Misc Topics 2

NOT SURE IF SHOULD NUKE IT FROM ORBIT

OR BURN IT WITH FIRE
Pre Lecture Facepalm...
From just a year ago!

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Welcome to Hell Week....

- Mental pressure of "Curl up in a ball with a rifle" vs "Pretend everything is normal" continues...
  - Highly likely Biden will be the winner:
    But we won't know for sure for another few days at least....
  - Really a massive screwup:
    We *should* just have preliminary results announced on Friday at once for all states

- Today is More Off Topic Stuff:
  - Nukes
  - Tor Hidden Services
  - Sidechannels
And Checking In With Everyone Again...
How Are You on the Fauci Scale?
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.
  • Modern bombs don’t work without the tritium boost-gas: If you blow the gas you disable the nuke. Don’t know if this is done or not
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?
Side Channels & Other Hardware Attacks: Worry

- A side channel attack requires measuring some other piece of information
  - EG, time, cache state, power consumption, etc...
- And using it to deduce a secret about the system
- Side channels are very, very powerful
Requirements

- Often the biggest limitation is attacker requirements
  - Timing attack
    - Need to measure the timing of the operation with potentially very high precision
  - Power attack
    - Need physical access to the device: Generally only applicable to smart-cards and similar devices
  - EMF ("Tempest")
    - Need close physical access
  - Processor side-channel attacks
    - Need to co-locate the attacker code: EG, cloud computing, web browsers, etc
Example Timing Attack: Keystrokes...

- User is inputting a password
  - And the user is using a Bluetooth keyboard...
  - Or the user is using a remote connection over ssh
- Someone nearby can observe when keys are pressed
  - They are sent immediately
  - But not *what* keys are pressed
- Can this leak sensitive information? Of course!
Timing Leakage

• Some keys are faster to press
• Can use this to model timing
  • Either generically or specific to the user
• Lots of ways to do this
  • Hidden markov models
  • Throw machine learning at it...
• Really really hard to hide
  • Can't delay interactive requests without adding latency
  • "Cover traffic" only adds additional data, can't remove the underlying signal
• From https://people.eecs.berkeley.edu/~daw/papers/ssh-use01.pdf
Timing Attacks & Cryptography

• The classic timing attack:

  • Compute $y^x \mod n$

  • Easy solution ends up being

    Let $s_0 = 1$.
    For $k = 0$ upto $w - 1$:
      If (bit $k$ of $x$) is 1 then
        Let $R_k = (s_k \cdot y) \mod n$.
      Else
        Let $R_k = s_k$.
        Let $s_{k+1} = R_k^2 \mod n$.
    EndFor.
    Return $(R_{w-1})$.

Implications: Public Key Operations Need "Constant Time"

• Optimizing cryptographic code can be dangerous...
  • Instead it needs to take the same amount of time no matter what the input is
  • Even compiler optimizations can be a problem

• First identified 20 years ago...
  • So you think we'd have solved it...
    But you'd be wrong
Reminder DSA/ECDSA Brittleness...

**DSA algorithm**

- Global parameters: primes $p$ and $q$, generator $g$
- Message $m$, private key $x$, public key $y=g^x \mod p$
- Sign: select random $k$ from 1 to $q-1$
  
  \[
  r = (g^k \mod p) \mod q \quad \text{(retry if } r = 0) \\
  s = (k^{-1} (H(M) + xr)) \mod q \quad \text{(retry if } s = 0) 
  \]

- $k$ needs to be random and secret and unique
  - An attacker who learns or guesses $k$ can find $x$
    - An attacker can even just try all possible $k$s if the entropy of $k$ is low
  - Even just learning a few bits of $k$, and then having several signatures with different $k$ for each one, and you break it!
Just **A YEAR AGO:**

**The Minerva Attack**

- A timing side-channel attack to get a few bits of $k$ from the ECDSA signatures on Athena smart cards and lots of others
  - So have the smart card generate a lots of signatures
  - Then some math and brute force to get the actual $x$

- These devices were certified…
  
  *Including that they were supposed to resist timing attacks!*

- But, naturally, the certification doesn't actually test whether they are vulnerable to timing attacks...

- The root cause for many was a common code component: The Atmel Toolbox 00.03.11.05 library
- M10.6 the TSF shall provide digital signature confirming to EC-DSA standard.
  - Secure digital signature generate
  - Secure digital signature verify
  - Fast digital signature generate (see note*)
  - Fast digital signature verify (see note*)

- M10.7 the TSF shall provide point multiplication on an elliptical curve, conforming to EC-DSA standard.
  - Secure multiply
  - Fast multiply (see note*)

* The Fast functions of M10.3, M10.4, M10.5, M10.7, M10.8, M10.9, do not offer any DPA/SPA protection and must not be used for secure data.
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Once Again: Bad API

• Once again we have a case of “If you offer a programmer two ways, >50% of the time they will chose the wrong way”
  • In this case “why wouldn’t I chose the fast version?”

• You have a now growing list of “red flag/canary APIs”
  • system(), raw SQL, now this example

• Keep a growing list as a “cheat sheet”

• When you get to an existing software project…
  • Search the code for these APIs

• When you start a new project
  • NEVER use the dangerous version, even if you are using it safely…
    (EG, never use system(), only execve())
Power Attacks: The Bane of Smart Cards...

- Smart Cards are effectively small computers
  - In a handy credit-card sized package...

- Some are used to hold secrets on behalf of the cardholder
  - So really, if the person holding the card can get the secrets, 🤦

- Some are used to hold secrets from the cardholder
  - So if the user can extract the secrets, 🤦

- The bane: Power Analysis
  - SPA == Simple Power Analysis
  - DPA == Differential Power Analysis
The Idea...

- Different operations use different amounts of power
  - EG, square vs multiply in RSA
- Hook up smart card to a reader that can measure the power
  - Have it encrypt/sign something
  - Look at the power trace to get information about hidden secrets
    - Including statistical techniques

Countermeasures...

• Lots of work can make "simple" power analysis not work
  • But now you are using more power: Have to use the max all the time for the encryption
• Harder for more detailed differential analysis
  • Which can detect even small leaks
• If possible, punt!
  • Use your systems in a way where the person who holds the card is not your adversary!
• EG, you are building a “stored value” smart card
  • Option #1: The smart card has the value:
    If you tamper with the smart card, you can change the value
  • Option #2: The smart card just has an ID:
    You actually look up in the central database
Real Freaky: Electromagnetic Emissions...

- Every time a circuit switches...
  - It leaks out some radio frequency energy

- Some sources are even easier
  - A old-school monitor paints the image with an electron beam on the screen...

- Which means it is a radio!
  - Transmitting an image of the screen!

- Cheap, too
  - $15 in 1984 for van Eck to read images off a monitor!

Solution: The SCIF

- The US government's paranoia: The SCIF (Sensitive Compartmented Information Facility)
  - A room (or even a whole building) specifically designed for Top Secret "stuff"
  - Paranoia further enhanced by incidents like the "Project Gunman" Bug

- Multiple layers of security:
  - Physical access to the building
  - No outside electronics
    - With some caveats, fit bits can be OK depending...
  - No windows
    - Beam a laser at a window and can detect vibrations!
  - Electromagnetic shielding
    - So your cellphone wouldn't work in there anyway
And An Asside: The Second Coolest Bug *EVER!*

- The "Project Gunman" bug
  - [https://www.cryptomuseum.com/covert/bugs/selectric/](https://www.cryptomuseum.com/covert/bugs/selectric/)
  - "Project Gunman" was the NSA effort to *remove* the bug...

- In the late 70s and early 80s, the USSR bugged the electric typewriters in the US embassy!
  - Modify the mechanism that selects which character the print head goes to with magnetically tagged pieces
  - Hide a pickup & transmitter in an aluminum support rail
  - Broadcast really close in spectrum to a major TV station
  - We call this a "keylogger" when done in software
And Funky Hardware
SideChannels...

• The recent Meltdown and Spectre Intel bugs...
  • Both were effectively side-channels

• The key idea:
  • You could trick the speculative execution engine to compute on memory that you don't own
  • And that computation will take a different amount of time depending on the memory contents

• So between the two, you could read past isolation barriers
  • Meltdown: Read operating system (and other) memory from user level
  • Spectre: Read in JavaScript from other parts of the web browser
The Dark Web: 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 when we finally create a final connection
Tor Hidden Service: Setting Up Introduction Point
Tor Hidden Service:
Query for Introduction, Arrange Rendevous
Tor Hidden Service: Rendevous and Data
We highly recommend that you disable Javascript when viewing the marketplace for better security.
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
  • Facebook does this

• 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!
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
  • NSA kept a database of these people, called EPICFAIL!

• 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
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 initially But followup hasn’t replicated that success
A History of NITs:
Three 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 is a **hard** target
- 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 (break ASLR)
  - PLUS a conventional vulnerability
  - And now the Firefox rendering engine got sandboxed too…
  - And add 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