Universal Serial aBUSe

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Important Note

- This is the text-based version of the slides, and not the version we plan to present. We wanted to give you something meaningful to read through.

- The toolset will be released on our github:
  - https://github.com/sensepost/USaBUSe

- Details of the talk, latest slides and code will be written up at our blog:
  - https://sensepost.com/blog

Background http://sneakyninja95.deviantart.com/art/Stored-Memories-535612391

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Overview

In this talk, we'll cover some novel USB-level attacks, that can provide remote command and control of, even air-gapped machines, with a minimal forensic footprint, and release an open-source toolset using freely available hardware.

The Meta Point

- It's hard to defend at the best of times.
- Doing so well, requires a realistic threat model.
- Too often, that threat model is driven by vendor marketing rather than real attacks.
  - For example, advanced attackers have always existed, it's not clear "APT" would have been a thing, or as much of a thing without the significant vendor marketing spend put behind it.
- Penetration testers need to emulate real threats or they're just wasting your time

Why we're highlighting this issue

- We've seen real attackers doing it, but defenses haven't adapted.
  - The NSA's COTTONMOUTH toolkit showed these sorts of USB attacks
  - Technically unsophisticated criminals have defrauded banks using simple IP KVMs
- If your apex predators and low level bottom feeders are using the same sort of attacks; physical bypasses of software/network security via hardware, then you best pay attention.
- Plus, it makes sense, software is getting harder to exploit and changes more rapidly than hardware.

But we know about these attacks?

- Do we? Because the defenses in this space seem to be poor in our experience at clients.
- Hardware keyloggers have been around for decades, and are still near impossible to practically detect in software.
- Most organisations seem to think USB is about malware or tethering/wifi and rely on protections elsewhere in the stack:
  - malware deployment – proxy
  - malware on device – AV/endpoint
  - comms from device – FireEye and friends
- But there's little defense specific to malicious devices, something the USB standard makes very easy to implement.
- Finally, there wasn't an end-to-end implementation of this attack when we started.

Prior Work

- This work stands on the shoulders of giants. While numerous researchers have produced USB related work, prior work specific to this project includes:
  - Travis Goodspeed's Facedancer2 http://goodfet.sourceforge.net/hardware/facedancer21/
  - Michael Ossman & Dominic Spill's NSA Playset, TURNIPSCHOOL http://www.nsaplayset.org/turnipschool
  - Samy Kamkar's USBDriveBy http://samy.pl/usbdriveby/
  - USB Rubber Ducky Wiki http://usbrubberducky.com/
  - Adrian Crenshaw Plug & Pray; Malicious USB Devices http://www.irongeek.com/i.php?page=security/plug-and-prey-malicious-usb-devices & his PHUKD http://www.irongeek.com/i.php?page=security/programmable-hid-usb-keystroke-dongle
  - Seunghun Han's Iron-HID https://github.com/kkamagui/IRON-HID (released after our Defcon CFP submission)

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Objectives of our Work

- Build and end-to-end attack that's usable in a pentest
- Allow it to be remotely triggered and updated
- Work without requiring victim interaction
- Exclude typical USB malware vectors (for which typical defenses exist) e.g. malware via mass storage
- Don't sent any traffic via the victim's network
  - Avoids environmental complexities (firewalls, etc)
  - Avoids detection (IDS)
- Create a stealthy bi-direction pipe over innocuous USB devices (something forensic tools are unlikely to spot)
- Minimise forensic artefacts (e.g. execute in memory where possible)

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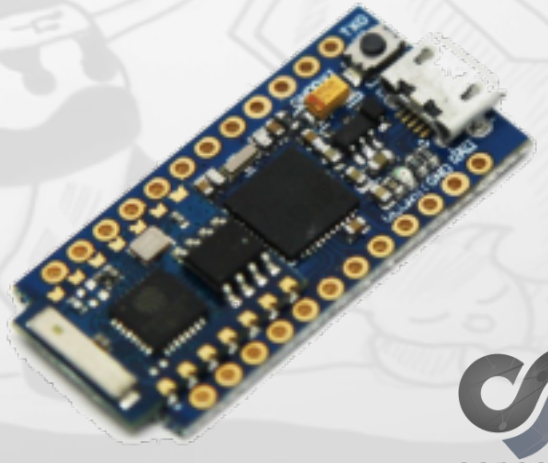
So what's different/new?

- Simpler networking; TCP/IP interface over WiFi
  - TURNIPSCHOOL uses custom RF protocol
  - IRON-HID uses Bluetooth
- More complete implementation
  - TURNIPSCHOOL never completed firmware for cc1111 against host
  - Numerous small improvements over IRON-HID
- Enables reuse of existing tools
  - Implements a VNC clients for keyboard and mouse input
  - Compatible with metasploit generated payloads
- More stealthy
  - No use of mass storage devices to load malware
  - No use of host's network i.e. works on airgapped hosts too
- An end-to-end attack
  - From plug in to remote network & command access
- Open Hardware
  - While it works on available hardware, we're releasing our open hardware design
- Minimal custom bootstrap

Initial Hardware

- April Brother Cactus Micro Rev2
  - Atmega32u4 on one side - host
  - ESP8266 WiFi on the other – our exfil
  - Compact enough to be a flash drive

- Advantages
  - Cheap & available
  - AVR & ESP gives us host side and wifi side
- Disadvantages
  - No I2C
  - No USB A
  - Can’t program ESP directly
  - Minimal storage
  - Can’t reset when in a case
  - LED not controllable from Atmega
  - Not open hardware



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New Hardware

- Very similar to the Cactus Micro, but with:
  - USB A male connector!
  - Micro SD Card slot for storage
  - I2C connected with pull up resistor
  - Programmable LED
  - Hall-effect switch to trigger reset when in case

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Firmware

- Lightweight USB Framework for AVR (LUFA)
  - Running on the atmega32u4
  - Implements the various USB interfaces seen by the victim
- ESP-Link (UART to TCP firmware)
  - Running on the ESP8266
  - Provides Wifi to device, connects to attacker's AP
  - Added a VNC implementation to receive key & mouse events to pass to the host
  - Added a multiplexing protocol over the UART to allow communication between various functions

USB Implementation

- Traditional Keyboard and Mouse
  - Emits events received via VNC
  - Can programmably emit events ala RubberDucky
    - Used to stage initial payload on host
    - Used to prevent screensaver engaging
- Generic HID
  - Allows bidirectional packet transfers
  - 64 byte packets
  - 1000 per second (in theory)

Alternate USB Implementations

- For stealthier, more innocuous bi-directional comms
- Text-only printer
  - “Prompt-less” driver installation in Windows
- Sound card
  - Gives us audio out and mic in
  - Problems: Might interfere with primary audio device
- Depends on default permissions

Targets

- Targeting Windows PCs at the moment, plans to expand to OSX then Linux hosts
  - Keyboard/Mouse is generic
  - Payload is platform dependent
- Powershell
  - Available on most Windows workstations
  - C# API available
  - P/Invoke CreateFile, ShowWindowAsync
  - Staged approach
  - Can avoid touching disk for the most part
    - Excludes P/Invoke-d function definitions above!

Payload Stages

- Stage 1 (PowerShell typed via the keyboard)
  - Optimised for size
  - Open device
  - Read Stage 2
  - Clear-History
  - Hide!
- Stage 2 (PowerShell read from device)
  - Arbitrary complexity

Stage 2 payload examples

- CMD.exe
- TCP Listener/Relay/Proxy
  - Enables existing network-based exploits
  - Localhost-only avoids firewalls/alerts
- Metasploit
  - Currently being redirected through the proxy
  - Can use arbitrary msf payloads; meterpreter, cmd, vnc etc.
- Purpose-built payloads
  - Knows how to access the USB device directly
  - Future development for meterpreter

Difficulties experienced

- Programming errors on the ESP8266 result in reboots, any debug logs disappear!
- Flow control
  - TCP is **much** faster than the UART, and ESP8266 triggers watchdog to reboot if you take too long to process the data. We had to rewrite the ESP-Link TCP handlers to support “resume-able” processing of data
  - UART is faster than the Keyboard
  - HID interrupt transfers occur regardless of a read()
- Disappearing UART interrupts
  - Data received by the ESP8266 would get stuck in the UART FIFO

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Demonstrations

- We'll provide a demo of the toolset in the talk.
- The software will be released at Defcon at:
  - https://github.com/sensepost/USaBUSe

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