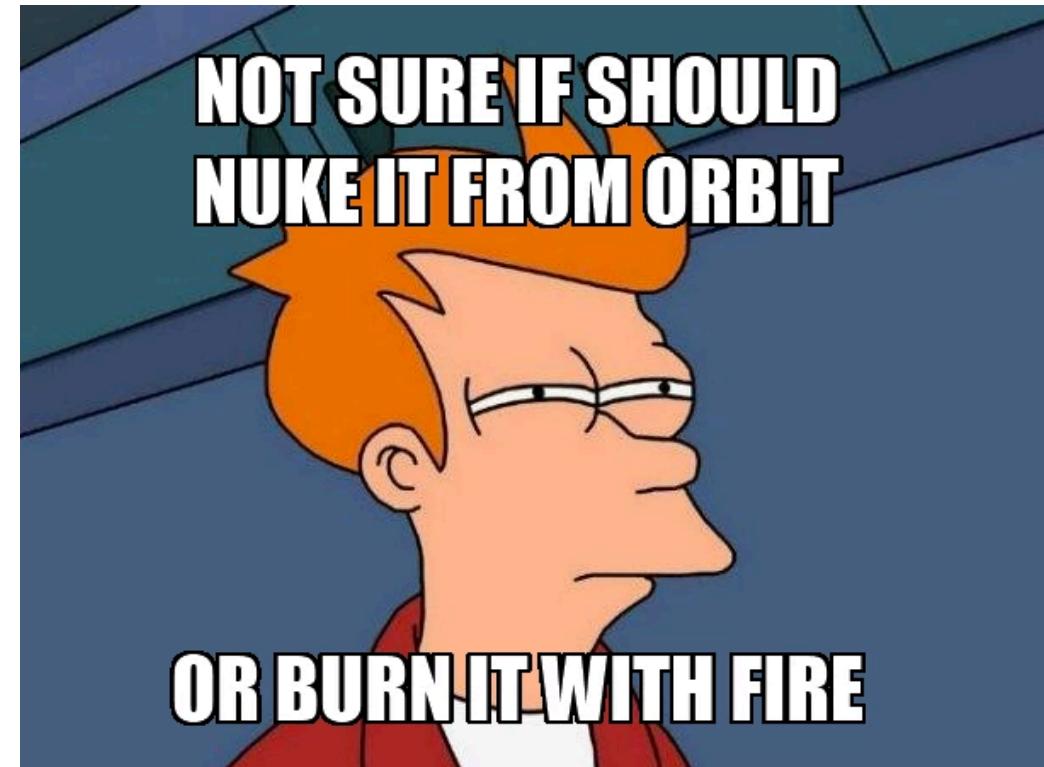


Tor, 737 Max, & Nuclear Weapons



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



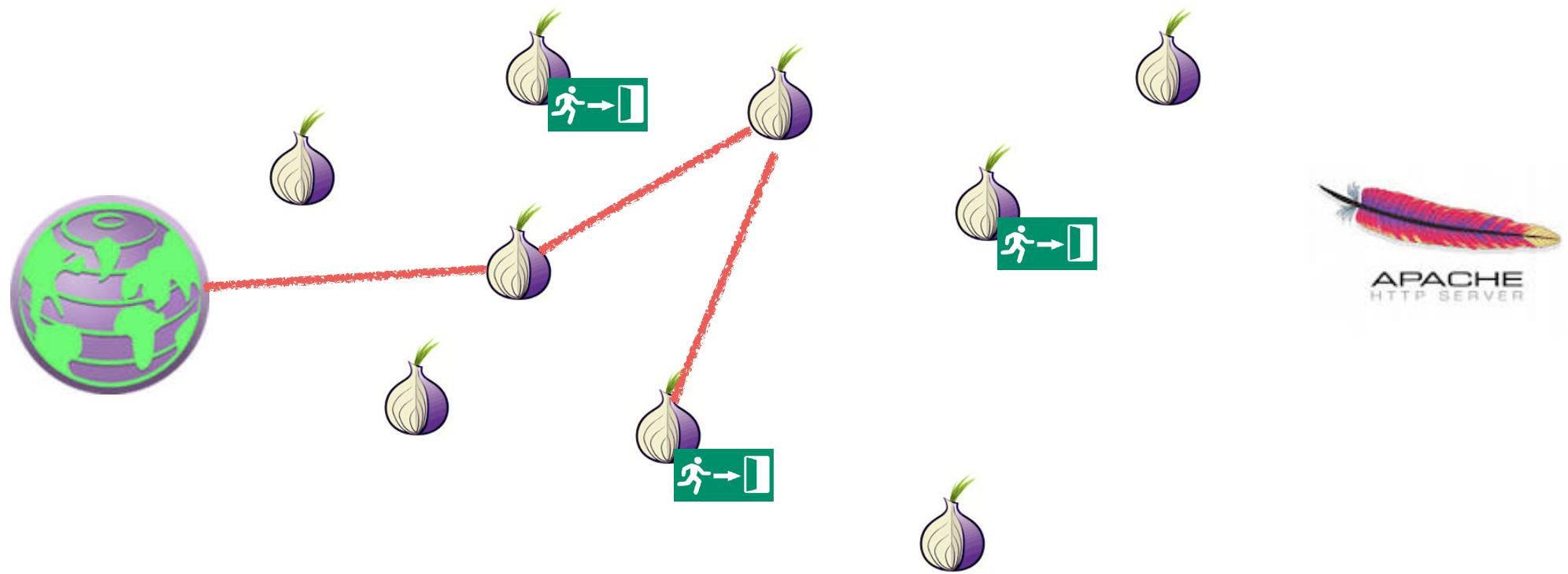
Low Latency & Efficiency...

- Tor is supposed to be "low" latency...
 - Which means if you send a message in, it should appear on the other side ASAP
- Tor is supposed 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

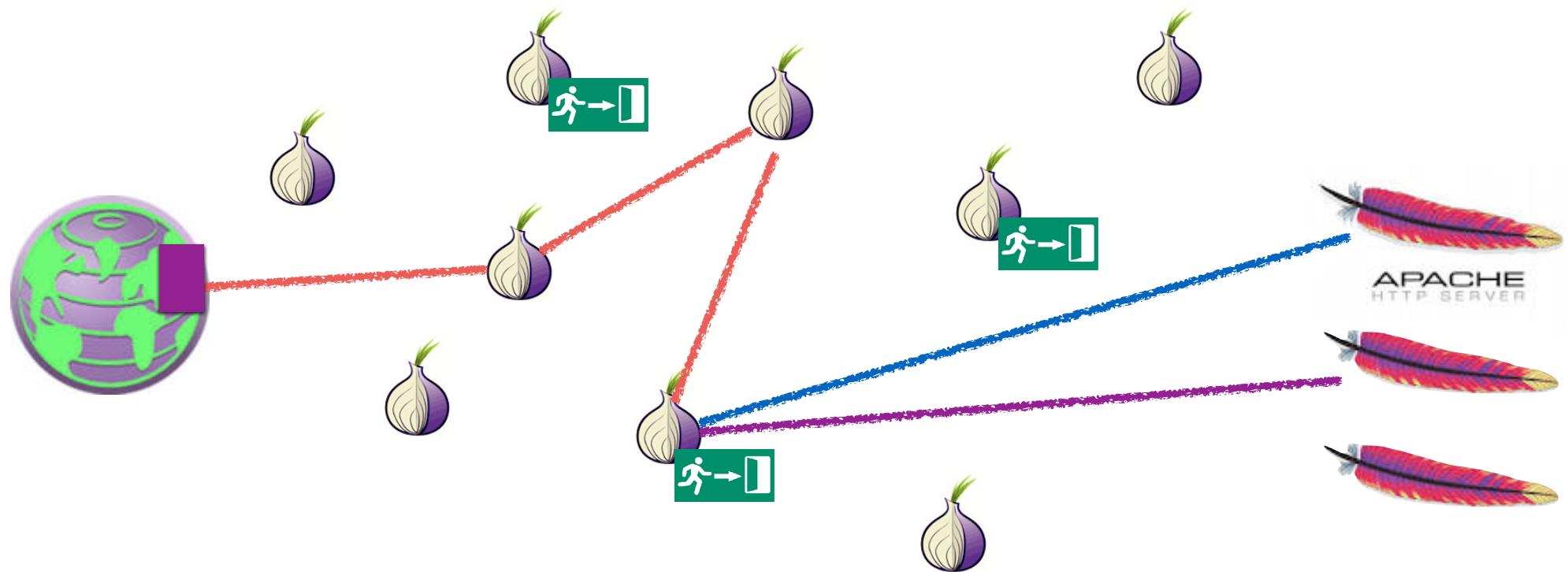
The High Level Approach: Onion Routing

- 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 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...
 - $E(K_{or1}, E(K_{or2}, E(K_{or3}, \text{Data})))$
- OR1 decrypts it and passes on to OR2
 - $E(K_{or2}, E(K_{or3}, \text{Data}))$
- 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...

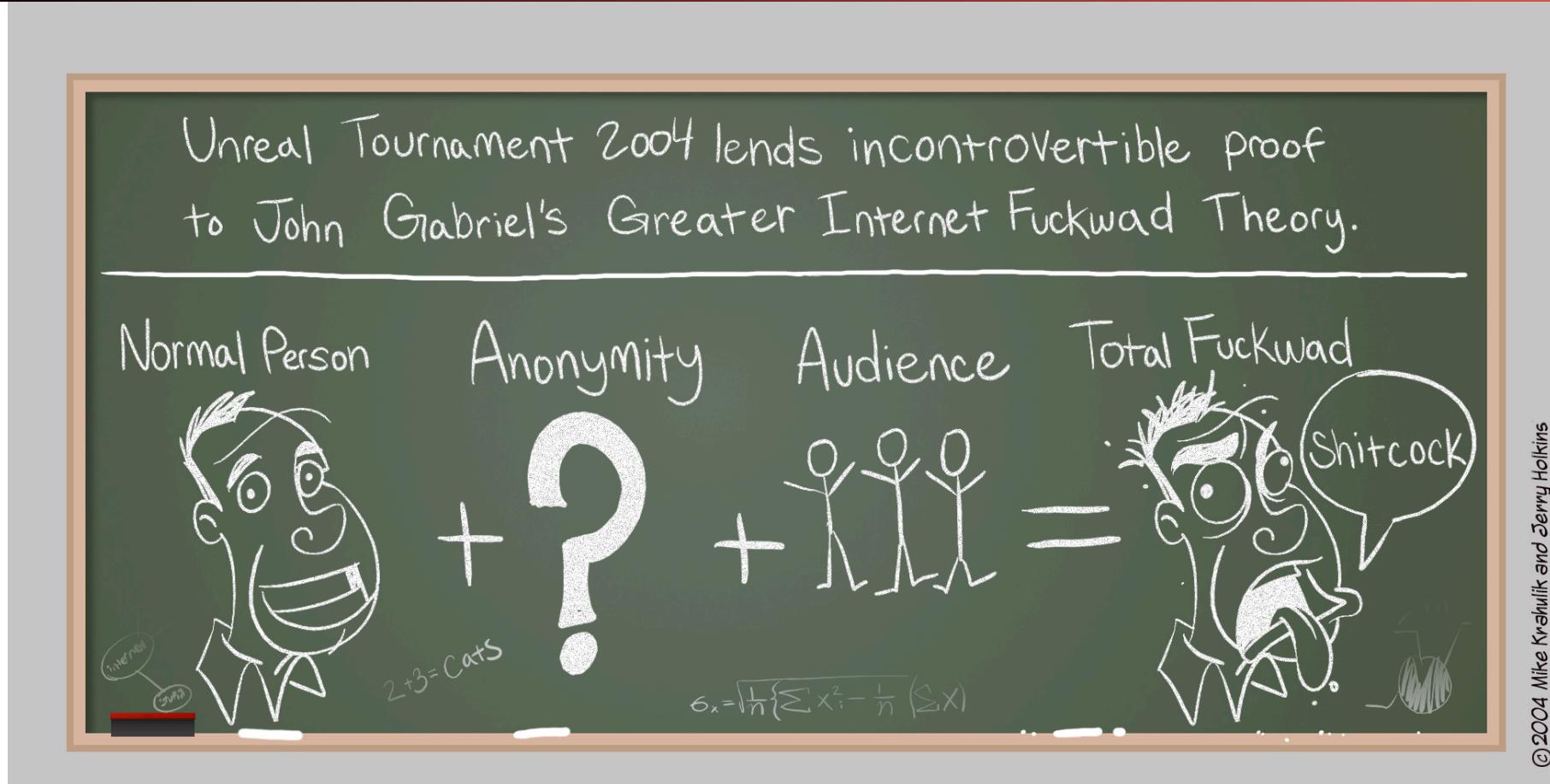
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- The exit node, where your traffic leaves the Internet, is a man-in-the-middle
 - Who can see and modify all non-encrypted traffic
 - The exit node also does the DNS lookup
- Exit nodes have not always been honest

The screenshot shows a web browser window with the URL https://www.reddit.com/r/Bitcoin/comments/43zhtb/i_just_fell_victim_to_a_tor_exit_node_scam/. The page is from the subreddit r/bitcoin. The post title is "I just fell victim to a Tor exit node scam." It has 112 upvotes and was submitted 10 months ago by user ImStupidAgain. The post content reads:
I was looking to mix some coins with bitmixer.io. I had visited their site and read up on reviews and decided to give them a try. I figured it would be wise to connect through Tor, so I went to the clearnet site and copied the onion address that was shown on the homepage. Stupid me not realizing that I should use a regular connection and not Tor to find the address. Fortunately I only lost a marginal amount, but everybody be warned once again. It's really easy to make a mistake like that.
The mixer site: <https://bitmixer.io>
The real onion site: <http://bitmixer2whesiai.onion/>

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 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
- 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

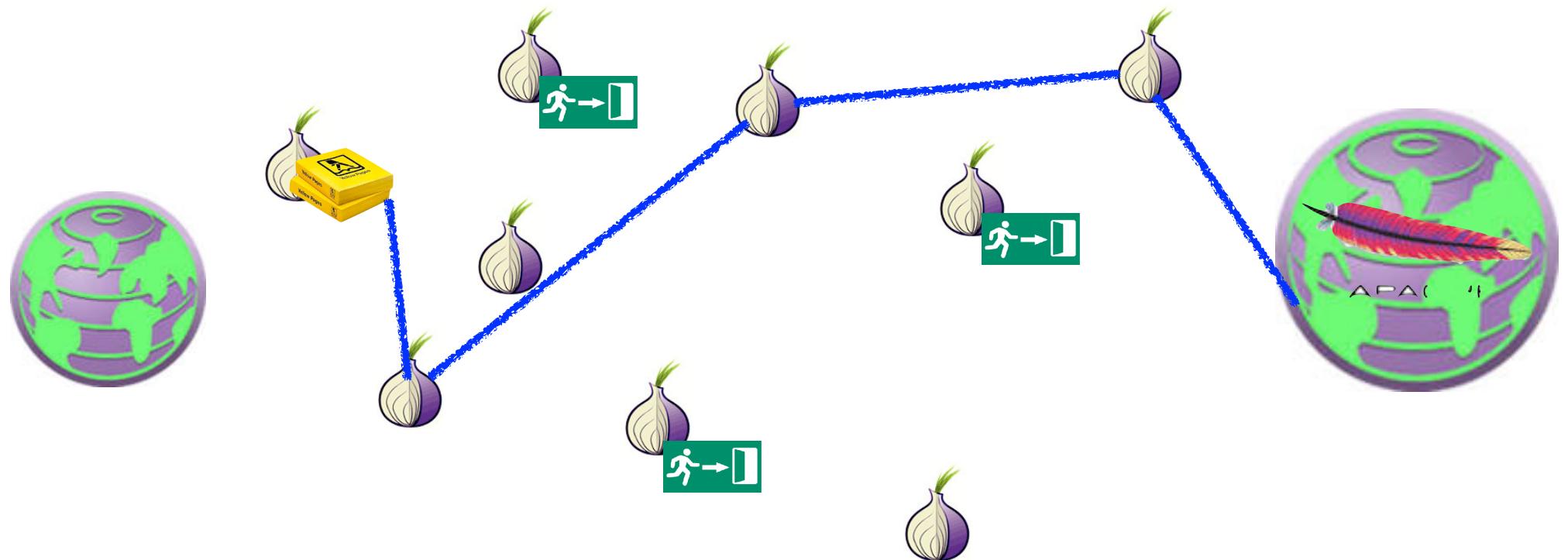
The End Of Collateral Freedom...

- 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!

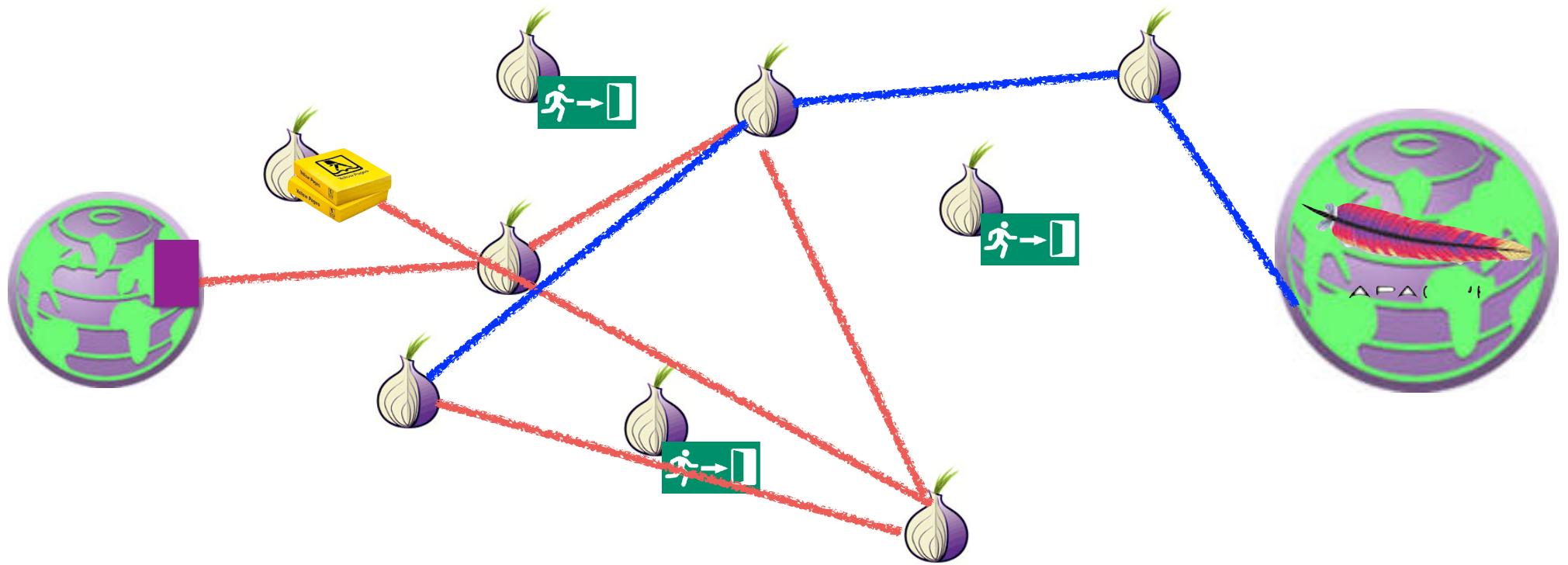
Tor Browser is also used to access Tor Hidden Services aka .onion sites

- 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://facebookcorewwi.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

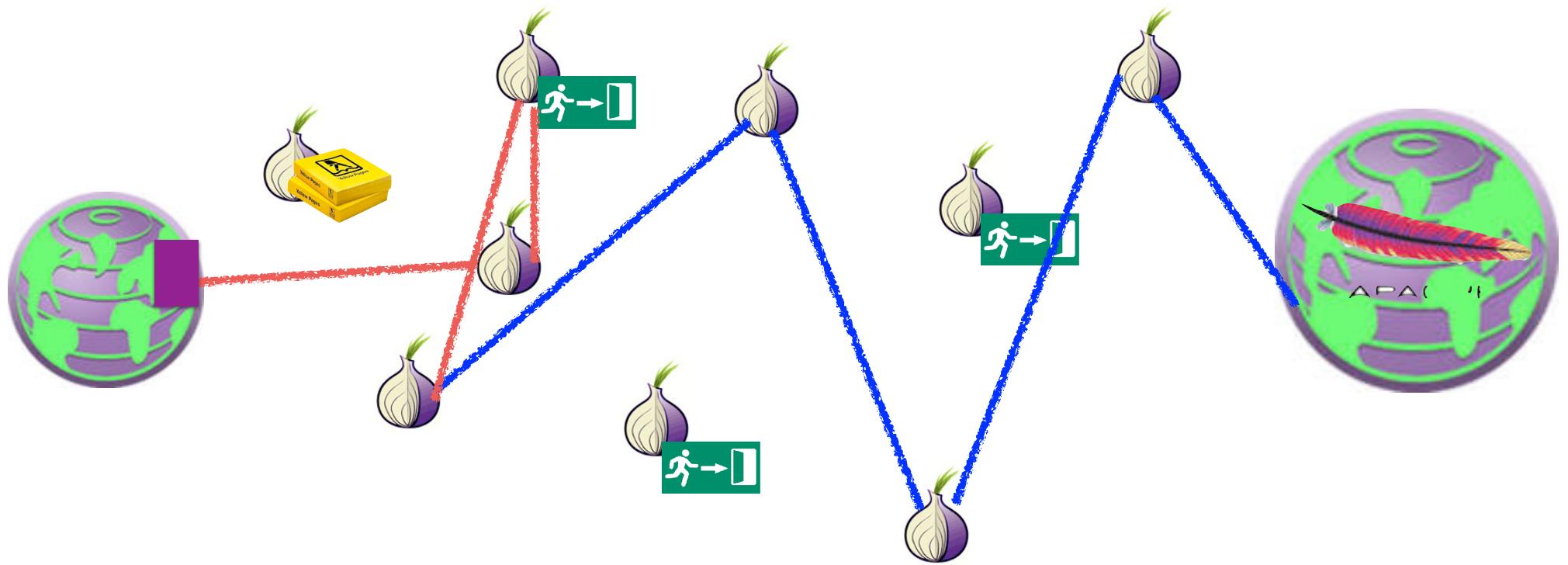
Tor Hidden Service: Setting Up Introduction Point



Tor Hidden Service: Query for Introduction, Arrange Rendevous



Tor Hidden Service: Rendevous and Data



Home | Alphabay Market About Tor x | +

S i pwoah7foa6au2pul.onion/index.php Search

a AlphaBay Market

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

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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:

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

Featured Listings

	[FE 100%]	[Bulk] USA HIGH LEVEL CC - VISA RANDOM CREDIT - BUSINESS/SIGNATURE	[MS] EDITABLE HQ DOCUMENTS WORLDWIDE - GET /PLATINUM [AUTO FULFILL ON - DAILY SUPPORT] Browse store for more types	Double Your Bitcoins in ONE Day !
► FRESH CC/CVV USA	VISA/MASTERCARD /DISCOVER/AMEX (OLD MAGIC	VERIFIED EVERYWHERE SUPPORT] Browse INSTANTLY! - OVER 250 TEMPLATES TO	TWENTY MINUTES (50 + COPIES SOLD	
QUALITY/VALIDITY) - (New Stock OF CC +10K) - (Delivery Instantly) - (Always Online)	store for more types # 6329 - CVV & Cards - st0n3d	CHOOSE FROM, SAMPLES ON ymhulceusuzrj3l5.onion	100% POSITIVE FEEDBACK!) # 183848 - Other - Bitcoin Thief	
		# E410E Other	Buy: USD 600.00	

CC / ACCOUNT AUTOSHOP
Access the CC autoshop
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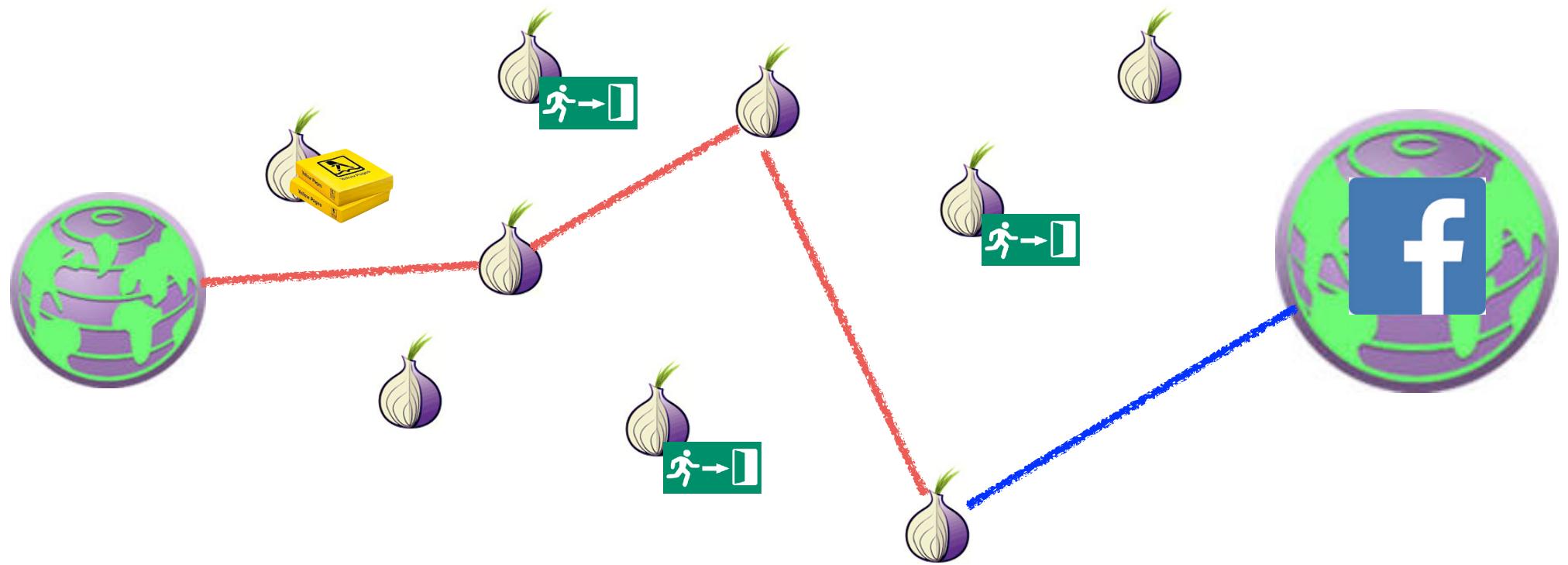
BROWSE CATEGORIES

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

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 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
- 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
- Accessible **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
 - But you can generally find the latest gossip on “deepdotweb”

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

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” record back to an FBI-controlled computer



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 small bit of Flash which contacts the server directly, revealing the visitor’s IP address

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 for a NIT payload to work

The screenshot shows the 'About Tor' page of the Tor Browser 6.0.2. At the top, there's a navigation bar with tabs for 'About Tor', 'Tor Browser', and a search bar. Below the bar, the text 'Welcome to Tor Browser' is displayed in large purple letters next to an onion icon. A green button labeled 'Test Tor Network Settings' is visible. A prominent warning message 'WARNING: this browser is out of date.' is centered in large black letters. Below it, a note says 'Click on the onion and then choose Check for Tor Browser Update.' To the right, the text 'Tor Browser 6.0.2' is shown. At the bottom, there's a search bar with a magnifying glass icon and the text 'Search securely with Disconnect.me.' Two call-to-action boxes are at the bottom: 'What Next?' on the left and 'You Can Help!' on the right.

About Tor

Tor Browser Search or enter address

Search

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?
 - I'll argue no, but some defense attorneys have successfully used a graymail technique

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

Safety and Security

- Safety and Security are closer than two sides of the same coin...
- Both have the objective of ***maintaining system properties*** under all conditions
- The only real difference are the source of deviance
 - Security we deviate because of ***deliberate action by an adversary***
 - Safety we deviate because of ***chance, failure, and inadvertent actions***

The Airline Industry...

- A rough rule of thumb I once heard about an airline's costs:
 - 1/3 for fuel
 - 1/3 for people
 - 1/3 for the aircraft
- And the business is brutally competitive
 - Warren Buffett once joked that if he had a time machine he'd take a shotgun to the runway at Kitty Hawk to save subsequent investors a huge amount of money
- So when developing a new aircraft...
 - Make it ***cheap***:
 - Limit the necessary retraining
 - Limit the fuel costs

The Boeing 737...

- Probably the most successful commercial airliner
- First flown in 1967, over 10,000 of various types sold!
- The first version: 737-100 and 737-200
- Notice the relatively tiny jet engine...
We will get back to that later



Then the "737-Classic": -300, -400, -500

- First major revision
 - Sold from 1984-2000
- Bigger, Better, More Efficient
 - Major change in the concept of how the engines are mounted...
- Not quite a "separate plane"
 - But substantial retraining necessary for pilots & crew to shift from the original to the "classic"



Then the 737-NG -600, -700, -800, -900

- Almost a new plane
 - Bigger wings, new cockpit, new engines, more people etc...
 - Notably the "flat bottomed" engines to get them to fit!
- First on sale in 1997
- Really a "new plane"
 - Completely different cockpit for the pilots



In The Meantime: Enter Airbus

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- The A320 family
 - Entered service in 1987...
 - Slightly bigger than a 737
 - And claimed to be cheaper...
 - A major new version entered service in 2016: the A320neo (New Engine Option)
 - Moderate pilot retraining necessary: it flies different from the A320 due to significantly larger engines



Why Larger Engines?

- Bigger engines that burn hotter are ***much*** more fuel efficient
 - Thermodynamic efficiency of the engine core
 - Bigger bypass fans move more air
- Core problems:
 - Efficiency of the core is improved by making it bigger
 - Thrust goes up by moving a bigger volume of air ("high bypass")
 - $E=mv^2$, but $p=mv$
 - And the area of the engine is $\sim r^2$

The 737-MAX program

- In 2011, Boeing responded to the A320...
 - American Airlines just ordered a bunch of A320ceo and A320neo planes
 - Effectively sidelined the planned 737 replacement...
 - It would have been close to a "baby Dreamliner (787)"
 - And instead decided to "re-engine" and improve the 737-NG in other ways
 - Goal was 14% improvement in efficiency
- Fatal Decision #1:
 - Unlike the A320neo, there must be ***no significant pilot retraining***: If a pilot is certified for a 737-NG, the pilot should be able to fly the 737-MAX with just a bit of written material

Fatal Decision #2: Larger Engines

- Went from a 61" engine to a 69" engine
 - But the previous 61" engine already had the minimum available ground clearance!
- Forced to move the engines further forward and upward
 - Which changes the dynamic balance of the aircraft
 - Other option would have required effectively reengineering the entire wing setup
 - At which point, why not just design a new plane from scratch: the initial 737 design had much much smaller engines
- Dynamic balance changes are significant
 - Significantly higher tendency to want to pitch the nose up under acceleration

Fatal Decision #3: The "Software" Fix

- If the plane goes too nose-up, it wants to stall
 - aka, "just drop from the sky", major not-good
- The larger nacels for the engines also act like wings
 - Even further increasing the propensity to stall
- "Hey, we have a computer that can fly the plane..."
 - So lets modify the computer to have the plane try to adjust itself so it flies like the 737-NG:
MCAS: Maneuvering Characteristics Augmentation System

Fatal Decision #4: Engineering the software fix

- In an Airbus, the computer is the boss
 - So the computer design is very paranoid
- In a Boeing, the **pilot** is supposed to be the boss
 - So although there are two flight computers, each one only listens to its own set of sensors...
 - Because on all previous 737s, the computer **mostly** acted as an advisor
 - Which means you can be fairly slack with things
- MCAS program stuck with that design
 - So if the computer saw that **it's** pitch sensor said the nose was too high, it would act
- Plus other factors:
 - If you fight the computer on the 737-NG, the computer gives up
 - But on MCAS, it just tries again... and again... and again...

Fatal Decision #5: Regulatory Capture

- In the old days, the FAA certified planes...
 - But this requires significant expertise
 - And the government can't pay nearly as much as Boeing
- Now, the aircraft is ***mostly*** self certified by the company...
 - And even here they screwed up!
 - MCAS was determined to create a "hazardous" condition if it erroneously activated at the wrong time...
 - ***Yet they kept the single-sensor design!***

Magnifying Culpability: Blaming the user...

- After the first crash, Boeing blamed the pilots
- "Yeah, we didn't tell them about MCAS, but it should have been treated just like a runaway stabilizer where the autopilot goes wonky..."
- But that wasn't true!
 - Runaway trim, you fight it and it stops fighting
- And they are ***still*** blaming the pilots!

Asked about what led to the safety flaws in the 737 Max, Muilenburg said Boeing didn't make any mistakes in its design of the planes. "There was no surprise or gap or unknown here or something that somehow slipped through the certification," Muilenburg said. "We know exactly how the airplane was designed, and we know exactly how the airplane was certified."

The CEO said both crashes were caused by a "series of events" that included erroneous sensor data being fed into the maneuvering characteristics augmentation system, or MCAS, an anti-stall system that played a role in both crashes. "There were actions — or actions not taken — that contributed to the final outcome," he said, alluding to the role of the pilots.

Conclusions...

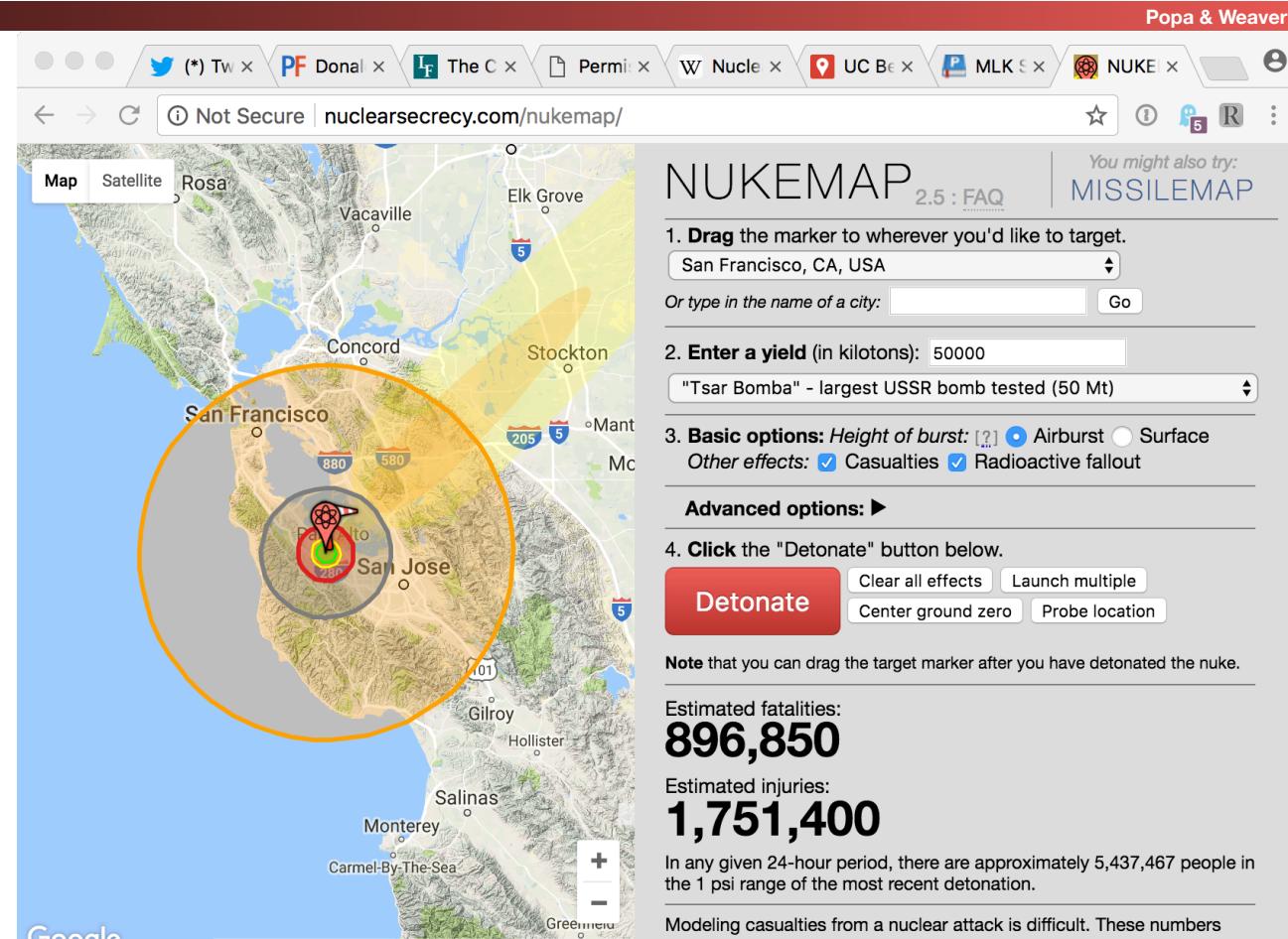
- It is a massive Charlie Foxtrot of epic proportions
- If it was an American or Southwest plane involved, there would already be indicted executives
- Every system on the 737-Max that changed needs to be viewed with suspicion
 - And I won't fly on one for at least 3 years post recertification.

Why talk about nukes?

Computer Science 161 Spring 2019

Popa & Weaver

- Nukes are big and scary and in the news...
- But have interesting security and safety properties
- Lots of material stolen borrowed from Steve Bellovin's excellent talk on PALs



How a Nuclear Weapon Works...

- 1960s-level technology...
 - A hollow sphere of fissile material
 - Plutonium and/or Plutonium + Uranium
 - Use this as a primary to ignite a Teller/Ulam secondary to make it a hydrogen bomb...
- Very careful sequencing needed
 - D/T pump to fill the hollow with Deuterium & Tritium ("Boost gas")
 - Initiator sprays neutrons to start the chain reaction
 - Detonator needs to trigger multiple points on the explosive shell
 - Squiggly-traces of explosive so that all around the shell everything detonates at once

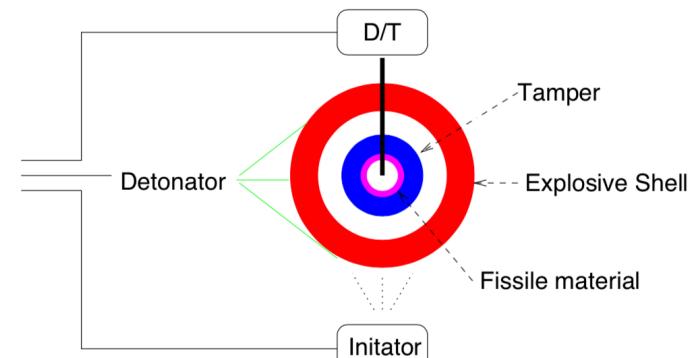
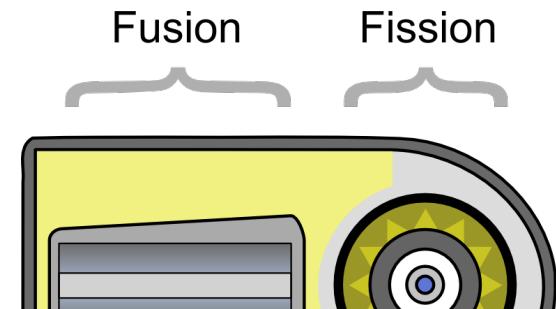


Diagram by Steve Bellovin

And H-Bombs...

- A "Teller/Ulam" 2-stage device:
A A-bomb ignites a fusion stage
- Fusion stage has Lithium Deuteride...
 - Neutrons and pressure from the A-bomb convert the Lithium to Tritium
 - Then Deuterium/Tritium fusion makes it go boom!
 - And sprays a crap-ton of neutrons around that increase the fissions as well
- Still 1960s technology!
 - Biggest issue overall is materials:
6 or 7 countries have built H-Bombs



And How To Deliver Them...

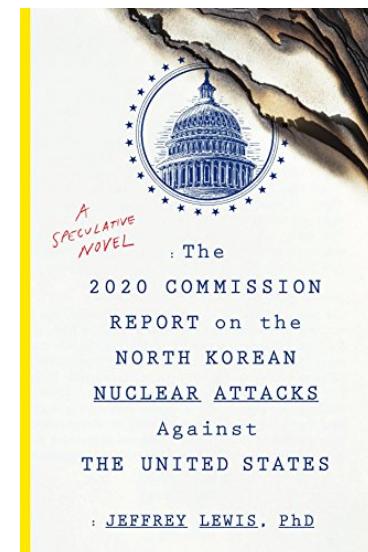
- Stick em on a rocket
 - This *is* rocket science: It is probably easier to build the nuke than build the ICBM...
 - Alternatively, stick it on an unmanned miniature airplane ("Cruise Missile") or just hang it under a plane as a old-fashioned bomb
- Then stick the rocket on something
 - In a hardened silo
 - But the other side can drop a nuke on it...
 - On a truck
 - In a sub
 - On a plane...

The Problem: When To Use Nukes...

- Nuclear weapon systems can fail in two ways:
 - Launch the nukes when you shouldn't...
 - Fail to launch the nukes when you should...
- The latter is (badly) addressed by how our nuclear decision making happens
 - "Launch on warning": If we ***think*** we are under attack, the President has a couple minutes to decide to order a nuclear strike before the attacker hits our ICBMs!
 - This is often regarded as ***insanely*** stupid: We have both nuclear bombers with long-range cruise missiles and nuclear armed submarines, both of which ***will*** be able to launch enough retaliatory hellfire
 - Far better is the "French model" (cite @armscontrolwonk):
"We have subs. You nuke us ***or*** attack our strategic weapons and we nuke you":
 - This removes the time pressure which can cause errors

"Launch on Warning" and North Korea...

- Let us assume that North Korea's leadership are *rational* actors
 - They act in what they perceive as their self interest: survival!
- North Korean leadership ***will eventually lose*** a war with South Korea and the US
 - So they may be provocative, but they want to make ***sure*** the US and South Korea won't start a war
- Nukes are a critical deterrent for them
 - Especially since Donald Trump doesn't seem to care that a war would kill hundreds of thousands in South Korea
- IRBMs and ICBMs are as important as the nukes themselves!
 - Need to be able to hit the US bases in Okinawa and Guam as military targets
 - And Mar-a-lago and Washington DC to dissuade Trump personally:
The Hwasong-15 ICBM can just barely range South Florida.
- "***Empathy*** for the devil"
 - Computer security is adversarial, think about your adversary's needs, wants, and desires



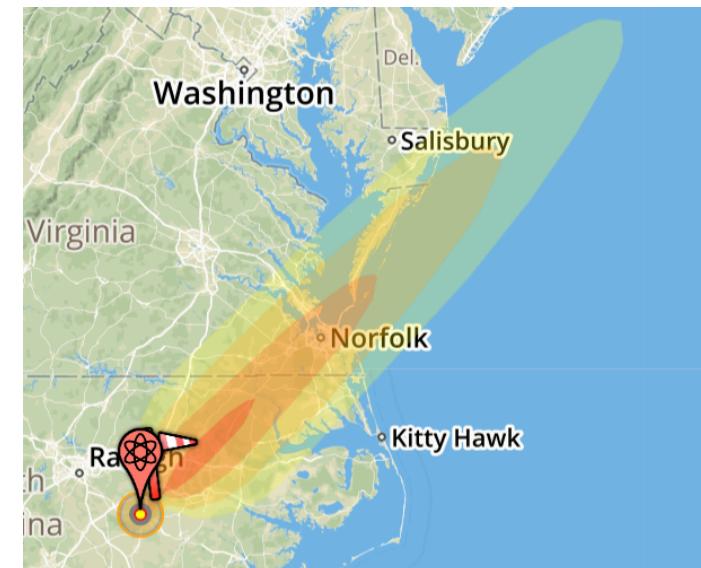
The Interesting Problem: Limiting Use

- Who might use a nuke without authorization?
 - Our "allies" where we station our nukes
 - Original motivation: Nukes stored in Turkey and Greece
 - Someone who can capture a nuke
 - This is what sold the military on the need for the problem:
We had nukes in Germany which **would** be overrun in case of a war with the USSR
 - Our own military
 - General Jack D Ripper scenario
- The **mandated** solution:
 - Permissive Access Link (PAL)



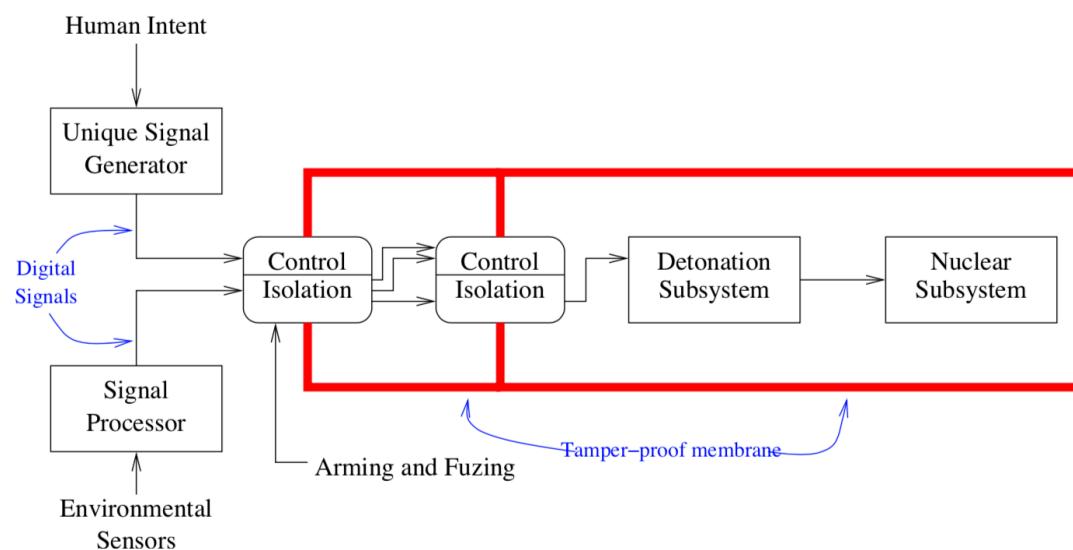
Nuke Safety Features

- One-point safety – no nuclear yield from detonation of one explosive charge.
- Strong link/weak link –
 - strong link provides electrical isolation;
 - weak link fails early under stress (heat, etc.)
- Environmental sensors – detect flight trajectory.
- Unique signal generator – digital signal used for coupling between stages.
- Insulation of the detonators from electrical energy.
- “Human intent” input.
- Tamper-resistant skin
- Use Control Systems
- Not always the case: In 1961 in South Carolina a B52 broke up
 - One of the two 4MT bombs **almost** detonated on impact, since it thought it was being dropped!



Bomb Safety Systems

- We have a "trusted base"
 - Isolated inside a tamper-detecting membrane
 - Breach the membrane -> disable the bomb
- We have human input
 - Used to generate a signal saying "its OK to go boom"
 - The user interface to the PAL can follow the same path/concepts
- We have critical paths that we can block
 - Complete mediation of the signal to go boom!



Unique Signal Generator

- Part of the strong link
 - Prevent any detonation without clear, unambiguous showing of “human intent”
- A **safety** system, not a security system
- Looks for a 24-bit signal that is extremely unlikely to happen during any conceivable accident. (Format of input bits not safety-critical)
 - Accidents can generate random or non-random data streams
 - Desired signal pattern is unclassified!
- Unique signal discriminator locks up on a **single** erroneous bit
- At least partially mechanical

PALs

- Originally electromechanical. (Some weapons used combination locks!)
- Newest model is microprocessor-based. There may still be a mechanical component.
 - Recent PAL codes are 6 or 12 digits.
- The weapon will permanently disable itself if too many wrong codes are entered.
- PALs respond to a variety of codes – several different arming codes for different groups of weapons, disarm, test, rekey, etc.
- It was possible, though difficult, to bypass early PALs.
 - Some even used false markings to deceive folks who didn't have the manual.
- It does not appear to be possible to bypass the newest “CAT F” PAL.

How are PALs built?

- We don't know, but some informed speculation from Steve...
- It is ***most likely*** based around the same basic mechanism as the unique signal generator
 - Gives a single point of control already in the system
 - Reports about it indicate that it was successfully evaluated in isolation
 - Take advantage of the existing trusted base of the tamper-resistant barrier around the warhead to protect the device

Deployment History

- Despite Kennedy's order, PALs were not deployed that quickly.
 - In 1974, there were still some unprotected nukes in Greece or Turkey
- PALs and use control systems were deployed on US-based strategic missiles by then
 - But the launch code was set to 00000000
 - Rational: the Air Force was more worried about failure to launch!
- A use control system was added to submarine-based missiles by 1997
- In 1981, half of the PALs were still mechanical combination locks

Steve Bellovin's Lessons Learned

- Understand what problem you're solving
- Understand ***exactly*** what problem you're solving
- If your abstraction is right:
you can solve the key piece of the overall puzzle
- For access control, find the One True Mandatory Path —
and block it.
 - And if there is more than one, you're doing it wrong!
 - What is the real TCB of our systems?