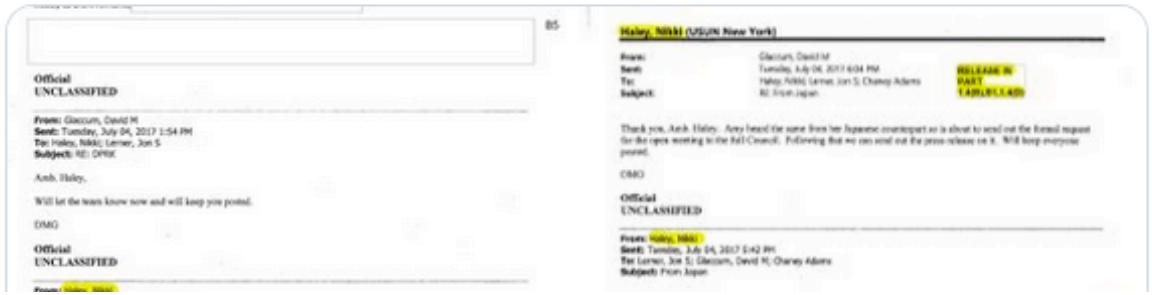
Use Signal?!
?Use Tor?

American Oversight ✓
@weareoversight

NEW: Shortly after North Korea tested a missile, Nikki Haley, former ambassador to the United Nations, sent classified information over an unclassified email system — according to records we obtained via FOIA litigation.

Why? She forgot her password. thedailybeast.com/nikki-haley-us...



Signal and Tor

- Signal is a messenger protocol and implementation
  - Signal (the company) is a 501(c)3 nonprofit
  - The protocol is also used by WhatsApp, Facebook Messenger, etc...
- Tor is an anonymity tool
  - Designed to provide anonymous but real-time network connectivity in the face of an ***aggressive but local adversary***
- Common (bad) information security advice is "Use Signal, Use Tor"
  - In reality, Signal is a great protocol, but some security compromises are annoying in the implementation, so for most, WhatsApp is about as good
  - While Tor is often not just a placebo but ***poison***!

End-To-End Messengers

- We love ***end to end*** cryptographic protocols...
  - After all, we just saw why we might want them
- We love ***forward secrecy***...
  - After all, we just saw why we want things to stay secret even if our keys are compromised
- Forward secrecy is "easy" for online protocols
  - Just make sure to do a DHE/ECDHE key exchange
- Forward secrecy is ***much more annoying*** for an offline protocol
  - Alice wants to share data with Bob, but Bob is ***not online***
    - Like in project 2...
    - Or any messenger system!

Signal Requirements For Key Agreement

- Three parties: Alice, Bob, and a messenger server
  - The messenger server is like the file store in project 2, an ***untrusted*** entity
  - A ***separate*** mechanism is used to provide ***key transparency***
- Bob is ***offline***:
  - He has prearranged data stored on the messenger server
- Alice and Bob want to create an ephemeral (DH) key...
  - To use for then encrypting messages
- They need ***mutual authentication***
  - Assuming Alice and Bob have the correct public keys, ***only*** Alice and Bob could have agreed on a key
- They also need ***deniability***
  - Alice or Bob can't create a record ***proving*** the other side participated in creating the key:
    So no "Alice just signs her DH..." design

Extended Triple Diffie-Hellman

- Key idea:
  - Lets use multiple Diffie-Hellman exchanges combined into one
    - Some to perform mutual authentication
    - Some to generate an ephemeral key
- They use elliptic curves, but the design would be the same for conventional DH, so we will use the former
  - We will use ***DH(A,B)*** as ***DH(g^a,g^b)*** where we know ***a*** but not ***b***.
  - Also have ***Sign(K,M)*** for signing and ***KDF(KM)*** which derives a bunch of session keys for a hash-based key derivation function

Lots of Keys!

- Alice:
  - IK_A: Alice's identity key: for both DH and signatures
  - EK_A: Alice's ephemeral key: Created and discarded.
- Bob:
  - IK_B: Bob's identity key, long lived
  - SPK_B: Bob's signed rekey, rotates ~weekly/monthly
    - Has corresponding signature $Sign(IK_b, SPK_b)$
  - OPK_B: Bob's one time use keys (One Time Prekey)
    - Can run out, but designed to increase security when available

Before We Start: Bob to Server, Server to Alice

- Bob uploads:
  - IK_B, SPK_B, $Sign(IK_B, SPK_B)$, {OPK_B^1, OPK_B^2, OPK_B^3 ...}
- Now when Alice wants to talk to Bob...
- Gets from the server:
  - IK_B, SPK_B, $Sign(IK_B, SPK_B)$, $OPK_B^?$
  - Told which ***OPK*** it is or "There are no ***OPKs*** left"
    - ***OPKs*** are designed to prevent replay attacks
- This is now the input into Alice's DH calculations

Alice now does a lot of DH...

- ***DH1 = DK(IK_A, SPK_B)***
  - Acts as authentication for Alice when Bob does the same
- ***DH2 = DK(EK_A, IK_B)***
  - Forces Bob to do mutual authentication
- ***DH3 = DK(EK_A, SPK_B)***
  - Adds in ephemeral ***EK_A*** to short lived ***SPK_B***
- ***DH4 = DK(EK_A, OPK_B)***
  - Adds in one-time used ***OPK_B***, if available
- ***SK = HKDF(DH1 || DH2 || DH3 || DH4)***
  - Skip DH4 if no one time pre-keys are available
- Now discard the private part of EKA and the intermediate DH calculations

Now Alice Sends To Bob

- IK_A, EK_A, which ***OPK*** used (if any), and $E(SK, M, IK_A \| IK_B)$
  - Using an AEAD encryption mode:
    Authenticated Encryption with Additional Data modes allow additional data to be protected by the MAC but sent in the clear
- Bob can do the same DH calculations to generate SK
  - If it fails to verify the AEAD data abort

Key Transparency

- For now, Alice and Bob are trusting the server to report IK_A and IK_B correctly
  - If the server lies, 🤷
- Fortunately there is an answer:
  If Alice and Bob are ***ever*** together:
  - One person's phone displays $H(IK_A \,||\, IK_B)$ as a QR Code
  - Other person's phone verifies that it is the same
- Plus the voice channel...
  - Display "Two Words" on screen:
    $F(H(IK_A \,||\, IK_B \,||\, SK))$
  - Assumption is a MitM attacker can't fake a voice conversation quickly enough, so if each person says one of the words...

Considerations

- Authentication requires the out-of-channel methods
  - Otherwise no guarantees
- Replay attacks
  - Only if no OPK is available: Can be potentially bad
- Deniability
  - No cryptographic proofs available as to the sender/receiver!

And Then Ratchets...

- A "ratchet" is a one-way function for message keys
  - ***Ratchet(K_i)*** -> ***K_{i+1}***, ***MK_i***
  - But can't take ***K_{i+1}*** and ***MK_i*** to find ***K_i***
- A symmetric key ratchet is easy
  - We've seen these already:
    Any PRNG with rollback resistance
  - Can do it slightly more efficiently with HMAC:
    HMAK(K_i, 0x01) -> ***MK_i***
    HMAC(K_i, 0x02) -> ***K_{i+1}***
- Its OK to keep around the intermediate session keys
  - Thanks to HMAC we can't go backwards with them anyway:
    Needed for out of order messages

Signal adds in DH ratchets too...

- So for a few messages in a chain you use a symmetric key ratchet...
  - You gain forward secrecy by discarding the old internal state
- But occasionally you rekey with an additional DH
  - Used to add into the ratchet internal state

The Protocol is Great...
BUT!

- The app itself does some ehh thing in the usability/security tradeoff...
  - ***No mechanism to back-up messages***!
    If your phone is toast, your messages are gone!
  - ***No mechanism to migrate to a new phone***!
    If you upgrade to a new phone, your messages are gone!
- This is where WhatsApp has a huge competitive advantage
  - They allow backup of messages
  - (perhaps a screwup) Whether or not you "allow backups", it is marked as "OK to back-up" in the phone's memory

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 bundle:
  - A copy of FireFox extended release with privacy optimizations, configured to only use the Tor network
- Tor 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

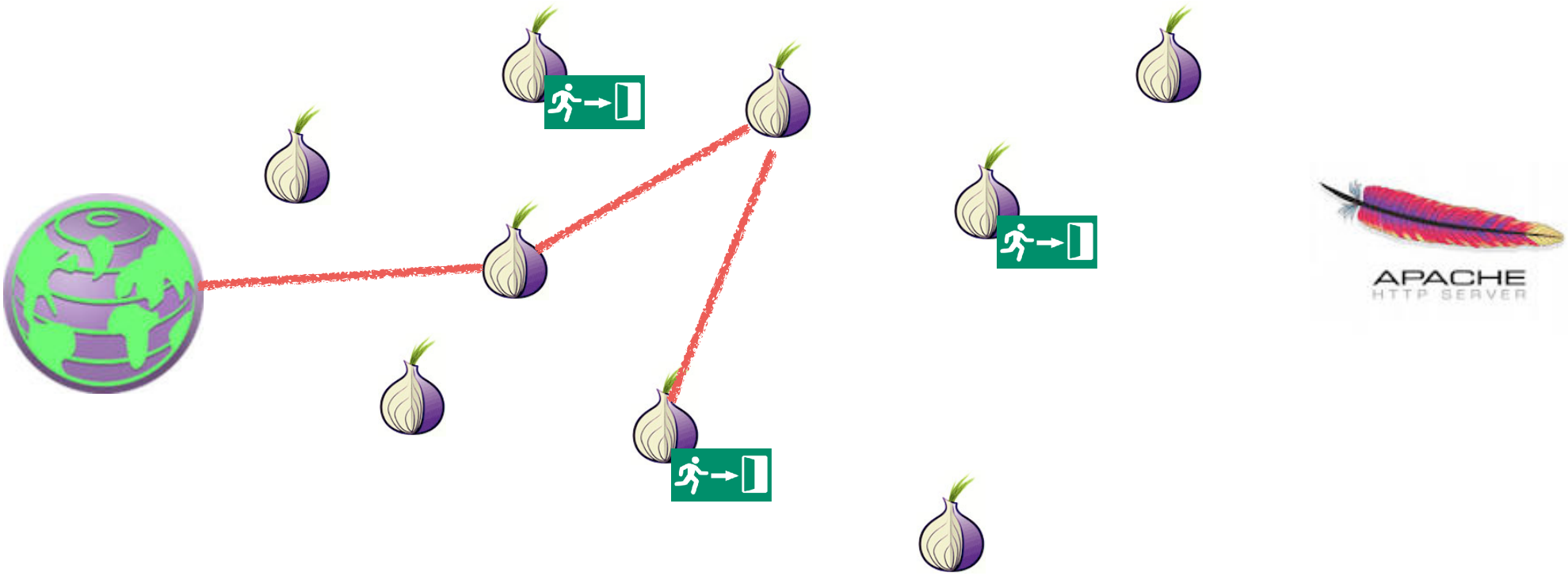
The Tor Threat Model: Anonymity of content against ***local*** adversaries

- 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

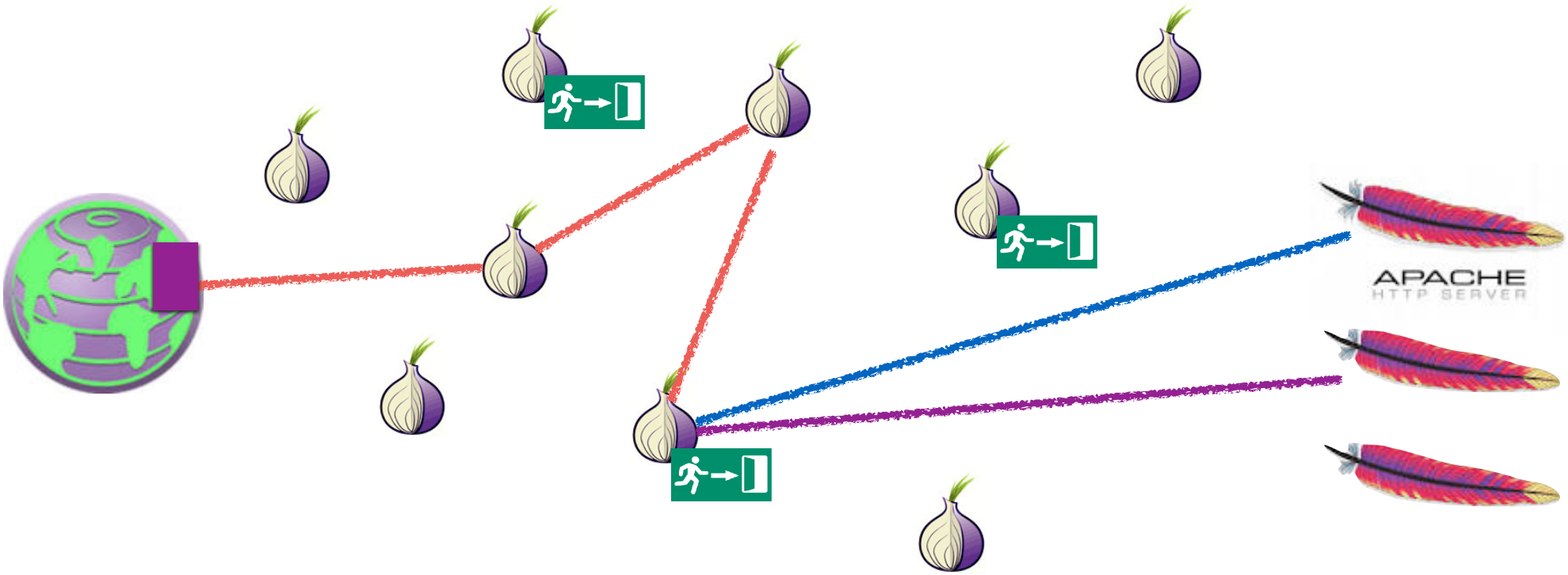
The High Level Approach: Onion Routing

- 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 g^a, signs it with public key in the directory, sends to client
    Client creates 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

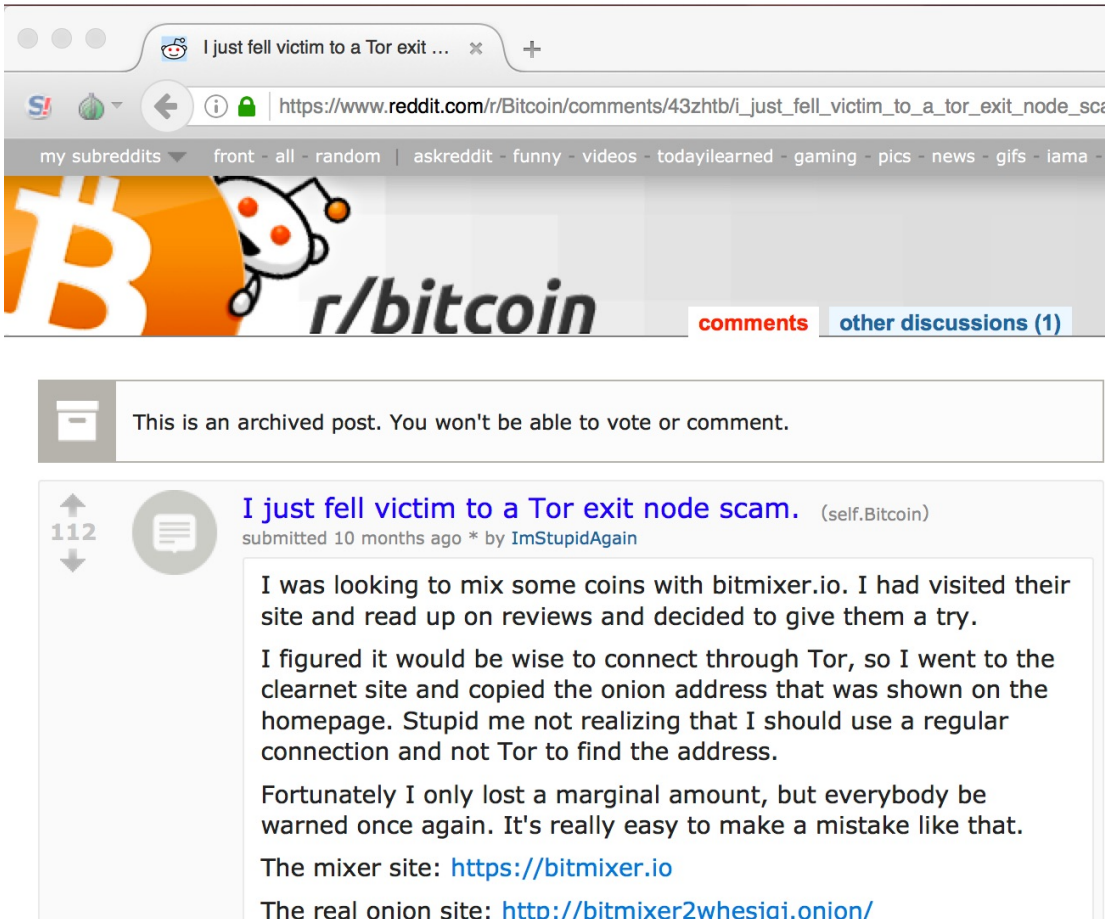
- Now the client sends some data…
  - $E(K_{or1},E(K_{or2},E(K_{or3}, Data)))$
- OR1 decrypts it and passes on to OR2
  - $E(K_{or2}, E(K_{or3}, Data))$
- OR2 then passes it on…
- Generally go through at least 3 hops…
  - Why 3? So that OR1 can't call up OR2 and link everything trivially
- Messages are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

The Tor Browser…

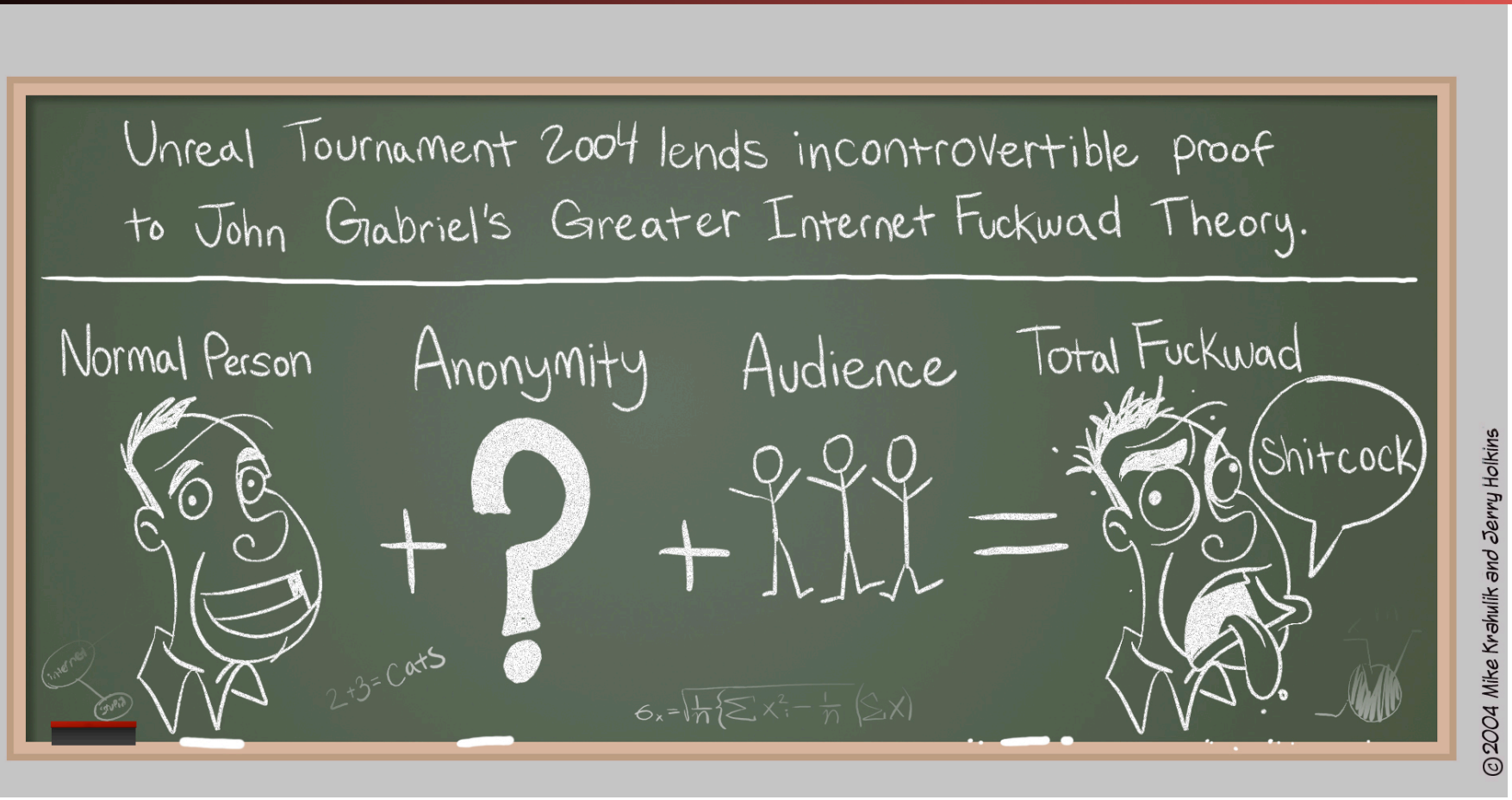
- Surfing "anonymously" doesn't simply depend on hiding your connection…
- But also configuring the browser to make sure it resists tracking
  - No persistent cookies or other data stores
  - ***No deviations from other people*** running the same browser
- Anonymity ***only works in a crowd***…
  - So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

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…



Anonymity Invites Abuse…
(Stolen from Penny Arcade)



This Makes Using Tor Browser Painful…

And Also Makes Running Exit Nodes Painful…

- If you want to receive abuse complaints…
  - Run a Tor Exit Node
- Assuming your ISP even allows it…
  - Since they don't like complaints either
- 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

Censorship Resistance: Pluggable Transports

- Tor is really used by 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
- Vanilla 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

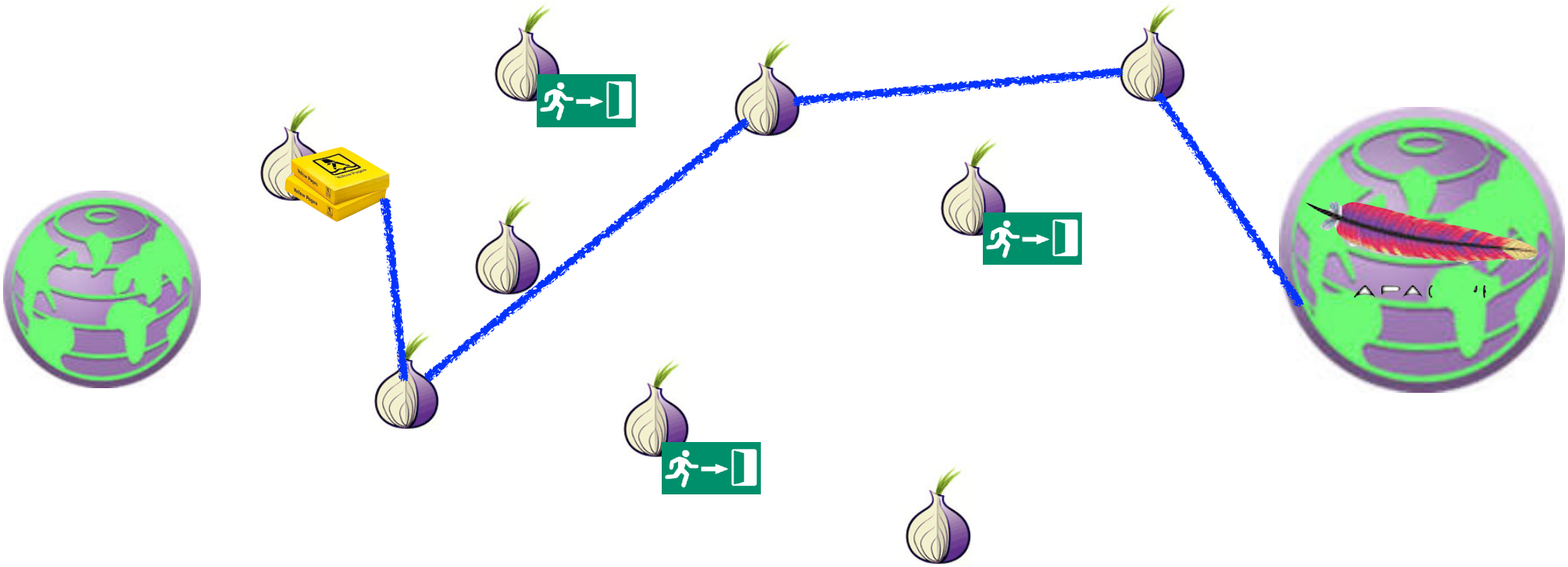
The End Of Collateral Freedom...

- 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!

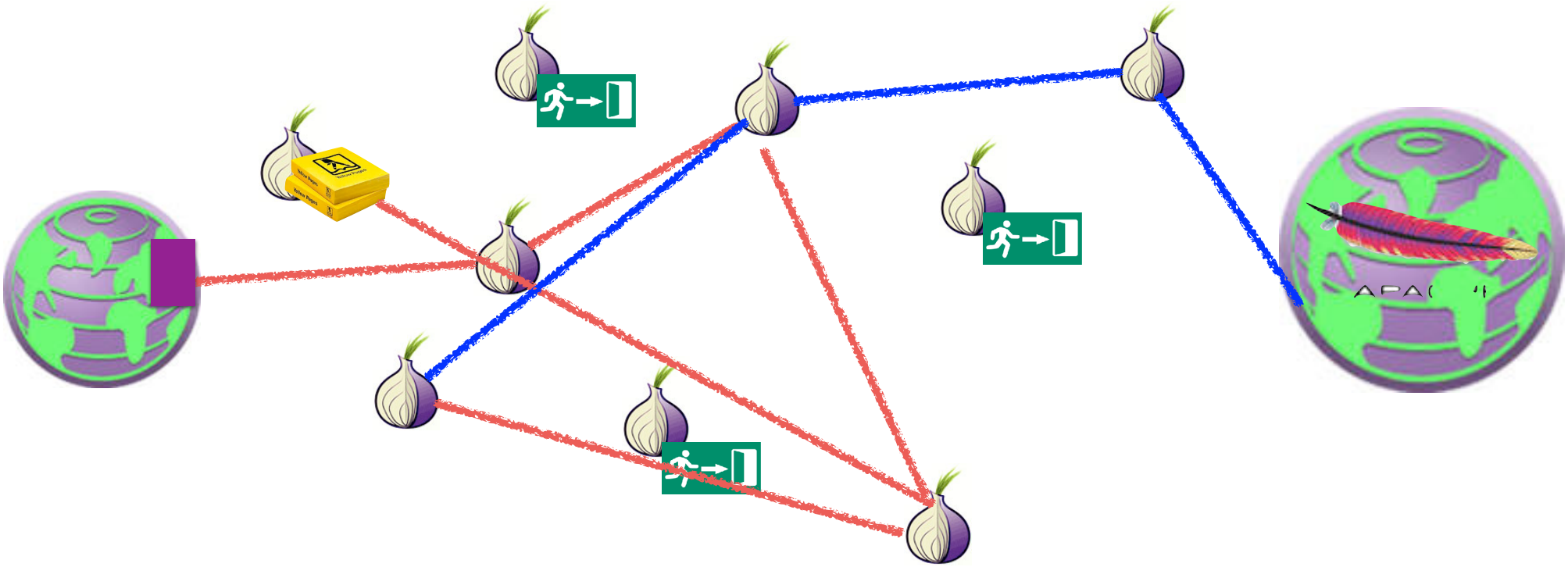
Tor Browser is also used to access Tor Hidden Services aka .onion sites

- 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
  - And because it is the hash of the key we have end-to-end security

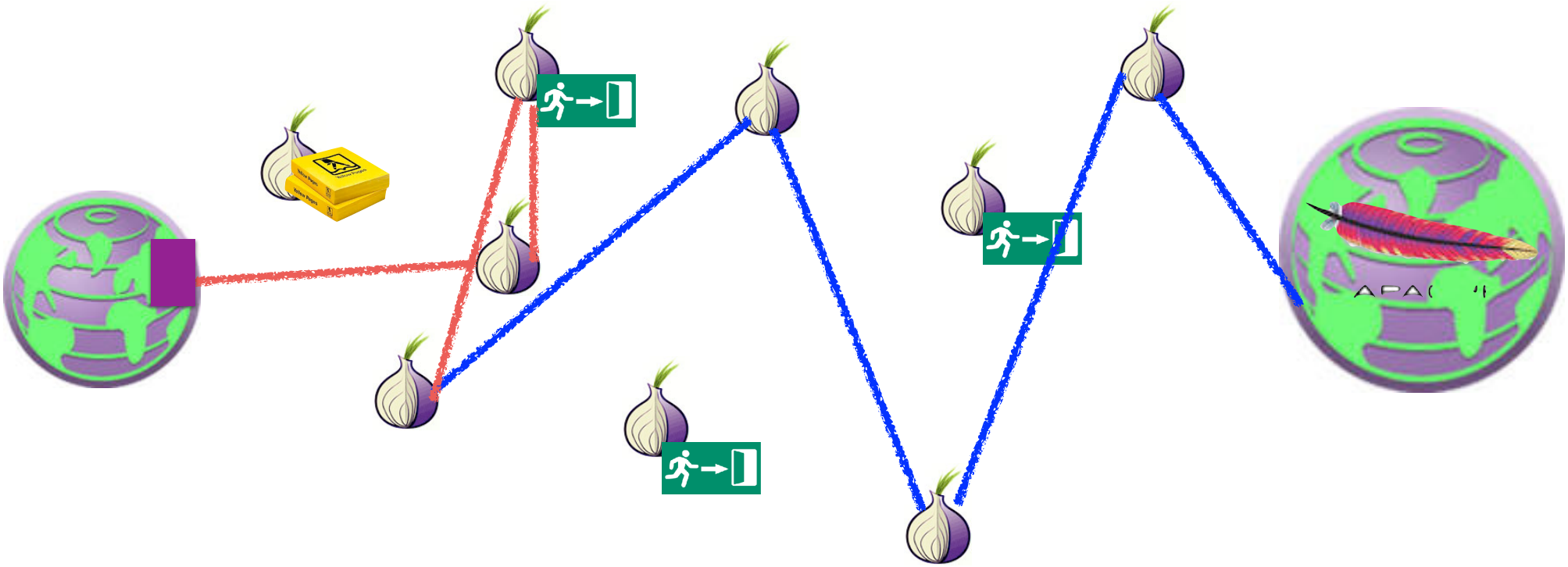
Tor Hidden Service:
Setting Up Introduction Point

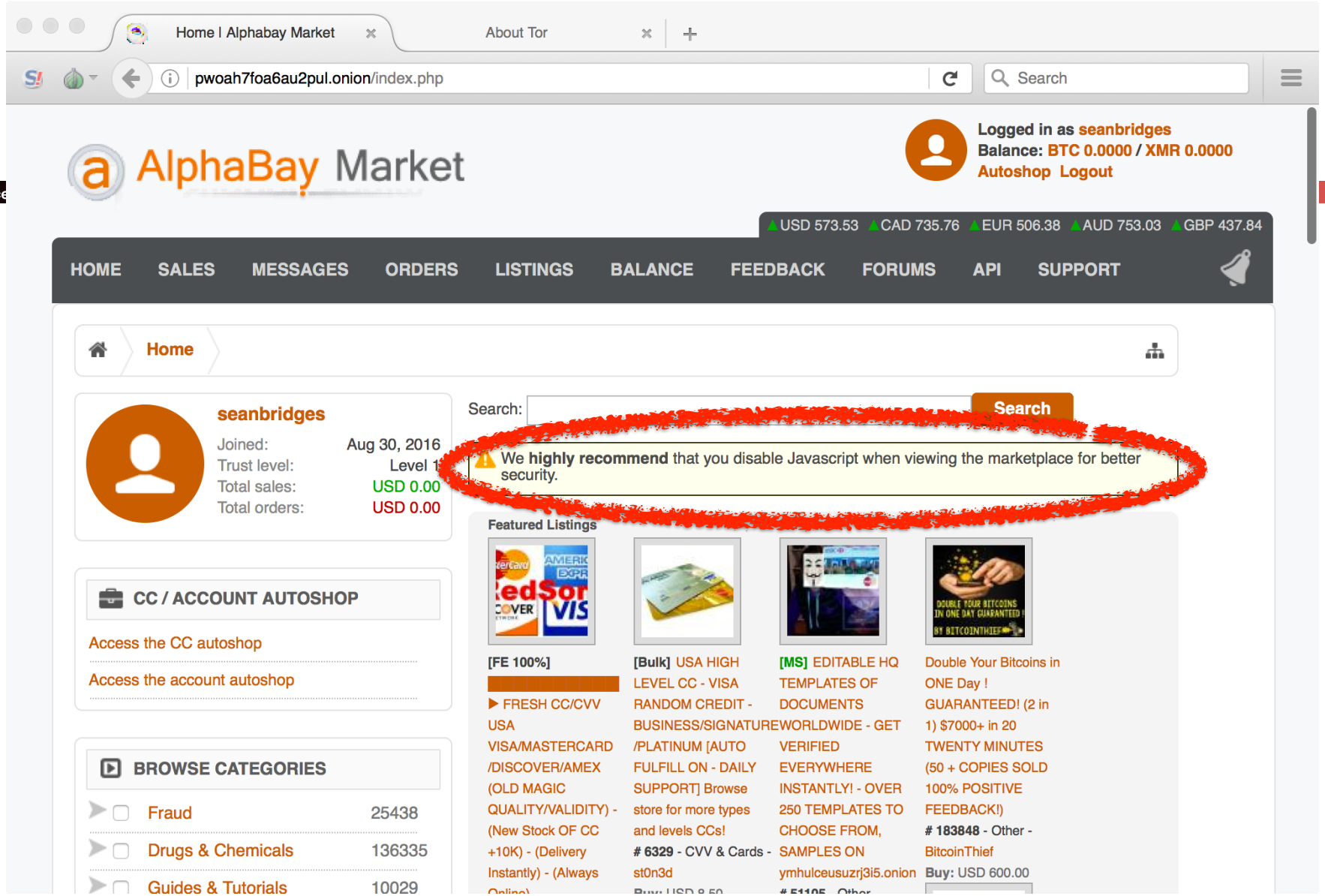


Tor Hidden Service:
Query for Introduction, Arrange Rendevous



Tor Hidden Service: Rendevous and Data




Home | Alphabay Market
About Tor
pwoah7foa6au2pul.onion/index.php
Search
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
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[FE 100%] ▶ FRESH CC/CVV USA VISA/MASTERCARD /DISCOVER/AMEX (OLD MAGIC QUALITY/VALIDITY) - (New Stock OF CC +10K) - (Delivery Instantly) - (Always
[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
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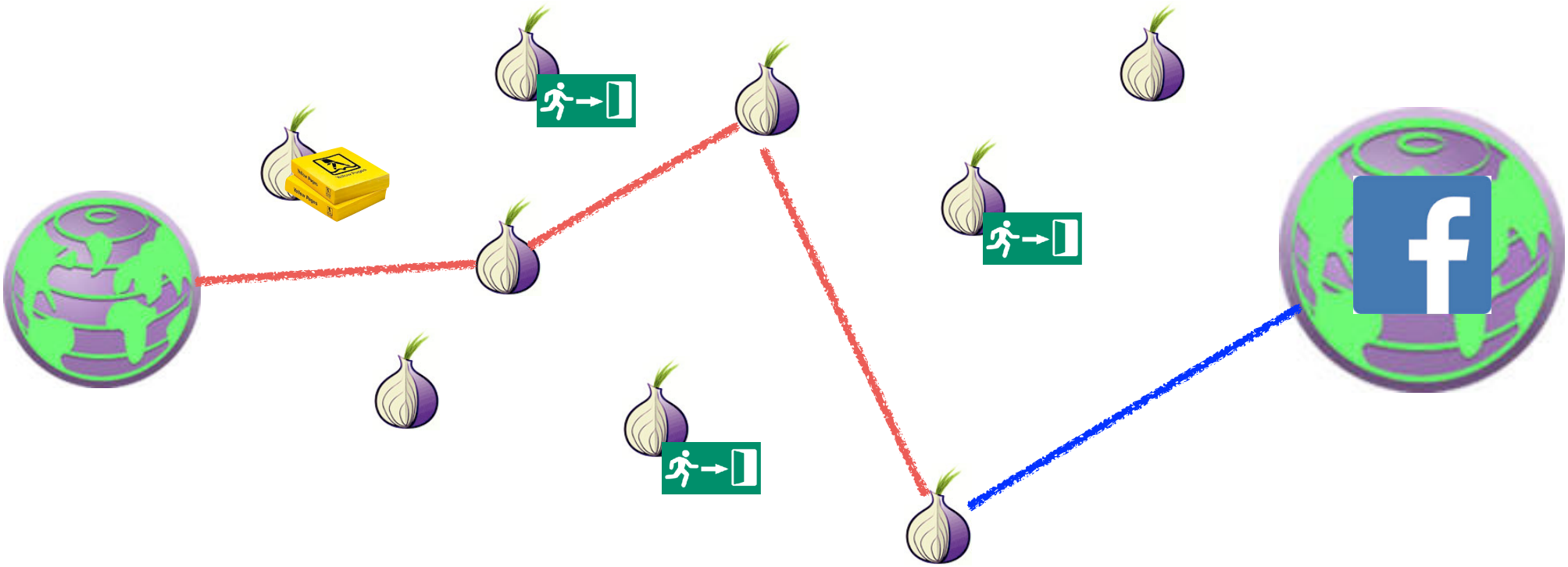
Remarks…

- 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 ***legitimate*** site offering a Tor hidden service should use this technique
  - Since legitimate sites don't need to hide!

Real use for ***true hidden*** 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 took forever to get rid of the actual nazis of Stormfront and the murderous shits of 8chan...
- Dark Markets
  - Marketplaces based on Bitcoin or other alternate currency
- Cybercrime Forums
  - Hoping to protect users/administrators from the fate of earlier markets
- Child Exploitation

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
- Accessable ***only*** as a Tor hidden service
  - Hiding the market from law enforcement

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...
  - And even information about them is harder:
    Reddit no longer supports them, deepdotweb got busted...
    Leaving "Dread": Reddit as a Tor Hidden Service

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"
    - But knock down any "winner" and another one takes its place

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
  - The "Sheep Marketplace" being the most famous

And then the Child Exploitation types

- This is ***why*** I'm quite happy to see Tor Hidden Services ***burn!!!***
  - Because these do represent a serious problem:
    The success against "PlayPen" shows just how major these are
- A far bigger systemic problem than the dark markets:
  - Dark markets are low volume, and not getting worse
    - Plus the libertarian attitude of "drug users are mostly harming themselves, its the drug-associated crime that is the problem"
      - No indication of any ***successful*** murder resulting from dark market activity
  - But these are harming others
- They are also harming Tor:
  Tor itself is a very valuable tool for many legitimate uses, but the presence of the child exploitation sites on hidden services is a stain on Tor itself

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
  - Those investigation .onion sites should use to see if the target site made a rookie mistake!