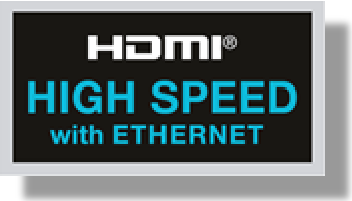

What the HEC? Security implications of HDMI Ethernet Channel and other related protocols

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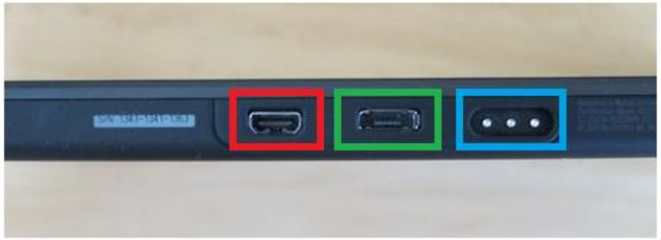
Agenda

- Why am I talking about video interfaces?
- What does HDMI bring with it?
- The CEC protocol – enabling the user to expend as little energy as possible
- CECSTeR – The CEC Security Testing Resource
- The HEC protocol – you mean I get network access too?
- HEC internals and potential security issues
- Conclusion

Why am I talking about video interfaces?

- It all started with a BlackBerry PlayBook research project…
- I was investigating USB security at the time (green interface)



- What other ports are available?
- A power connector (blue interface) – probably not that exciting…
- Hmm…microHDMI – what can I do with that? (red interface)

HDMI is an output isn’t it?

Well…yes and no

- Video out
- Audio out
- Display identification and capability advertisement in via EDID
- Remote control via CEC in and out
- Network data via HEC in and out
- Encryption and authentication data via HDCP and DPCP in and out

HDMI - High-Definition Multimedia Interface

- http://www.hdmi.org/manufacturer/specification.aspx (HDMI adopters only)
- Transmits encrypted uncompressed digital video and audio data using TMDS (Transition-Minimised Differential Signalling)
- Supports Enhanced DDC for display identification and capability advertisement
- Also it introduces a number of new technologies, which are potentially interesting from a security perspective; these include:
    - **CEC – Consumer Electronics Control**
    - **CDC – Capability Discovery and Control**
    - HDCP - High-bandwidth Digital Content Protection
    - **HEC – HDMI Ethernet Channel**

CEC – I've not heard of that before…

Trade names for CEC are:

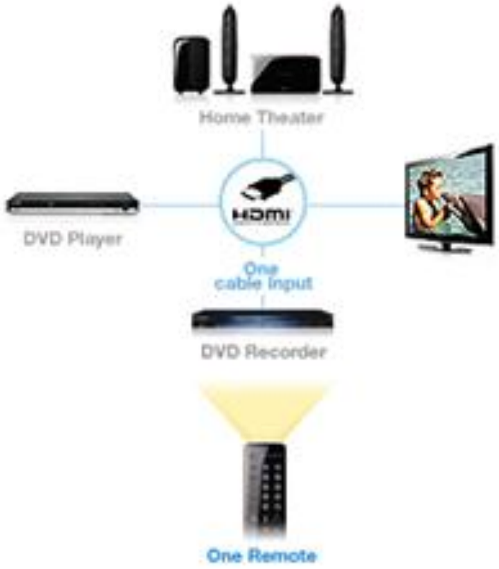
- BRAVIA Link and BRAVIA Sync (Sony)
- VIERA Link , HDAVI Control, EZ-Sync (Panasonic)
- Anynet+ (Samsung)
- Aquos Link (Sharp)
- SimpLink (LG)
- EasyLink (Philips)

etc…

CEC - Consumer Electronics Control

Purpose:

- Control two or more HDMI devices using a single remote control
- Devices can control each other without user-intervention.



Physical:

- The architecture of CEC is an inverted tree
- One-wire bidirectional serial bus (AV.link)

Logical:

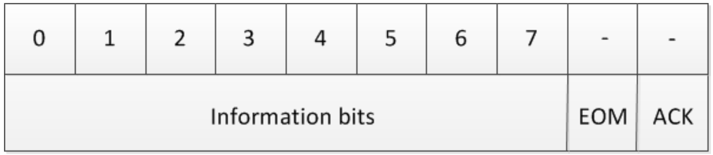
- Up to ten AV devices can be connected and the topology of a connected system is auto-discovered by the protocol.

Supported CEC commands

- One Touch Play, System Standby
- Pre-set Transfer, One Touch Record
- Timer Programming, System Information
- Deck Control , Tuner Control
- OSD Display, Device Menu Control
- Routing Control, Remote Control Pass
- Device OSD Name Transfer, System Audio Control

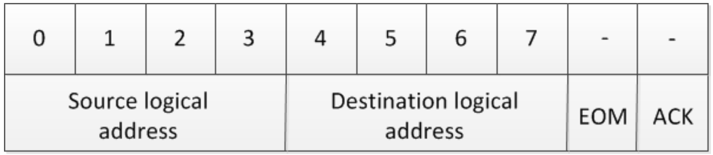
The CEC protocol

CEC Block layout:



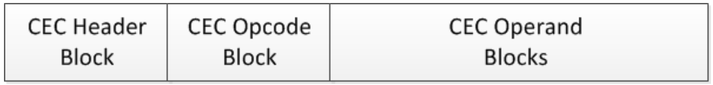
0	1	2	3	4	5	6	7	-	-
Information bits								EOM	ACK

CEC Header block:



0	1	2	3	4	5	6	7	-	-
Source logical address				Destination logical address				EOM	ACK

CEC Message:

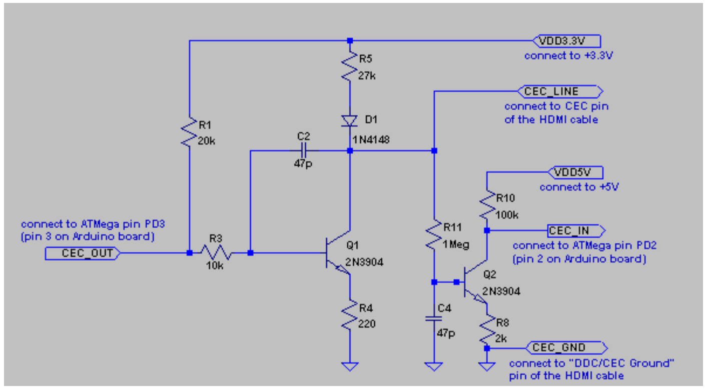


CEC Header Block	CEC Opcode Block	CEC Operand Blocks

- Messages are either Directed or Broadcast
- Logical addresses are 0x0 – 0xF (0 always TV, F always broadcast)
- Physical addresses x.x.x.x (TV = 0.0.0.0)

Can we fuzz CEC?

- Feature rich protocol - could potentially yield some interesting security vulnerabilities in different implementations
- Arduino library - http://code.google.com/p/cec-arduino/
- Publicly available Arduino - CEC interface circuit:



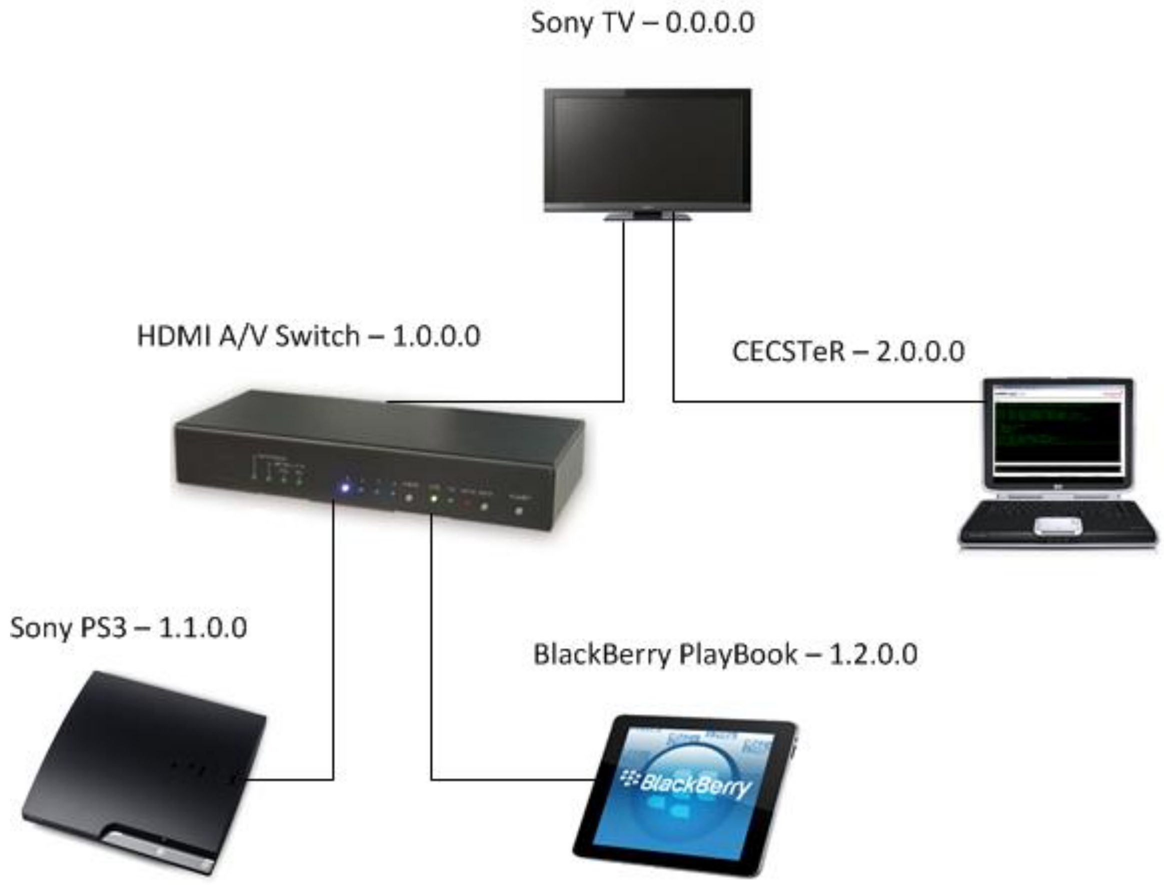
- USB-CEC Adapter from Pulse Eight:

- USB-CEC Bridge from RainShadow Tech:

Introducing **CEC**STeR

- **C**onsumer **E**lectronics **C**ontrol **S**ecurity **Te**sting **R**esource
- Download it here - http://tinyurl.com/ncctools
- Supports CEC and CDC (more on that later)
- Capture and display traffic
- Send arbitrary commands
- Fuzz the protocols
- Time for a demo…

HDMI Connectivity for the demo



What are the fuzzer results?

My CEC targets:

- Sony PS3 – no results
- Panasonic Blu-ray player (DMP-BD45) – “random” lockups
- BlackBerry PlayBook (very limited CEC functionality) - no results
- XBMC (using Pulse-eight USB-CEC Adapter) – Permanent DoS
    - It “bricked” the Pulse-eight adapter!
- Potentially interesting commands include:
    - “Vendor command” – Opcode 0x89
    - “Set OSD string” – opcode 0x64
    - “Set OSD name” – opcode 0x47
    - “CDC command” – opcode 0xF8

HEC - HDMI Ethernet Channel

- Introduced in HDMI v1.4 (latest version is 1.4a)
- Consolidates video, audio, and data streams into a single HDMI cable
- The primary intention is to reduce the amount of cables required to connect AV devices together.
- Uses CDC (Capability Discovery and Control) to control Ethernet channels

CDC (Capability Discovery and Control)

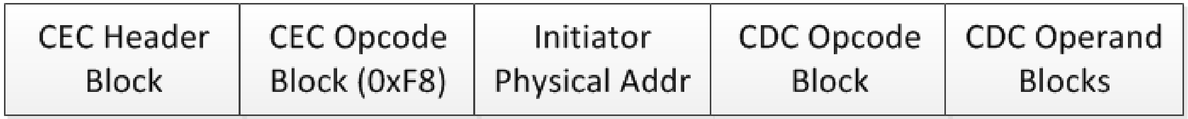
CDC is used to:

- Discover potential HDMI Ethernet channels
- Activate and deactivate channels
- Communicate status of channels

CDC messages are sent with the CEC “CDC Message” (0xF8) opcode

All CDC messages are sent to the CEC logical broadcast address (0xF)

CDC message format:



CEC Header Block	CEC Opcode Block (0xF8)	Initiator Physical Addr	CDC Opcode Block	CDC Operand Blocks

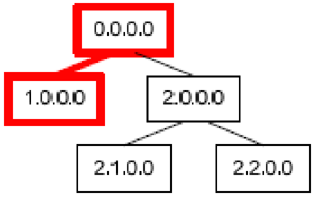
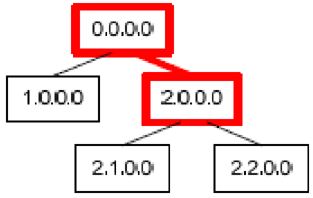
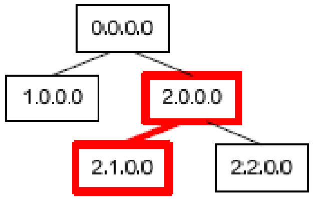
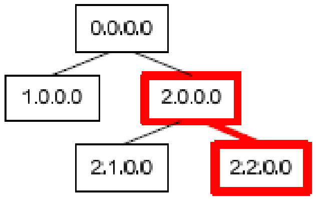
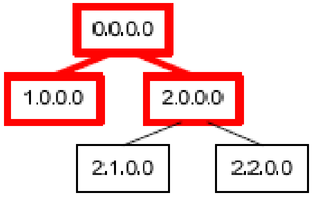
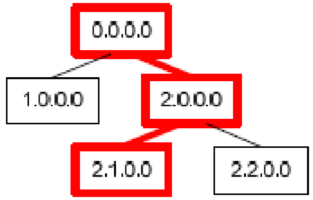
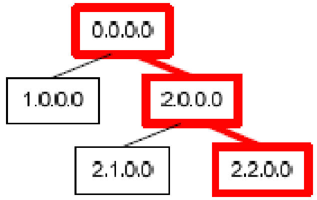
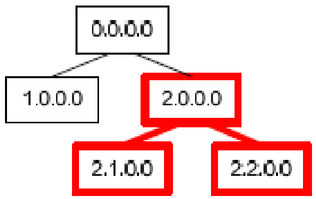
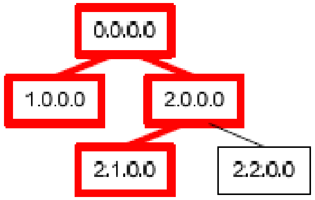
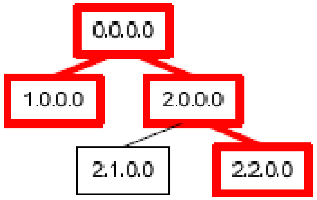
HEC (CDC) Messages

The following messages are used for Capability Discovery and Control:

- <CDC_HEC_InquireState>
- <CDC_HEC_ReportState>
- <CDC_HEC_SetState>
- <CDC_HEC_RequestDeactivation>
- <CDC_HEC_NotifyAlive>
- <CDC_HEC_Discover>
- <CDC_HEC_SetStateAdjacent>

HEC potential combinations

Possible HECs within a certain HDMI network:

 Terminating Devices: 1.0.0.0 and 0.0.0.0	 Terminating Devices: 0.0.0.0 and 2.0.0.0	 Terminating Devices: 2.0.0.0 and 2.1.0.0	 Terminating Devices: 2.0.0.0 and 2.2.0.0	 Terminating Devices: 1.0.0.0 and 2.0.0.0
 Terminating Devices: 0.0.0.0 and 2.1.0.0	 Terminating Devices: 0.0.0.0 and 2.2.0.0	 Terminating Devices: 2.1.0.0 and 2.2.0.0	 Terminating Devices: 1.0.0.0 and 2.1.0.0	 Terminating Devices: 1.0.0.0 and 2.2.0.0

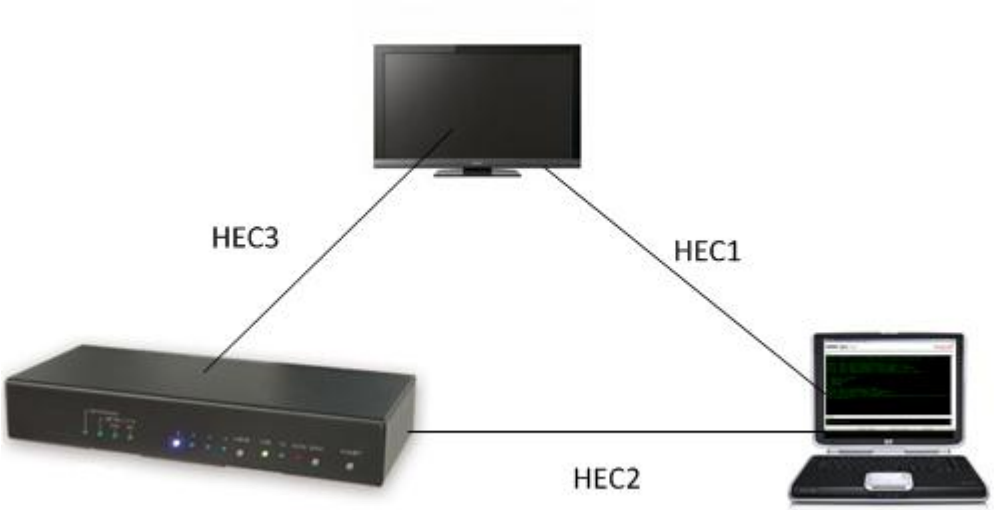
(referenced from HDMI specification v1.4a)

HEC States

- PHEC (Potential HDMI Ethernet Channel) – part of a PHEC if at least one HDMI connection is HEC capable
- VHEC (Verified HDMI Ethernet Channel) – part of a VHEC after CDC has confirmed HEC capability of all devices in a PHEC via a `<CDC_HEC_Discover>` message
- AHEC (Active HDMI Ethernet Channel) – part of an AHEC after activation of all devices in a VHEC via a `<CDC_HEC_SetState>` message

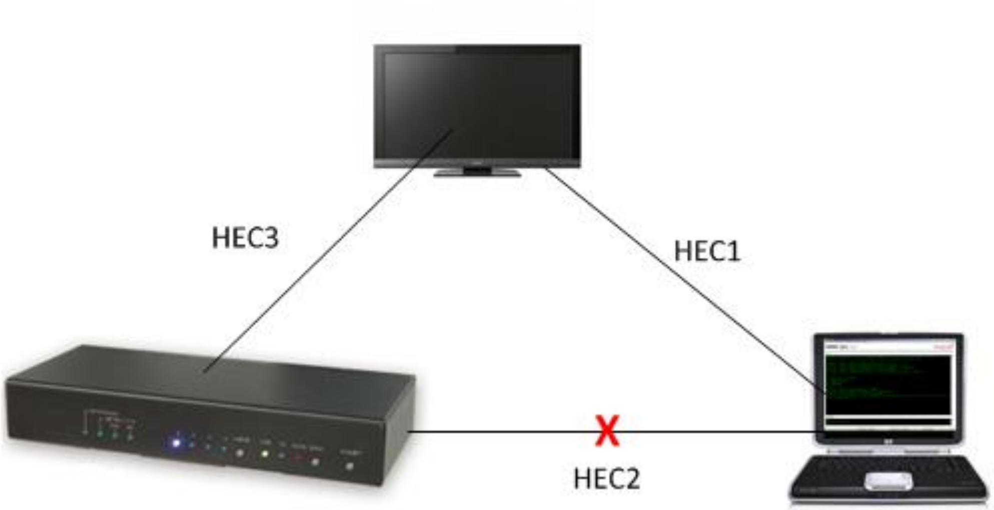
Network loop prevention

- Routing loops such as shown here are managed using RSTP (Rapid Spanning Tree Protocol)



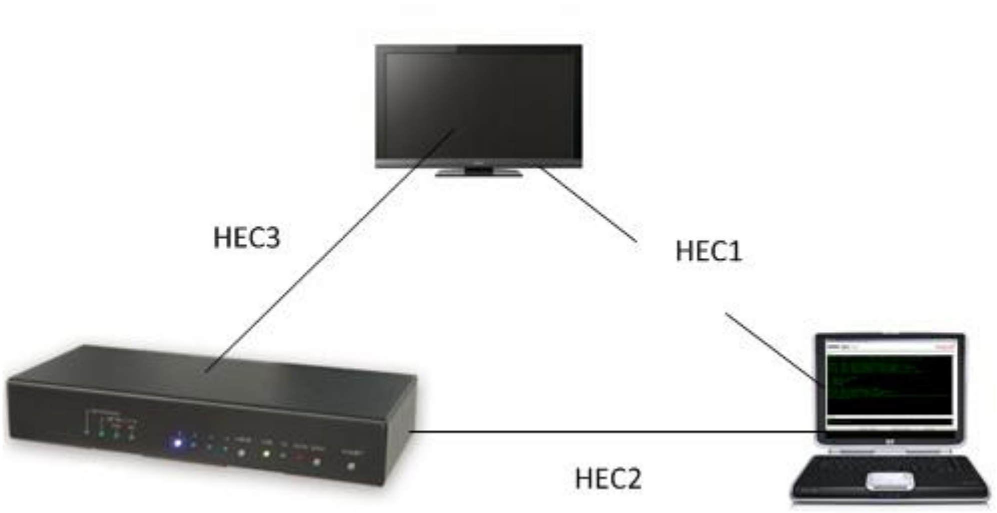
Network loop prevention

- Routing loops such as shown here are managed using RSTP (Rapid Spanning Tree Protocol)
- HEC2 is disabled to remove the loop



Network loop prevention

- Routing loops such as shown here are managed using RSTP (Rapid Spanning Tree Protocol)
- HEC2 is disabled to remove the loop
- If HEC1 link is broken, HEC2 is restored



Queue control

- Devices in a HEC network are expected to prioritise traffic. Time sensitive application traffic should be forwarded with higher priority than activities such as file downloads:
  - On-line gaming
  - Video
  - VoIP
- This is achieved using a 3 bit priority field in VLAN tags

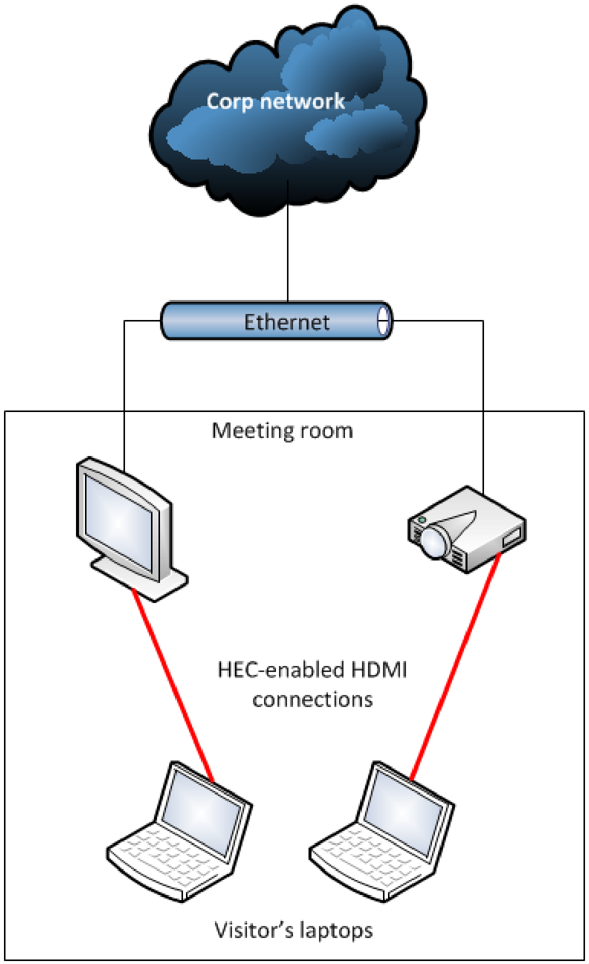
This is all very interesting, but…

- I’m never going to be pentesting a home AV network!
- HDMI connectors are appearing on new laptops and PCs – soon these protocols will be implemented in all the major operating systems

- If I found a bug in an HDMI enabled TV, so what?
- Plasma/LCD TVs are becoming part of the corporate network infrastructure

- So how could HDMI protocols affect corporate users?

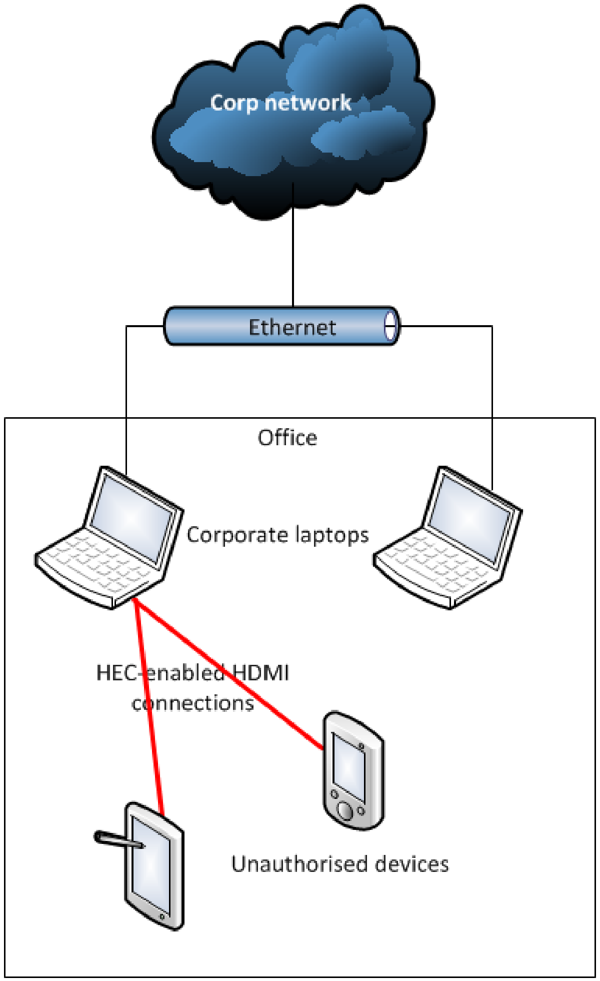
HEC Risk #1 – Corporate boundary breach



- Network-enabled projectors and TVs could circumvent corporate security boundaries

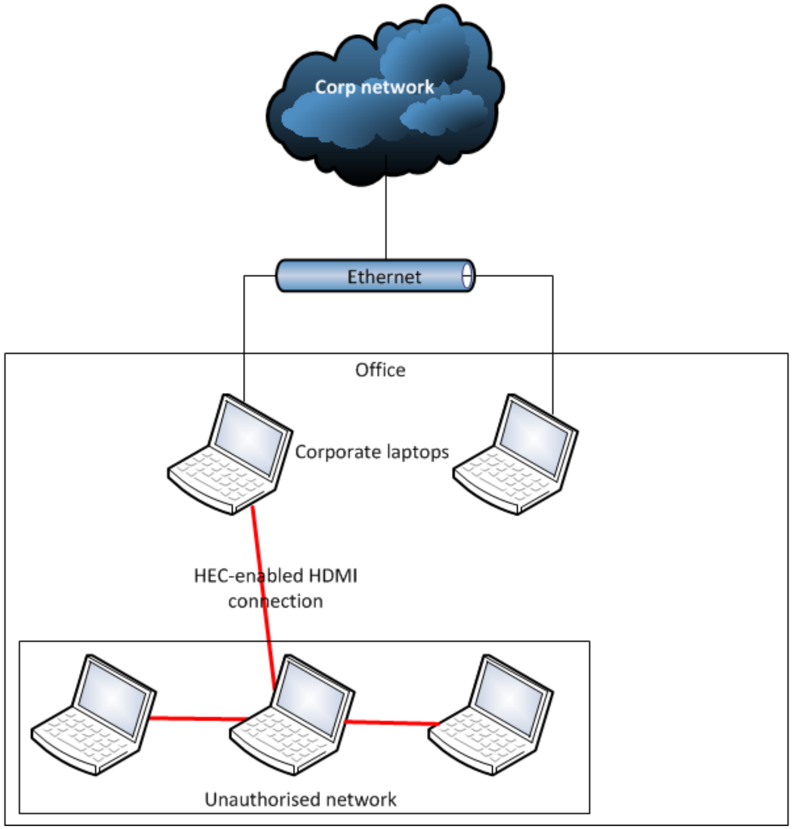
- Will users be aware of the capabilities of this technology within their own devices?

HEC Risk #2 – Endpoint Protection Circumvention



- HDMI could be used to connect unauthorised network-enabled devices to the corporate network
- Endpoint Protection systems (unless they are HEC-aware) will be unable to detect this
- Unauthorised devices could introduce malware or exfiltrate sensitive data

HEC Risk #3 – Unauthorised Network Extension



- HDMI could be used to create an unauthorised extension to the corporate network
- This “private network” would not be visible to corporate network monitoring tool / NIDS devices

Testing HDMI Ethernet Channel

Have I tested any HEC-enabled devices?

no…

The only device I could find that supports HEC is the T+A Blu-ray receiver:

It costs £6000!

Another corporate HDMI security risk

Remember hardware-based key loggers?

Here’s an HDMI video logger - VideoGhost:

- http://www.keydemon.com/tiny_frame_grabber/
  - “2GB storage”
  - “7 year battery life”

This is potentially much more powerful than a key logger!

Conclusions

- As users demand more and more “seamless” functionality in a plug-and-play world there will be a greater need for bi-directional data to be flowing in A/V links between devices
- HDMI Ethernet Channel could have a major impact on corporate security, but the technology is still very new and largely unsupported
- As well as checking for hardware key loggers you should now also be checking for video loggers connected to your corporate workstations
- Before long every laptop will have an HDMI port and they will all support CEC, CDC and HEC!

Questions?

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