Darrin Barrall
David Dewey

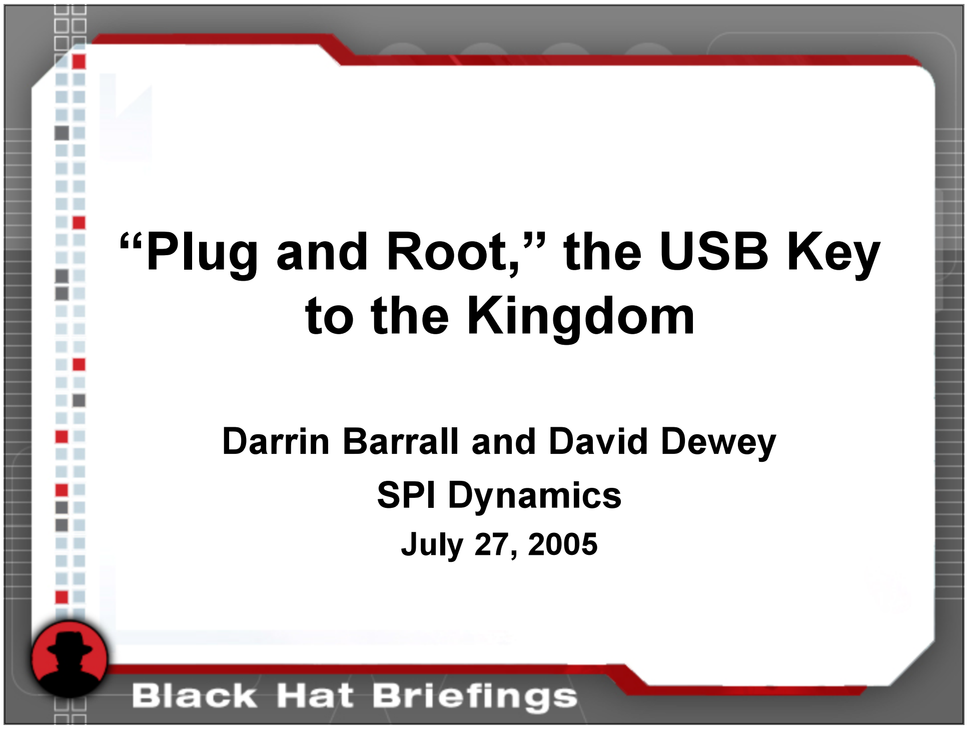
Plug and Root, the USB Key to the Kingdom

USB peripheral devices are made by reputable manufacturers and will not misbehave by attacking the host system's operating system. This device is not one of those. This discussion will cover the creation of a USB meta-device, the discovery and exploitation of flaws in operating system device drivers. In a nutshell, plug this device into an otherwise locked system and it will automatically take control of the system.

***Darrin Barrall** has a varied background in both hardware and software. While working in the hardware world, Darrin repaired electronics in devices ranging from televisions to sports arena lighting systems. After transitioning to the software world, his talents further diversified into banking applications, and recently into buffer overflows. Darrin is currently a R&D coder for the SPI Labs group at SPI Dynamics where he specializes in breaking things.*

***David Dewey** is a security engineer for SPI Dynamics. David came to SPI Dynamics with five years of information security experience ranging from firewall and IDS configuration and support to application level assessment and exploit research. As a pre-sales security engineer, and member of the SPI Labs team, the renowned application security research and development group within SPI Dynamics, David assists in developing new tools and researching new threats in the realm of Web application security.*

BLACK HAT BRIEFINGS



“Plug and Root,” the USB Key to the Kingdom

Darrin Barrall and David Dewey
SPI Dynamics
July 27, 2005

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Who wouldn’t plug these in??

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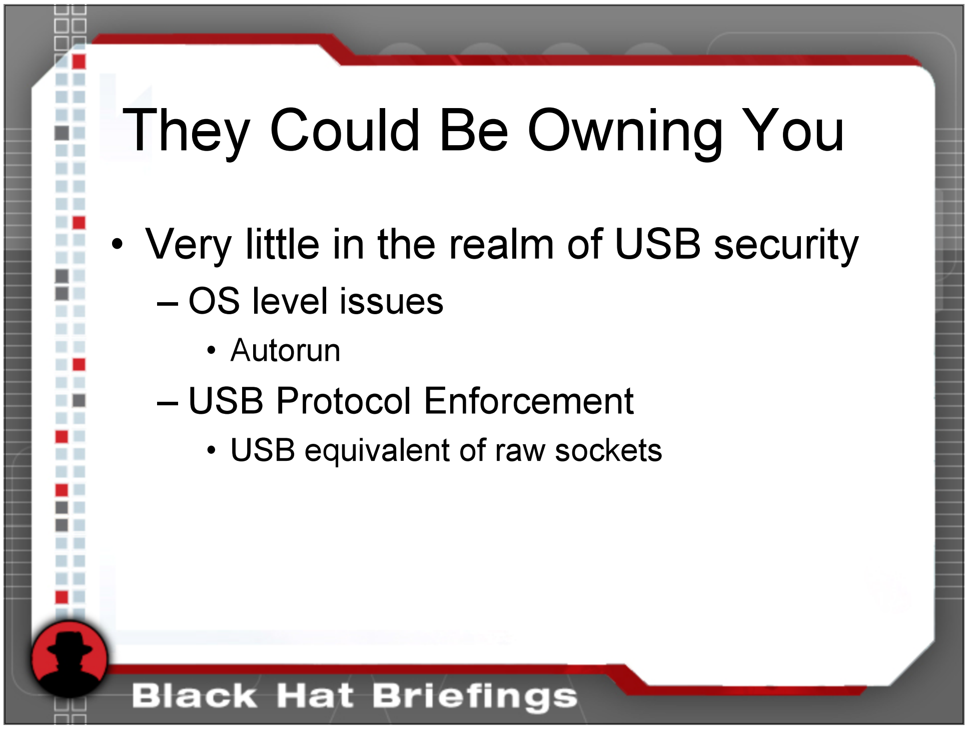

They Could Be Owning You

- Very little in the realm of USB security
  - OS level issues
    - Autorun
  - USB Protocol Enforcement
    - USB equivalent of raw sockets

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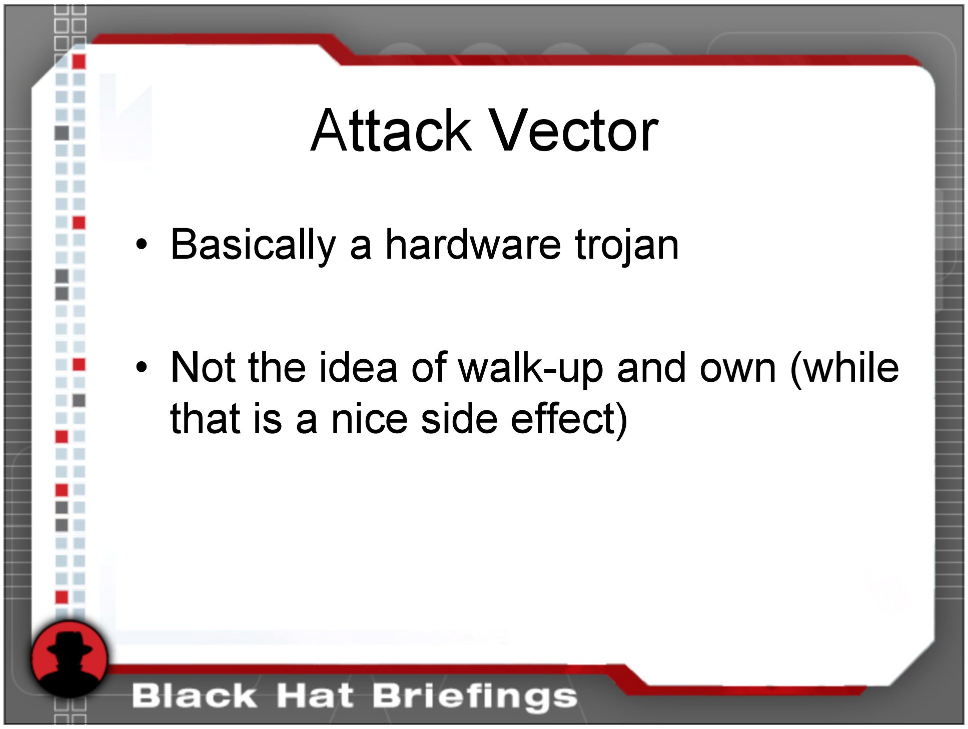

Attack Vector

- Basically a hardware trojan
- Not the idea of walk-up and own (while that is a nice side effect)

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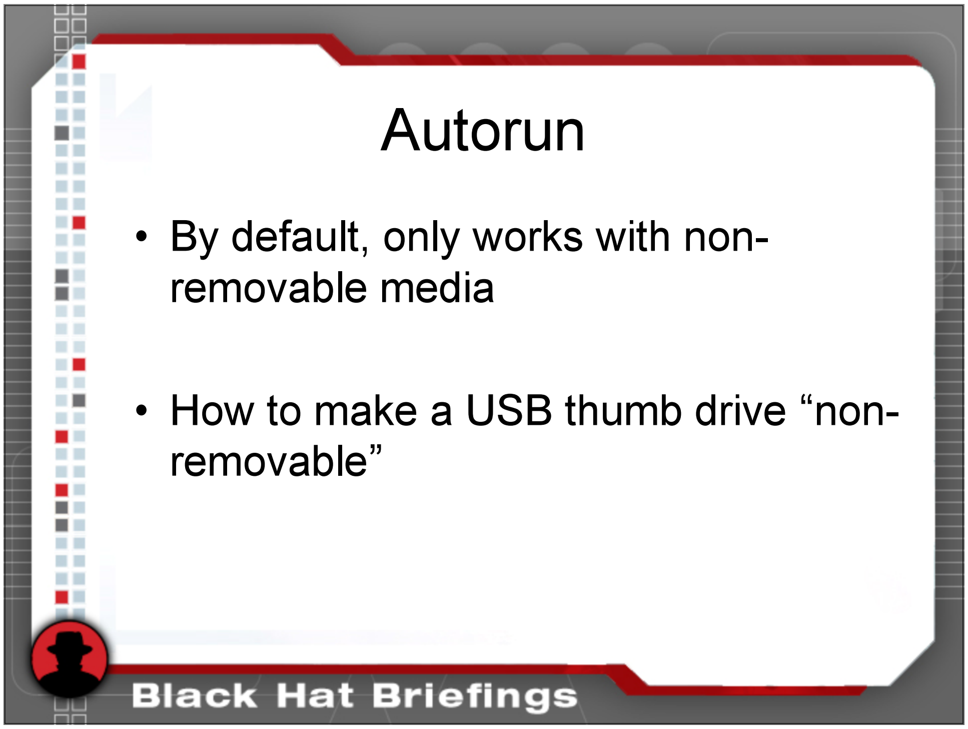

Autorun

- By default, only works with non-removable media
- How to make a USB thumb drive “non-removable”

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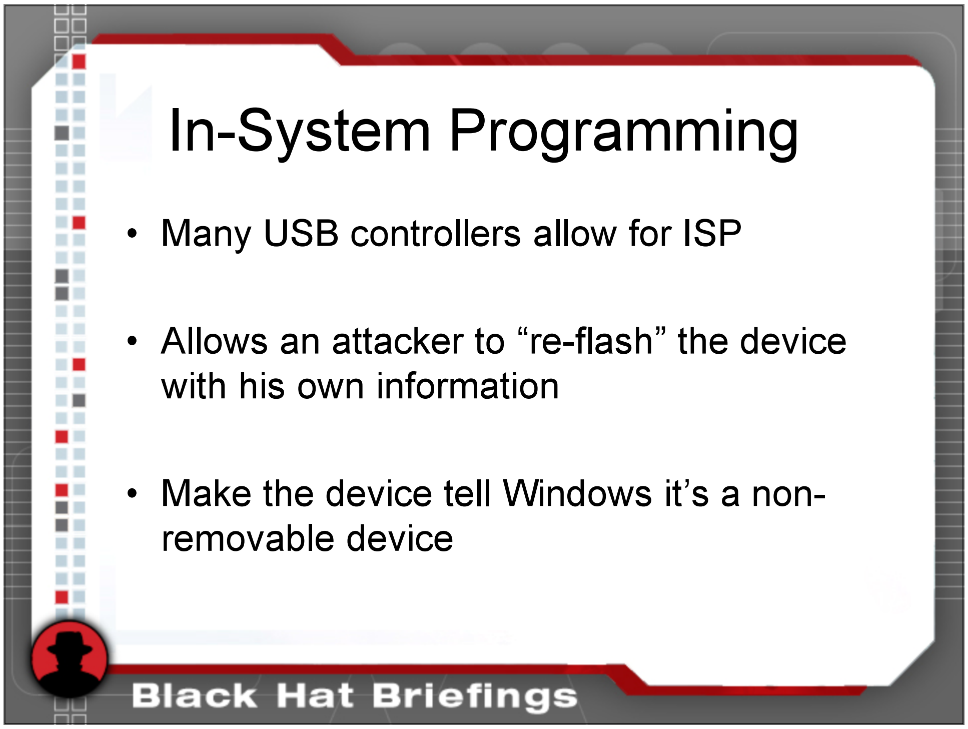

In-System Programming

- Many USB controllers allow for ISP
- Allows an attacker to “re-flash” the device with his own information
- Make the device tell Windows it’s a non-removable device

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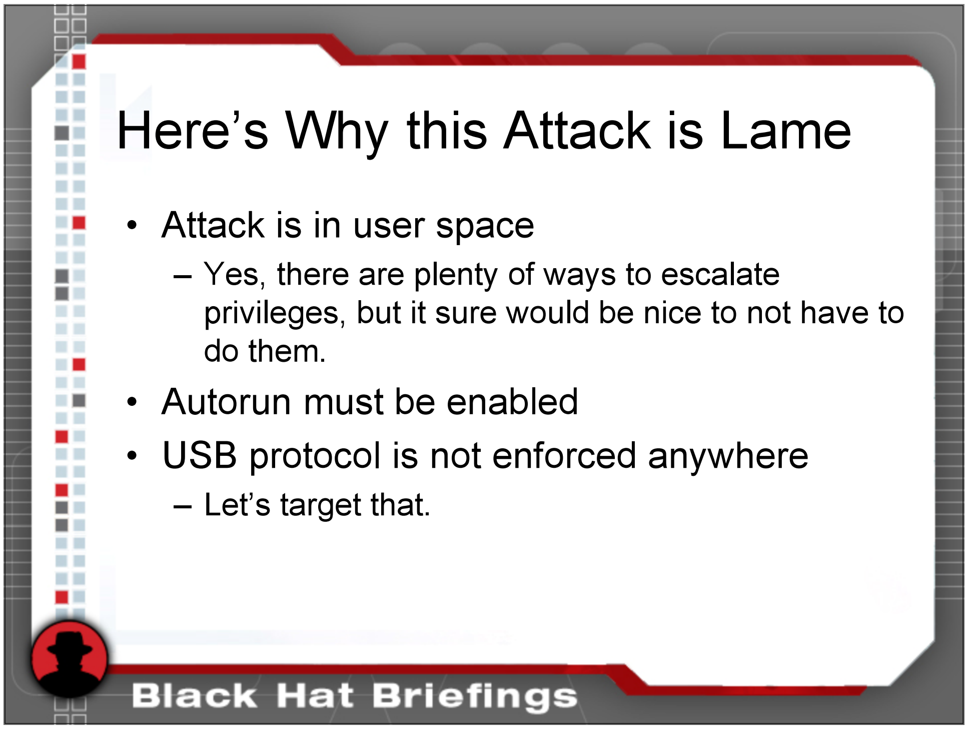

Here’s Why this Attack is Lame

- Attack is in user space
  - Yes, there are plenty of ways to escalate privileges, but it sure would be nice to not have to do them.
- Autorun must be enabled
- USB protocol is not enforced anywhere
  - Let’s target that.

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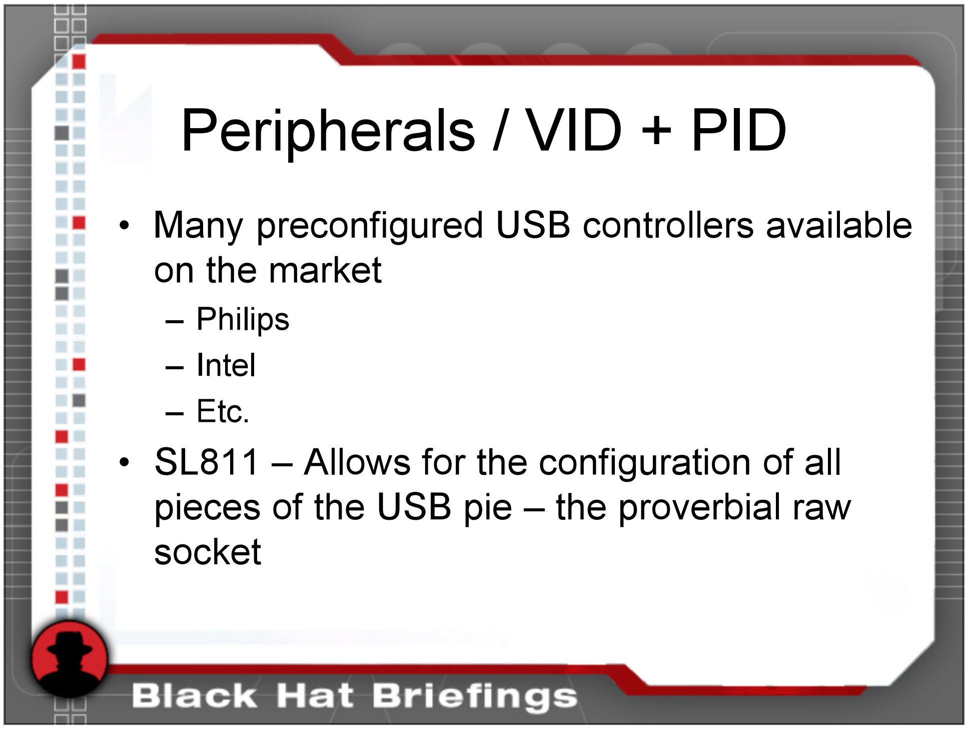

Peripherals / VID + PID

- Many preconfigured USB controllers available on the market
  - Philips
  - Intel
  - Etc.
- SL811 – Allows for the configuration of all pieces of the USB pie – the proverbial raw socket

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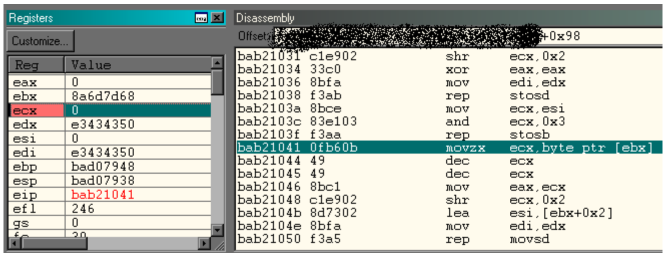
Host

- USB is like TCP
  - Built on a state machine
  - Believes that it will get what it wants

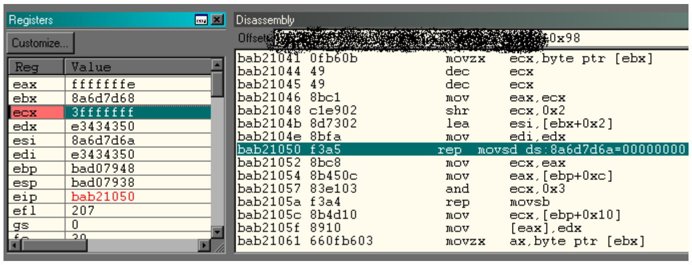
Windows Expecting Us to Be Nice



Reg	Value
eax	0
ebx	8a6d7d68
ecx	0
edx	e3434350
esi	0
edi	e3434350
ebp	bad07948
esp	bad07938
eip	bab21041
efl	246
gs	0
fs	30

```
Offset: [redacted]+0x98
bab21031 c1e902          shr     ecx,0x2
bab21034 33c0            xor     eax,eax
bab21036 8bfa            mov     edi,edx
bab21038 f3ab            rep     stosd
bab2103a 8bce            mov     ecx,esi
bab2103c 83e103          and     ecx,0x3
bab2103f f3aa            rep     stosb
bab21041 0fb60b          movzx   ecx,byte ptr [ebx]
bab21044 49              dec     ecx
bab21045 49              dec     ecx
bab21046 8bc1            mov     eax,ecx
bab21048 c1e902          shr     ecx,0x2
bab2104b 8d7302          lea     esi,[ebx+0x2]
bab2104e 8bfa            mov     edi,edx
bab21050 f3a5            rep     movsd
```

Windows Expecting Us to Be Nice (Cont'd)



```
Reg   Value
eax   fffffffe
ebx   8a6d7d68
ecx   3fffffff
edx   e3434350
esi   8a6d7d6a
edi   e3434350
ebp   bad07948
esp   bad07938
eip   bab21050
efl   207
gs    0
fs    30
```

```
Offset: [redacted]+0x98
bab21041 0fb60b       movzx   ecx,byte ptr [ebx]
bab21044 49           dec     ecx
bab21045 49           dec     ecx
bab21046 8bc1         mov     eax,ecx
bab21048 c1e902       shr     ecx,0x2
bab2104b 8d7302       lea     esi,[ebx+0x2]
bab2104e 8bfa         mov     edi,edx
bab21050 f3a5        rep  movsd ds:8a6d7d6a=00000000
bab21052 8bc8         mov     ecx,eax
bab21054 8b450c       mov     eax,[ebp+0xc]
bab21057 83e103       and     ecx,0x3
bab2105a f3a4         rep     movsb
bab2105c 8b4d10       mov     ecx,[ebp+0x10]
bab2105f 8910         mov     [eax],edx
bab21061 660fb603     movzx   ax,byte ptr [ebx]
```

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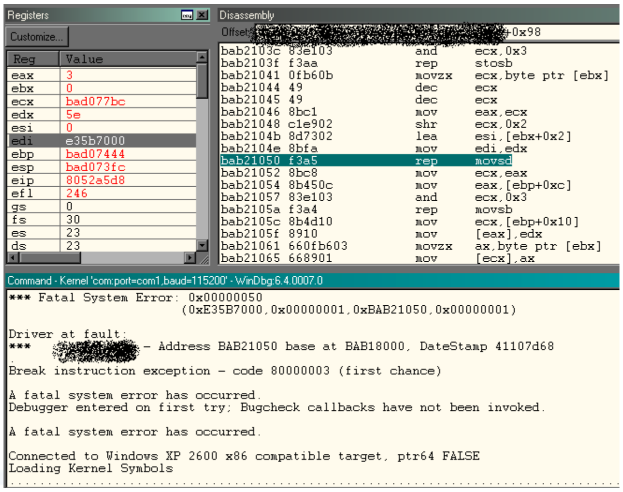
POOF!!



```
Reg   Value
eax   3
ebx   0
ecx   bad077bc
edx   5e
esi   0
edi   e35b7000
ebp   bad07444
esp   bad073fc
eip   8052a5d8
efl   246
gs    0
fs    30
es    23
ds    23
```

```
Offset: [redacted]+0x98
bab2103c 83e103       and     ecx,0x3
bab2103f f3aa         rep     stosb
bab21041 0fb60b       movzx   ecx,byte ptr [ebx]
bab21044 49           dec     ecx
bab21045 49           dec     ecx
bab21046 8bc1         mov     eax,ecx
bab21048 c1e902       shr     ecx,0x2
bab2104b 8d7302       lea     esi,[ebx+0x2]
bab2104e 8bfa         mov     edi,edx
bab21050 f3a5         rep     movsd
bab21052 8bc8         mov     ecx,eax
bab21054 8b450c       mov     eax,[ebp+0xc]
bab21057 83e103       and     ecx,0x3
bab2105a f3a4         rep     movsb
bab2105c 8b4d10       mov     ecx,[ebp+0x10]
bab2105f 8910         mov     [eax],edx
bab21061 660fb603     movzx   ax,byte ptr [ebx]
bab21065 668901       mov     [ecx],ax
```

Command - Kernel 'com:port=com1,baud=115200' - WinDbg:6.4.0007.0

```
*** Fatal System Error: 0x00000050
                       (0xE35B7000,0x00000001,0xBAB21050,0x00000001)

Driver at fault:
***    [redacted] - Address BAB21050 base at BAB18000, DateStamp 41107d68
.
Break instruction exception - code 80000003 (first chance)

A fatal system error has occurred.
Debugger entered on first try; Bugcheck callbacks have not been invoked.

A fatal system error has occurred.

Connected to Windows XP 2600 x86 compatible target, ptr64 FALSE
Loading Kernel Symbols
...............................................................
```

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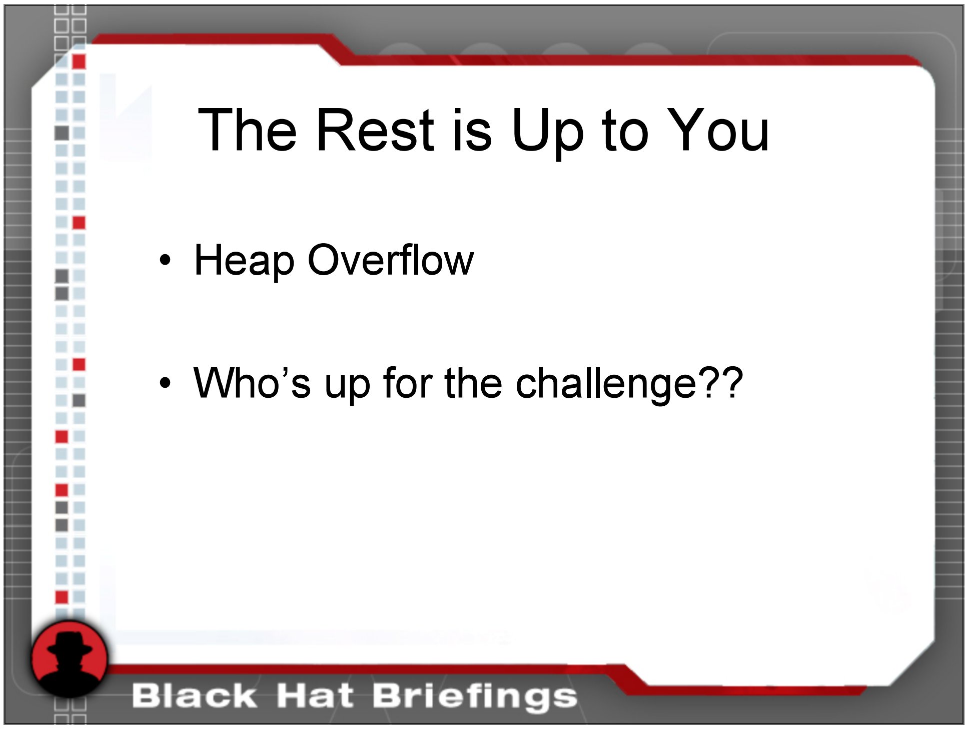

The Rest is Up to You

- Heap Overflow
- Who’s up for the challenge??

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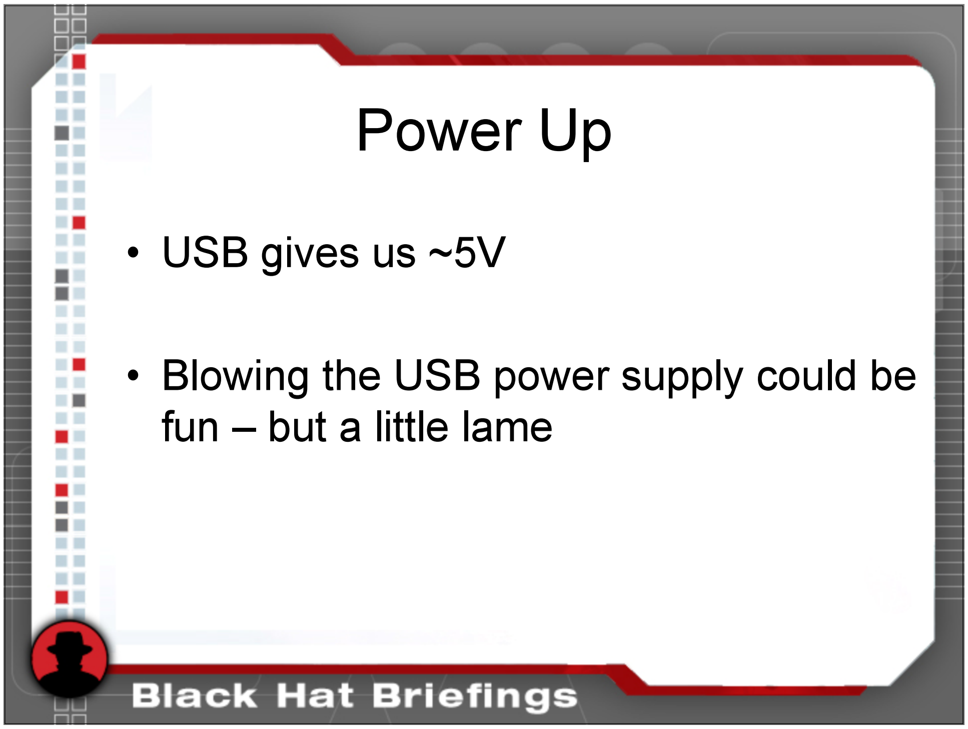

Power Up

- USB gives us ~5V
- Blowing the USB power supply could be fun – but a little lame

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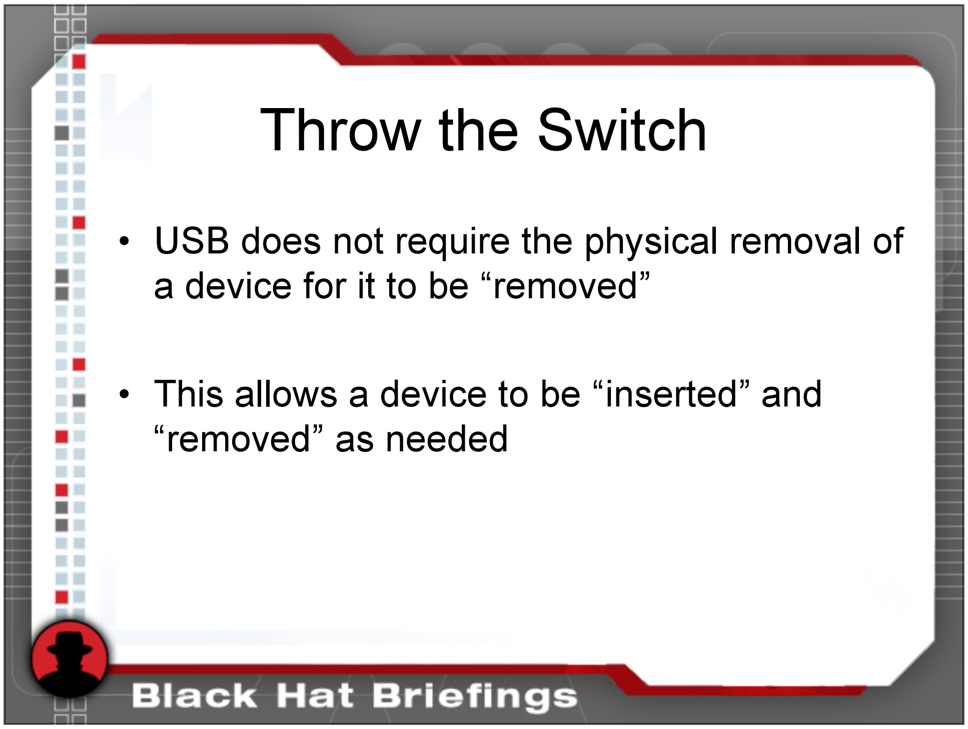

Throw the Switch

- USB does not require the physical removal of a device for it to be “removed”
- This allows a device to be “inserted” and “removed” as needed

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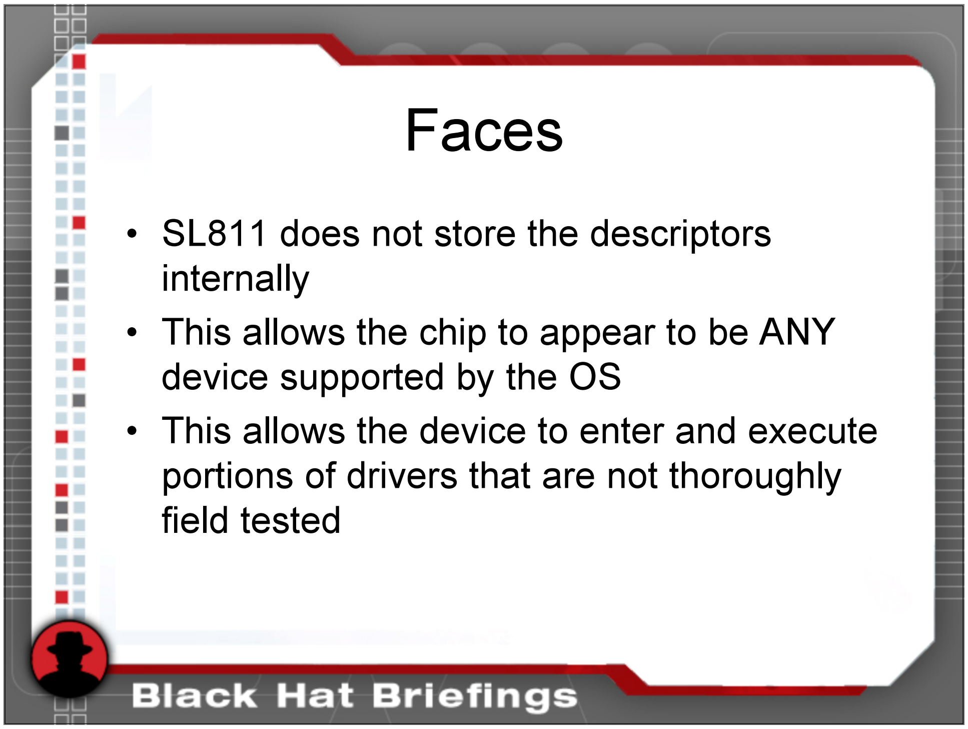

Faces

- SL811 does not store the descriptors internally
- This allows the chip to appear to be ANY device supported by the OS
- This allows the device to enter and execute portions of drivers that are not thoroughly field tested

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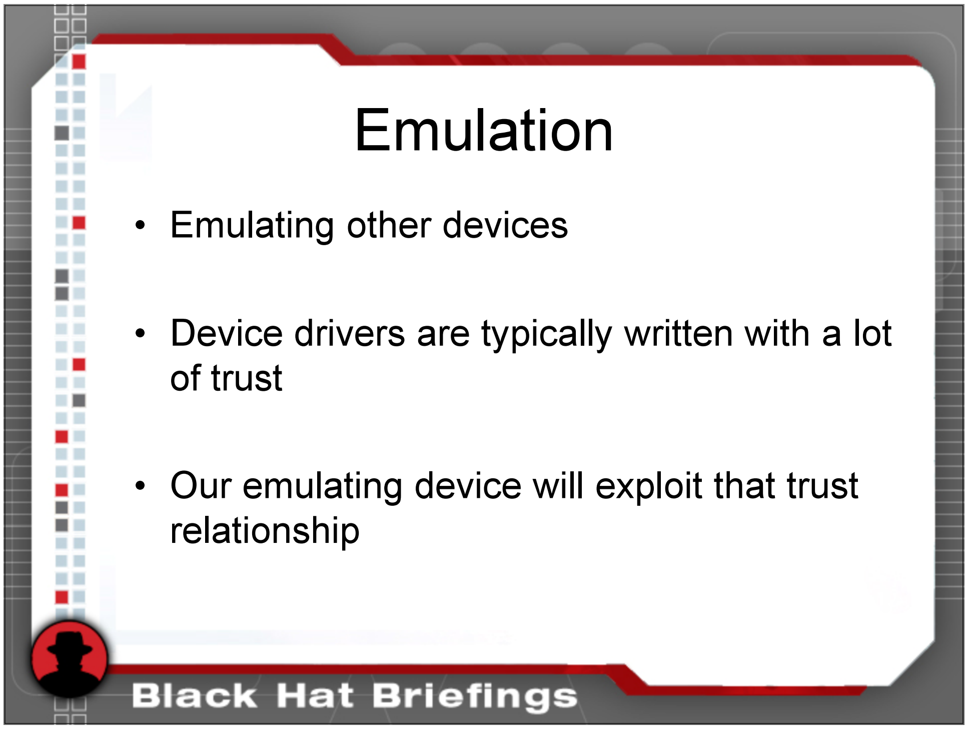
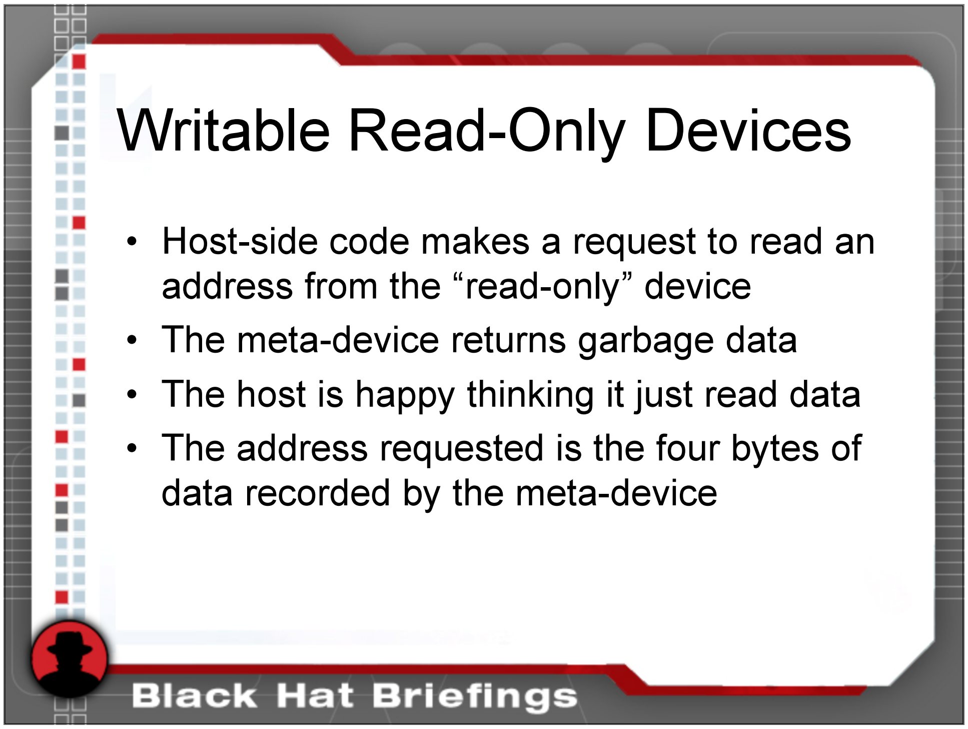


Emulation

- Emulating other devices
- Device drivers are typically written with a lot of trust
- Our emulating device will exploit that trust relationship

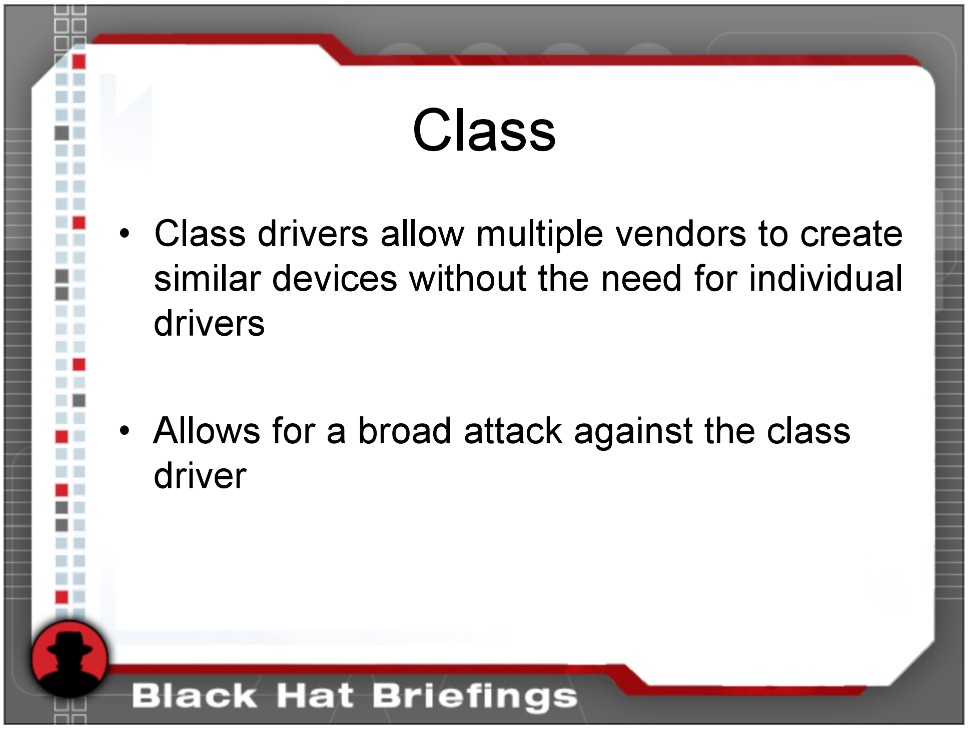


Writable Read-Only Devices

- Host-side code makes a request to read an address from the “read-only” device
- The meta-device returns garbage data
- The host is happy thinking it just read data
- The address requested is the four bytes of data recorded by the meta-device

Empty the “Trash”

- Hand one to your janitor and $20



Class

- Class drivers allow multiple vendors to create similar devices without the need for individual drivers
- Allows for a broad attack against the class driver

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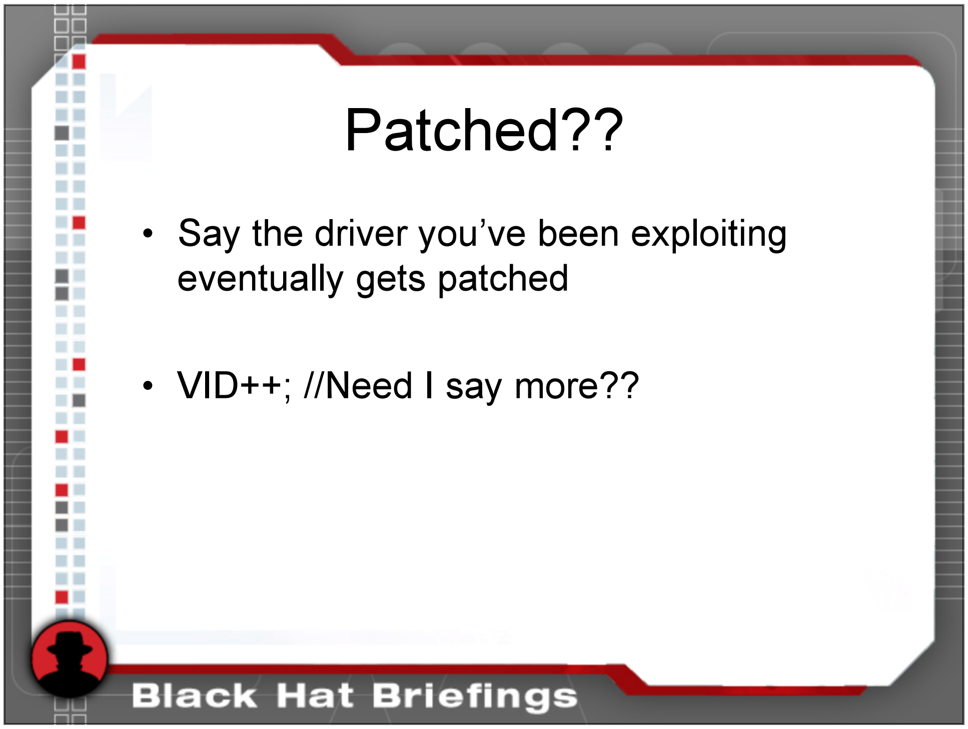

Patched??

- Say the driver you’ve been exploiting eventually gets patched
- VID++; //Need I say more??

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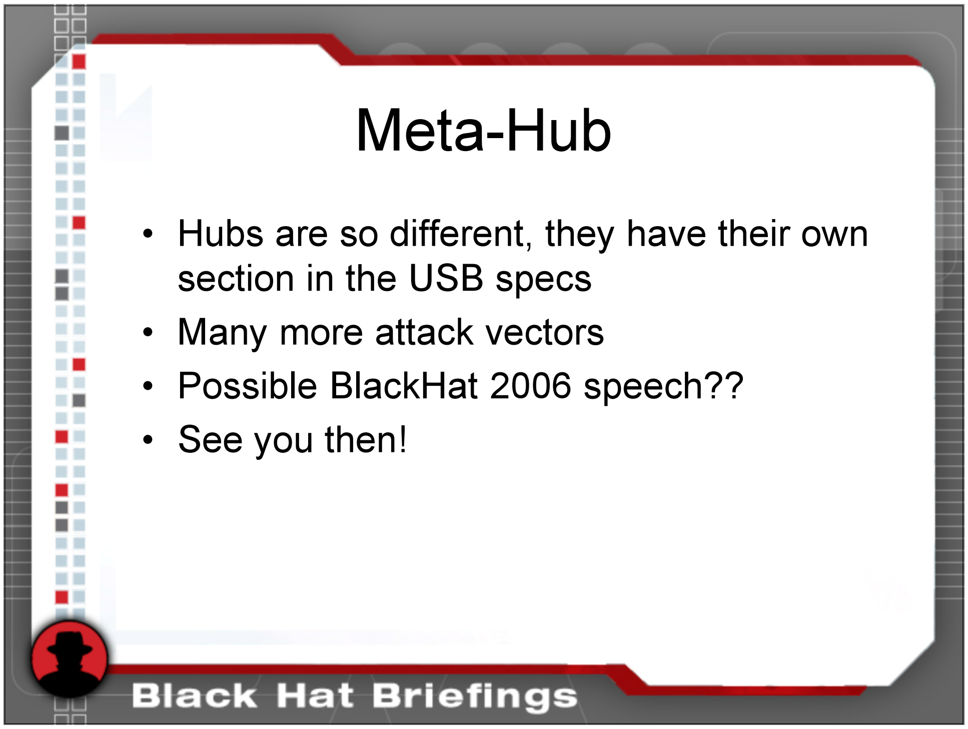

Meta-Hub

- Hubs are so different, they have their own section in the USB specs
- Many more attack vectors
- Possible BlackHat 2006 speech??
- See you then!

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Defense

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Epoxy the USB Port Shut

Just kidding

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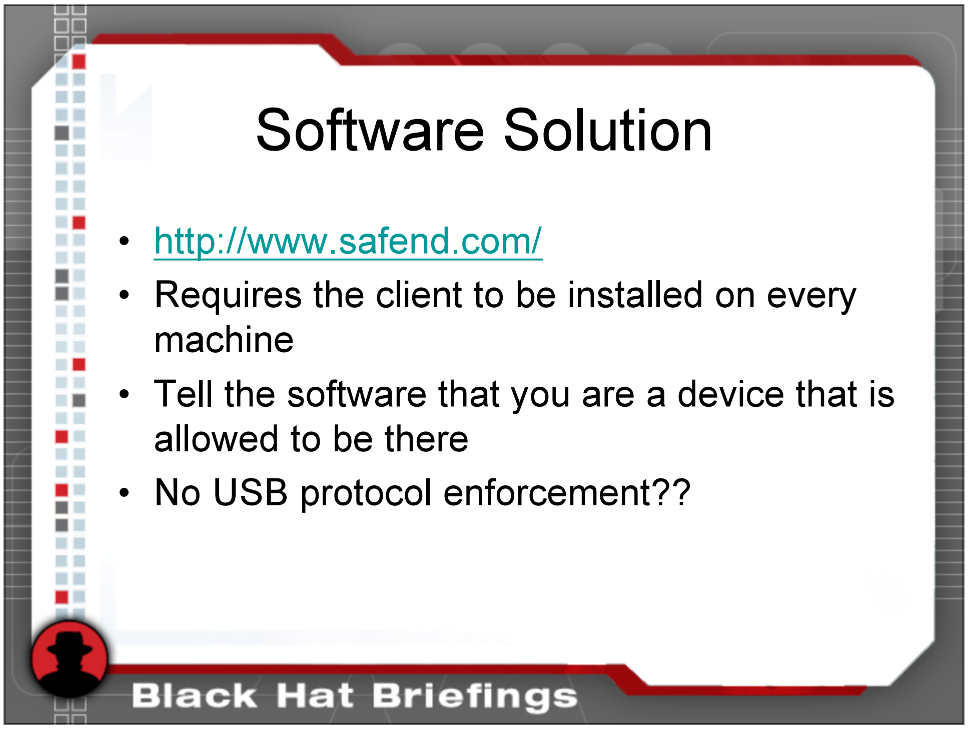

Software Solution

- http://www.safend.com/
- Requires the client to be installed on every machine
- Tell the software that you are a device that is allowed to be there
- No USB protocol enforcement??

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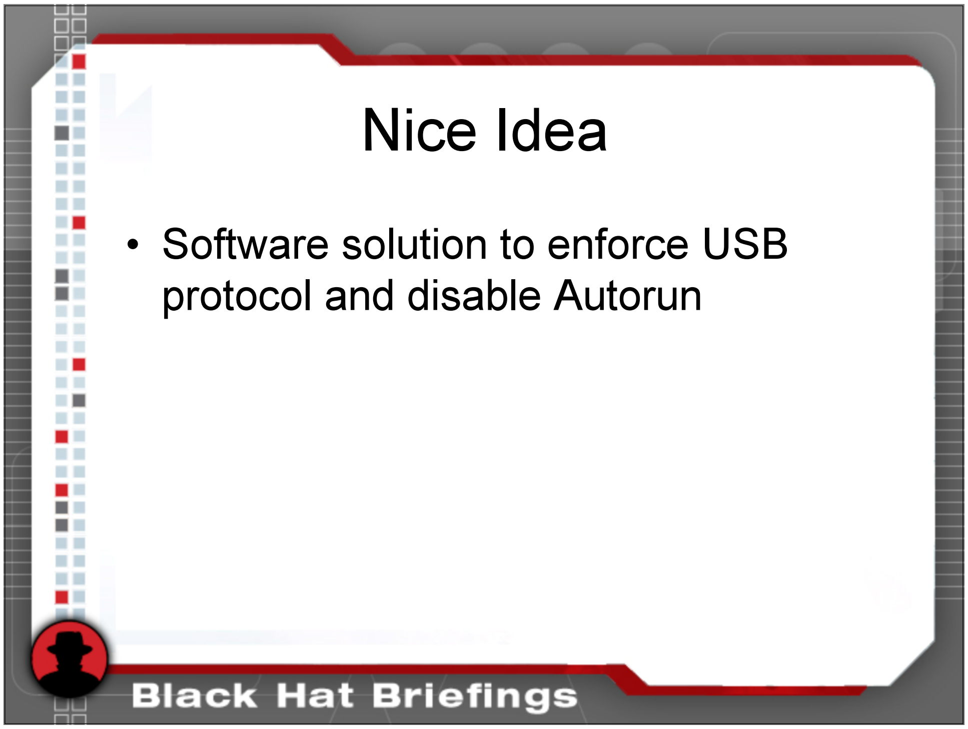

Nice Idea

- Software solution to enforce USB protocol and disable Autorun

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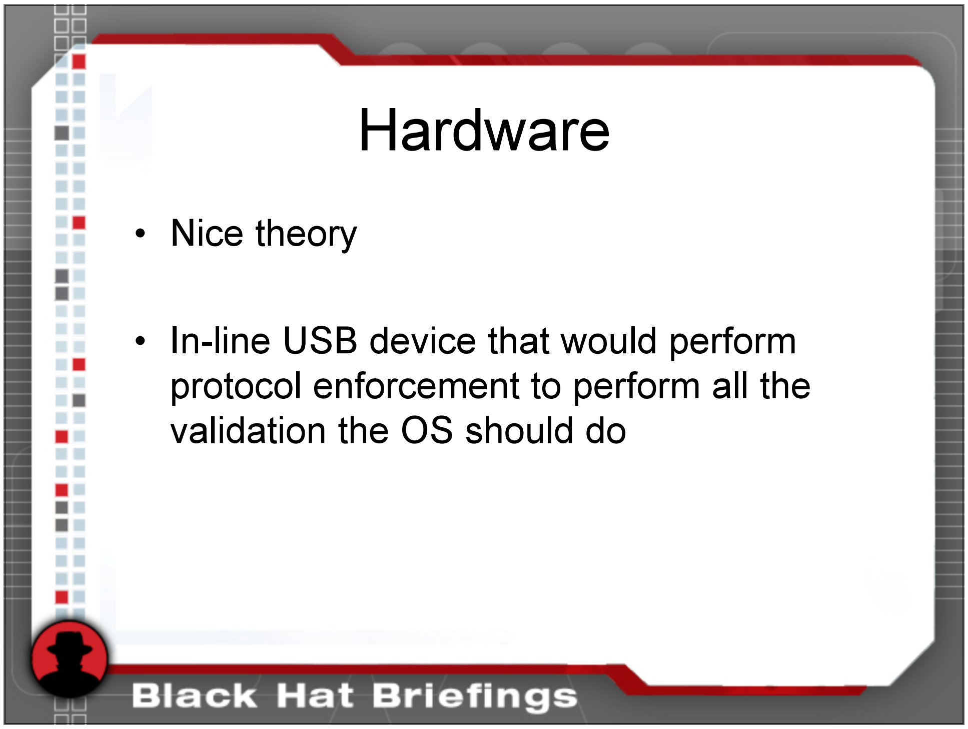
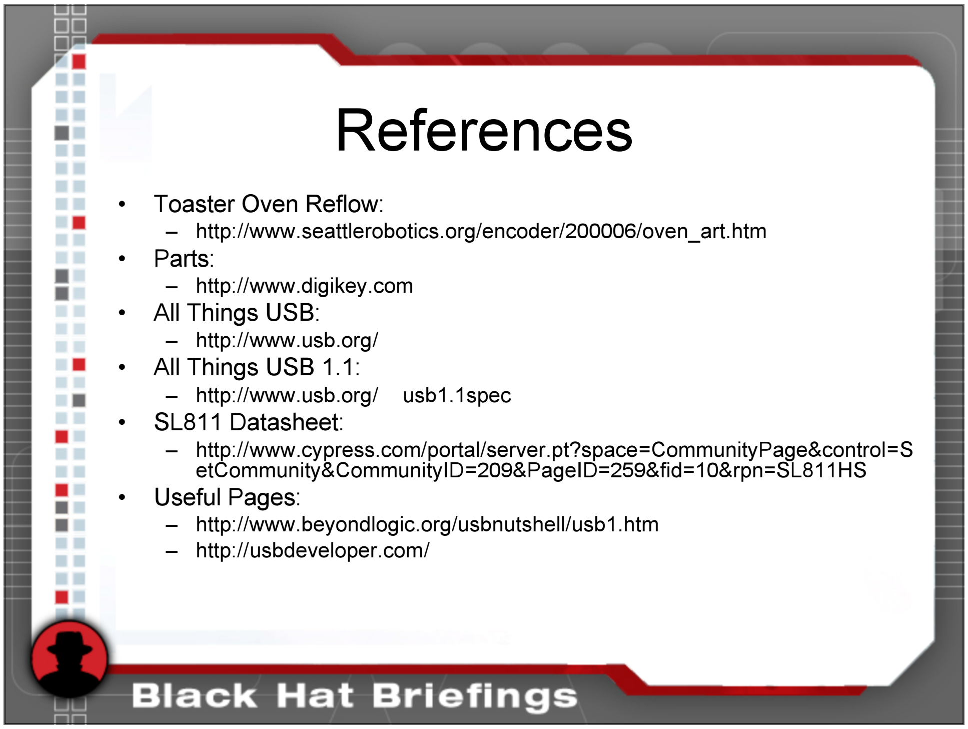


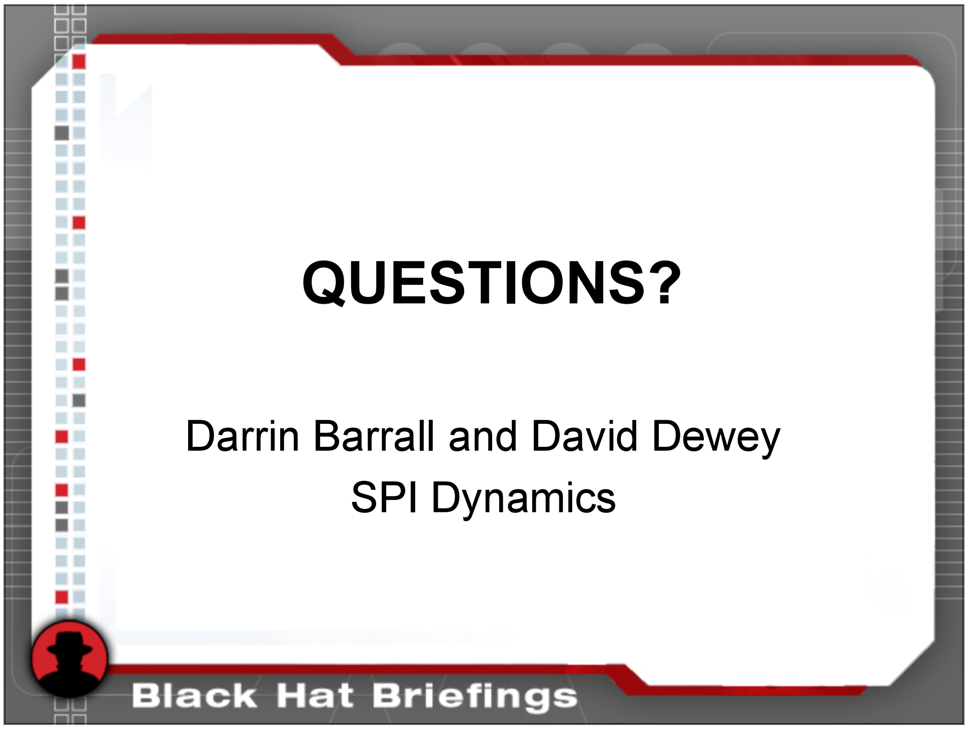
Hardware

- Nice theory
- In-line USB device that would perform protocol enforcement to perform all the validation the OS should do



References

- Toaster Oven Reflow:
  - http://www.seattlerobotics.org/encoder/200006/oven_art.htm
- Parts:
  - http://www.digikey.com
- All Things USB:
  - http://www.usb.org/
- All Things USB 1.1:
  - http://www.usb.org/ usb1.1spec
- SL811 Datasheet:
  - http://www.cypress.com/portal/server.pt?space=CommunityPage&control=SetCommunity&CommunityID=209&PageID=259&fid=10&rpn=SL811HS
- Useful Pages:
  - http://www.beyondlogic.org/usbnutshell/usb1.htm
  - http://usbdeveloper.com/



QUESTIONS?

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