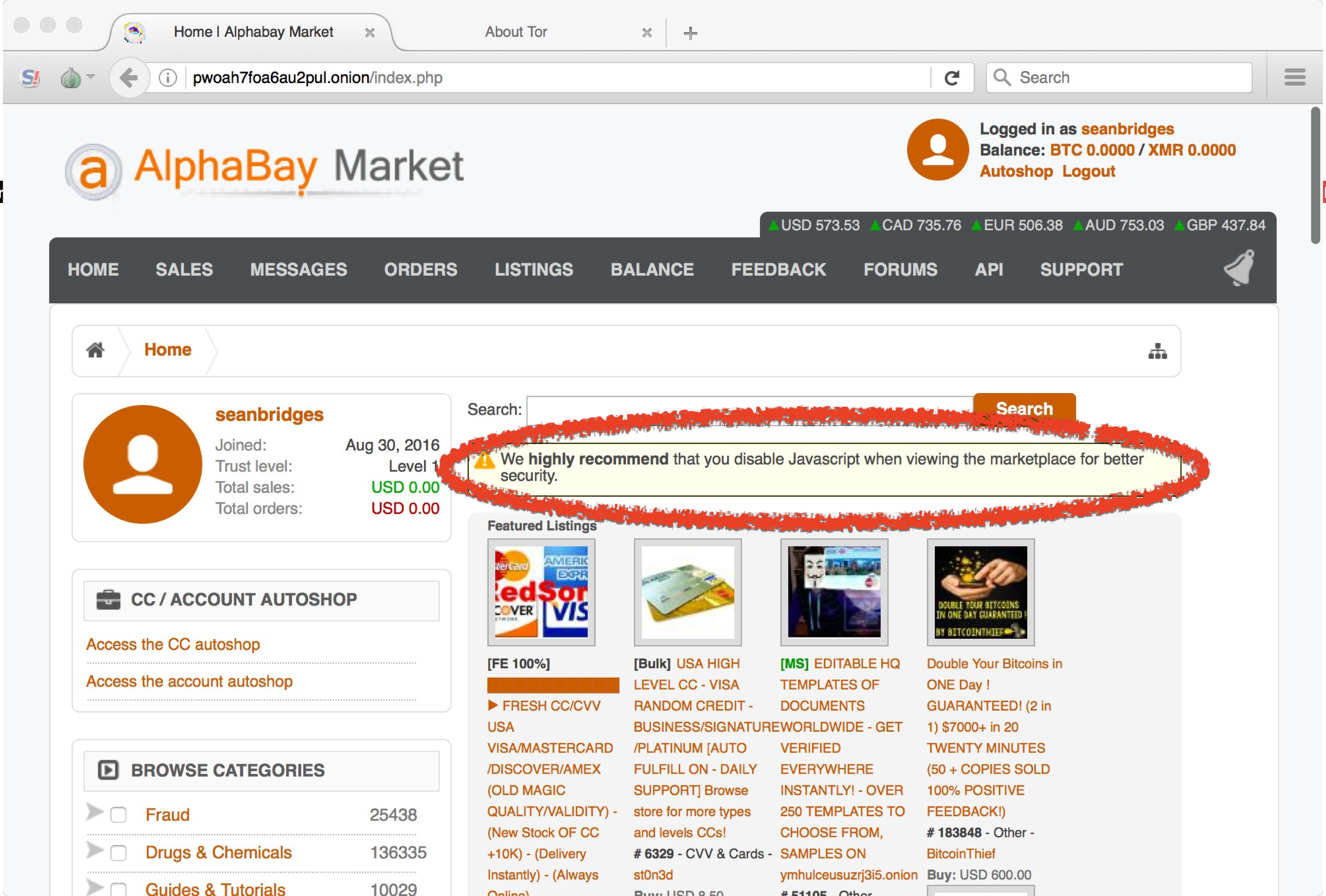


Tor Hidden Service:
Query for Introduction, Arrange Rendevous



Tor Hidden Service:
Rendevous and Data





AlphaBay Market

Logged in as seanbridges
Balance: BTC 0.0000 / XMR 0.0000
Autoshop Logout

▲USD 573.53 ▲CAD 735.76 ▲EUR 506.38 ▲AUD 753.03 ▲GBP 437.84

HOME SALES MESSAGES ORDERS LISTINGS BALANCE FEEDBACK FORUMS API SUPPORT

Home

seanbridges

Joined:	Aug 30, 2016
Trust level:	Level 1
Total sales:	USD 0.00
Total orders:	USD 0.00

Search: Search

⚠ We **highly recommend** that you disable Javascript when viewing the marketplace for better security.

CC / ACCOUNT AUTOSHOP

Access the CC autoshop

Access the account autoshop

BROWSE CATEGORIES

□	Fraud	25438
□	Drugs & Chemicals	136335
□	Guides & Tutorials	10029

Featured Listings

[FE 100%] ▶ FRESH CC/CVV USA VISA/MASTERCARD /DISCOVER/AMEX (OLD MAGIC QUALITY/VALIDITY) - (New Stock OF CC +10K) - (Delivery Instantly) - (Always Online)

[Bulk] USA HIGH LEVEL CC - VISA RANDOM CREDIT - BUSINESS/SIGNATURE /PLATINUM [AUTO FULFILL ON - DAILY SUPPORT] Browse store for more types and levels CCs!
6329 - CVV & Cards - st0n3d
Buy: USD 8.50

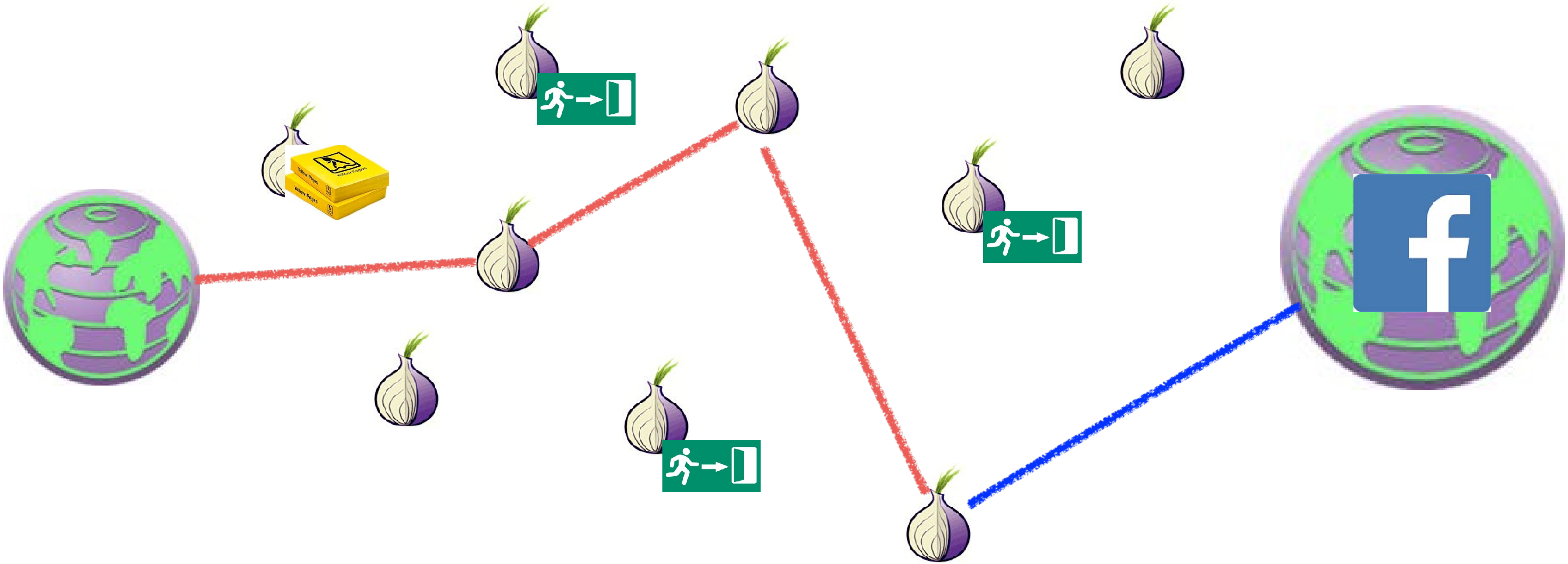
[MS] EDITABLE HQ TEMPLATES OF DOCUMENTS WORLDWIDE - GET VERIFIED EVERYWHERE INSTANTLY! - OVER 250 TEMPLATES TO CHOOSE FROM, SAMPLES ON ymhulceusuzrj3i5.onion
51105 - Other

Double Your Bitcoins in ONE Day ! GUARANTEED! (2 in 1) $7000+ in 20 TWENTY MINUTES (50 + COPIES SOLD 100% POSITIVE FEEDBACK!)
183848 - Other - BitcoinThief
Buy: USD 600.00

Remarks…

- Want to keep your guard node constant for a long period of time…
  - Since the creation of new circuits is far easier to notice than any other activity
- Want to use a different node for the rendezvous point and introduction
  - Don’t want the rendezvous point to know who you are connecting to
- These are ***slow!***
  - Going through 6+ hops in the Tor network!

Non-Hidden Tor Hidden Service: Connect Directly to Rendezvous



Non-Hidden Hidden Services Improve Performance

- No longer rely on exit nodes being honest
  - No longer rely on exit node bandwidth either
- Reduces the number of hops to be the same as a not hidden service
- Result: Huge performance win!
  - Not slow like a hidden service
  - Not limited by exit node bandwidth
- Any site that doesn’t require anonymity can use this technique

Onion service uses

- Censorship resistance
- End-to-end security
  - Protected against CA compromise
  - Bypass NAT/Firewalls
- Journalist and whistle-blowing websites
  - Protect anonymity of the source

Illegal activities on hidden services

- "Non-arbitrageable criminal activity"
  - Some crime which is universally attacked and targeted
    - So can't use "bulletproof hosting”, CDNs like CloudFlare, or suitable “foreign” machine rooms:
      And since CloudFlare will service the anti-Semitic shitheads like gab.ai and the actual nazis at Storefront are still online...
- Dark Markets
  - Marketplaces based on Bitcoin or other alternate currency
- Cybercrime Forums
  - Hoping to protect users/administrators from the fate of earlier markets

The Dark Market Concept

- Four innovations:
- A censorship-resistant payment (Bitcoin)
  - Needed because illegal goods are not supported by Paypal etc
    - Bitcoin/cryptocurrency is the ***only game in town*** for US/Western Europe after the Feds smacked down Liberty Reserve and eGold
- An eBay-style ratings system with mandatory feedback
  - Vendors gain positive reputation through continued transactions
- An escrow service to handle disputes
  - Result is the user (should) only need to trust the market, not the vendors
- Accessible ***only*** as a Tor hidden service

The Dark Markets: History

- All pretty much follow the template of the original “Silk Road”
  - Founded in 2011, Ross Ulbricht busted in October 2013
- The original Silk Road actually (mostly) lived up to its libertarian ideals
  - Including the libertarian ideal that if someone rips you off you should be able to call up the Hell’s Angels and put a hit on them
    - And the libertarian idea if someone is foolish enough to THINK you are a member of the Hell’s Angels you can rip them off for a large fortune for a fake hit
- Since then, markets come and go

The Dark Markets:
Not So Big, and ***Not Growing!***

- Kyle Soska and Nicolas Christin of CMU have crawled the dark markets for years
  - These markets ***deliberately*** leak sales rate information from mandatory reviews
- So simply crawl the markets, see the prices, see the volume, voila...
- Takeaways:
  - Market size has been relatively steady for years, about $300-500k a day sales
    - Latest peak got close to $1M a day
  - Dominated by Pot, MDMA, and stimulants, with secondary significance with opioids and psychedelics
  - A few sellers and a few markets dominate the revenue: A fair bit of “Winner take all”

The Scams…

- You need a reputation for honesty to be a good crook
  - But you can burn that reputation for short-term profit
- The “Exit Scam” (e.g. pioneered by Tony76 on Silk Road)
  - Built up a positive reputation
  - Then have a big 4/20 sale
  - Require buyers to “Finalize Early”
    - Bypass escrow because of “problems”
  - Take the money and run!
- Can also do this on an entire ***market*** basis

Deanonymizing Hidden Services: Hacking...

- Most dark-net services are not very well run...
  - Either common off-the-shelf drek or custom drek
- And most have now learned ***don't ask questions on StackOverflow***
  - Here's looking at you, frosty...
- So they don't have a great deal of IT support services
  - A few hardening guides but nothing really robust

Onionscan...

- A tool written by Sarah Jamie Lewis
  - Available at https://github.com/s-rah/onionscan
- Idea is to look for very common weaknesses in Tor Hidden services
  - Default apache information screens
  - Web fingerprints
  - I believe a future version will check for common ssh keys elsewhere on the Internet
- Its really "dual use"
  - .onion site operators should use to make sure they aren't making rookie mistakes
  - Investigators can use to find vulnerabilities

Deanonymizing Visitors To Your Site FBI Style

- Start with a Tor Browser Bundle vulnerability...
  - Requires paying for a decent vulnerability:
    Firefox lacks sandboxing-type protections but you have to limit yourself to JavaScript
- Then take over the site you want to deanonymize visitors to...
- And simply hack the visitors to the site!
  - With a limited bit of malcode that just sends a “this is me” back to an FBI-controlled computer
  - Was sent without any encryption/integrity

A History of NITs

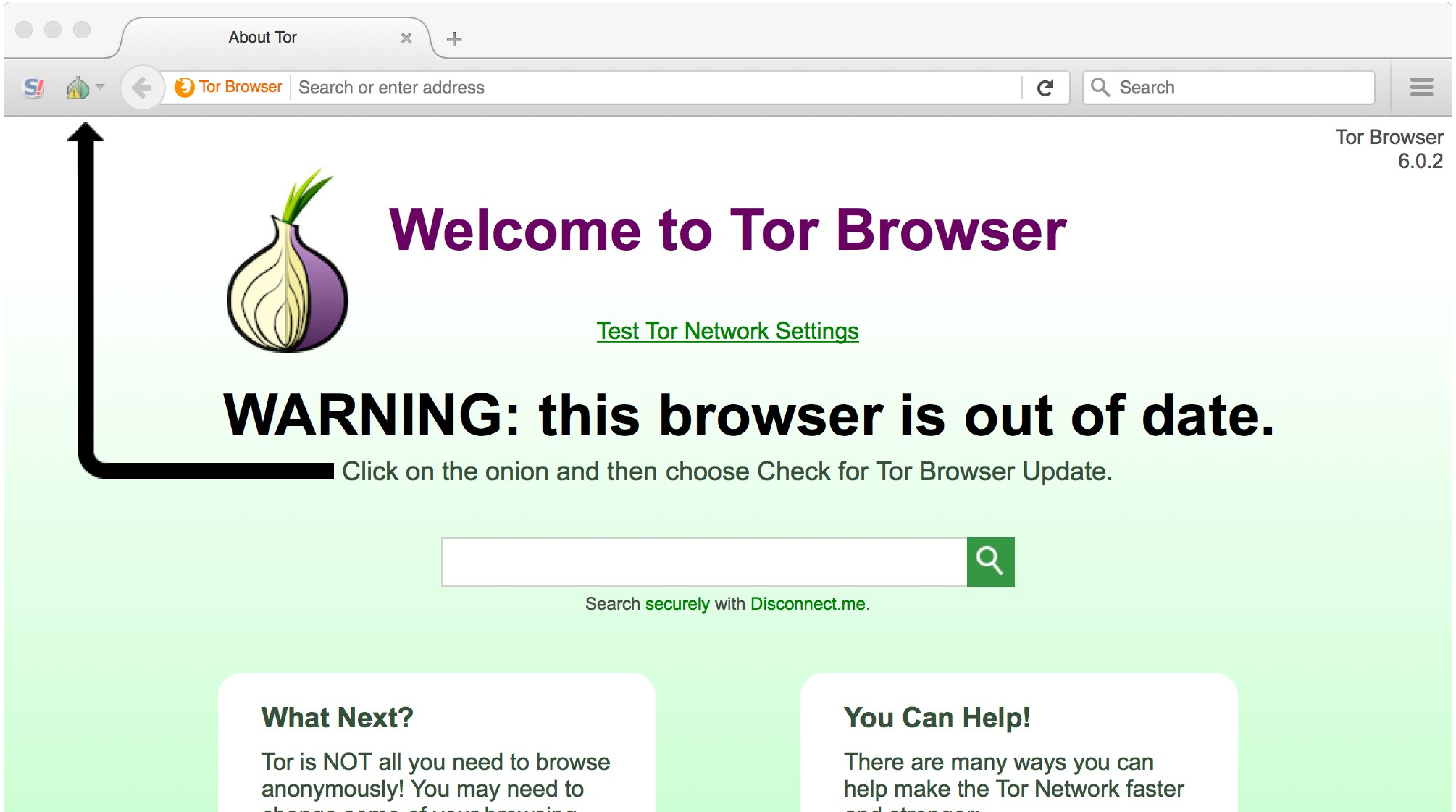
- The FBI calls their malicious code a NIT or Network Investigatory Technique
    - Because it sounds better to a magistrate judge than saying "we're gonna go hacking"
- The exploit attempts to take over the visitor's browser
- But the payload is small: just a "I'm this computer" sent over the Internet to an FBI controlled Internet address

A History of NITs: PedoBook

- The first known NIT targeting a hidden service was “PedoBook” back in 2012
  - Back then, many people used other web browsers to interact with Tor hidden services
- The NIT actually didn’t even qualify as malcode
  - And a ***defense*** expert actually argued that it isn’t hacking and probably didn’t actually need a warrant
- Instead it was the “Metasploit Decloaking” flash applet:

A History of NITs: Freedom Hosting

- The second big NIT targeted FreedomHosting
  - A hosting provider for Tor Hidden services with an, umm, generous policy towards abuse
    - Hosted services included TorMail (a mail service through Tor) and child porn sites
- FBI replaced the entire service with a NIT-serving page
- Fallout:
  - Very quickly noticed because there are multiple legit users of TorMail
  - Targeted an older Firefox vulnerability in Tor Browser
- Tor browser switched to much more aggressive autoupdates:
  Now you ***must*** have a zero-day



Tor Browser 6.0.2

Welcome to Tor Browser

Test Tor Network Settings

WARNING: this browser is out of date.

Click on the onion and then choose Check for Tor Browser Update.

Search securely with Disconnect.me.

What Next?

Tor is NOT all you need to browse anonymously! You may need to

You Can Help!

There are many ways you can help make the Tor Network faster

A History of NITs: Playpen

- The big one: PlayPen was a hidden service for child pornographers
  - In February 2015, the FBI captured the server and got a warrant to deploy a NIT to logged in visitors
    - The NIT warrant is public, but the malcode itself is still secret: >100,000 logins!
- What we do know:
  - This was big: hundreds of arrests, many abuse victims rescued
  - It almost certainly used a zero-day exploit for Tor Browser
- Courts are still hashing this out over two big questions
  - Is it valid under Rule 41?
    - ***Most*** have conclude "no, but a technical not constitutional flaw":
      Good faith says that previous violations are OK, but not future violations
  - Does the defense have a right to examine the exploit?

A History of NITs: Two Years Ago

- Someone (probably the French police) captured a child porn site called the "GiftBox"
  - They modified it to serve up a NIT
- The NIT payload was almost identical to the one in the Freedom Hosting case
  - Suggesting assistance from either the FBI or the FBI's contractor
- The exploit was a ***new*** zero-day exploit targeting Firefox
  - Patch released within ***hours***
    - And yes, it was a C-related memory corruption (naturally)

NITs won’t work well in the future against Tor!

- The current Tor browser hardened branch is just that, ***hardened***
  - And it will become mainstream in a future version:
    it uses a technique, ***selfrando***, with ***no currently known workaround!***
- Hardening will require that breaking Tor browser, even to just send a "I'm here" message, will require a chain of exploits
  - An information leakage to determine the address of a function and enough content in that function to enable an attack
    - Or the leakage of a lot of functions
  - PLUS a conventional vulnerability
  - And just wait until the Firefox rendering engine gets sandboxed too…
  - And ad in darknet users who are running without JavaScript
- Upshot: the current FBI exploit will need a massive upgrade if it will work at all!
  - And future exploits will be ***vastly*** more expensive and rarer
  - We should thank the FBI for their very valuable contributions to software hardening