# EtherSniff

How to stealthily monitor an established Ethernet network

*by Mark Smith, aka Smitty*

# Introduction

- Hardwired network paths are secure.
- No encryption needed internally.
- A physical sniffer insertion would break link on network interfaces, triggering alarms.

***Right?***

- …maybe not…

# Introduction: Me

- Mark Smith, aka Smitty
- By day: Network engineer and system administrator for over 15 years
- By night: Maker, ham radio nerd, musician, podcaster, husband, father, closet tree hugger
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  - @SmittyHalibut just about everywhere else.

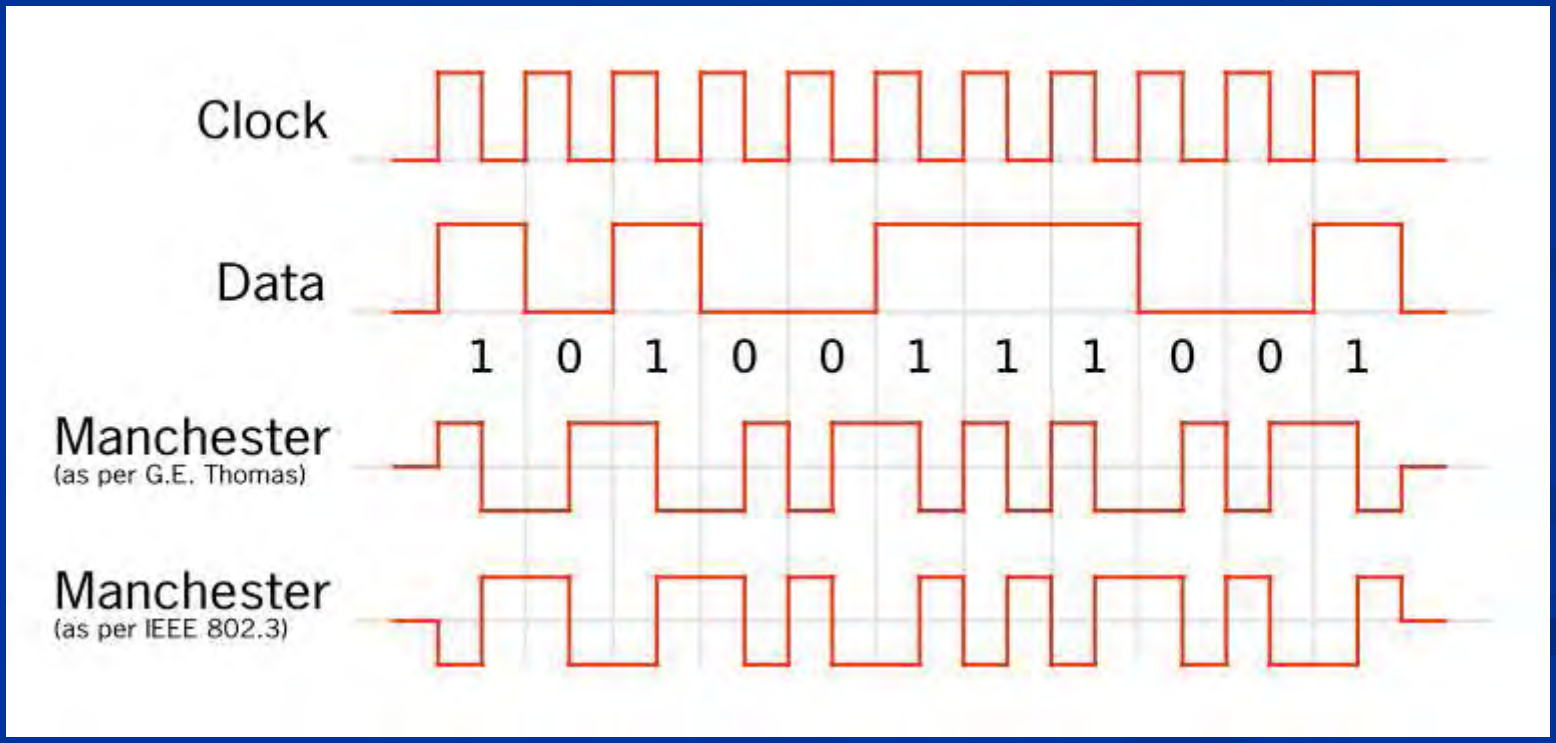
# Encoding Techniques: 10baseT

- 10Mbps, baseband (not carrier modulated), Twisted pair.
- 10Mbps data stream, Manchester coded, produces 20MHz square wave signal.
- Bi-state output: +2.5v and -2.5v.
- Full duplex done with two separate simplex pairs: TX and RX

http://en.wikipedia.org/wiki/10BASET

# Encoding Techniques: 10baseT

- Manchester coding: Output = Data XOR Clock
- Guarantees a state transition with every bit.




http://en.wikipedia.org/wiki/Manchester_code

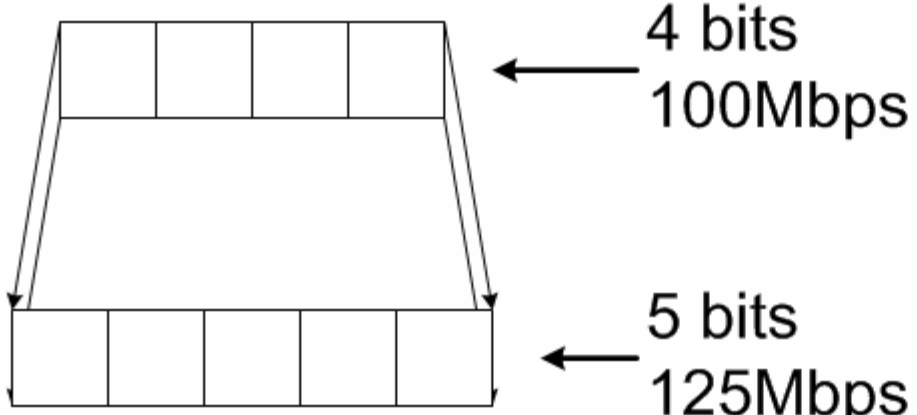
# Encoding Techniques: 100baseT

- 100Mbps, baseband, Twisted pair.
- 100Mbps data stream, 4B5B line coding to ensure sufficient clocking, produces 125Mbps symbol rate.
- MLT-3 encoding produces 31.25MHz tri-state output: +1v, 0v, and -1v.
- Full duplex done with two separate simplex pairs: TX and RX

http://en.wikipedia.org/wiki/Fast_Ethernet

# Encoding Techniques: 100baseT

- 4B5B line coding ensures sufficient 1s density for 0v DC offset. Includes signaling.

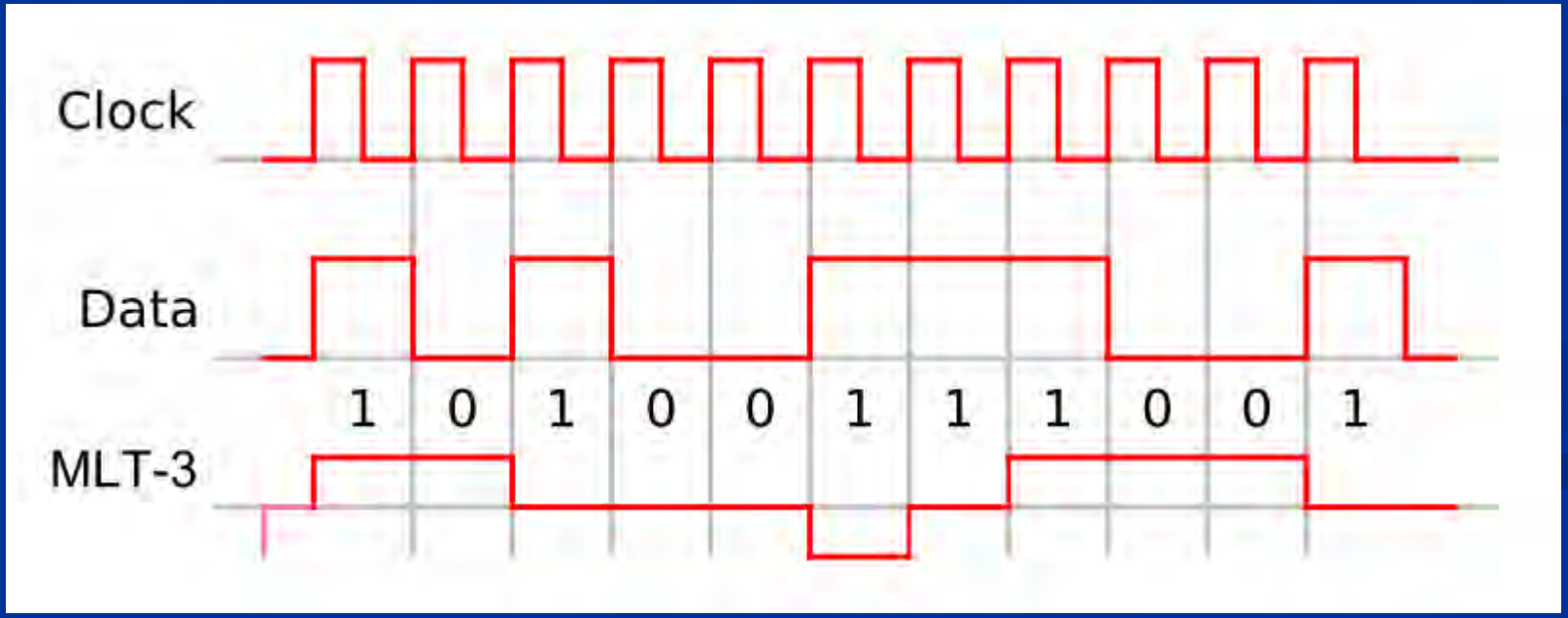



| 4 bits | 5 bits | Description |
|---|---|---|
| 0000 | 11110 | |
| 0001 | 01001 | |
| 0010 | 10100 | Hex Data |
| ... | ... | |
| 1111 | 11101 | |
| -NONE- | 00000 | Quiet (signal lost) |
| -NONE- | 11111 | Idle |
| -NONE- | 11000 | Start #1 |
| -NONE- | 10001 | Start #2 |
| -NONE- | 01101 | End |
| -NONE- | 00111 | Reset |
| -NONE- | 11001 | Set |
| -NONE- | 00100 | Halt |

http://en.wikipedia.org/wiki/4B5B

# Encoding Techniques: 100baseT

- MLT-3 coding. 3 voltage levels, 4 states. Moves to next state on 1, stays on current state on 0.
- Max base frequency is ¼ the data rate.




http://en.wikipedia.org/wiki/MLT-3

# Encoding Techniques: 1000baseT

- …uhh… I'll get back to this later in the talk…

http://www.ieee802.org/3/ab/index.html

http://en.wikipedia.org/wiki/Gigabit_Ethernet

http://en.wikipedia.org/wiki/Pulse_amplitude_modulation

http://en.wikipedia.org/wiki/Trellis_modulation

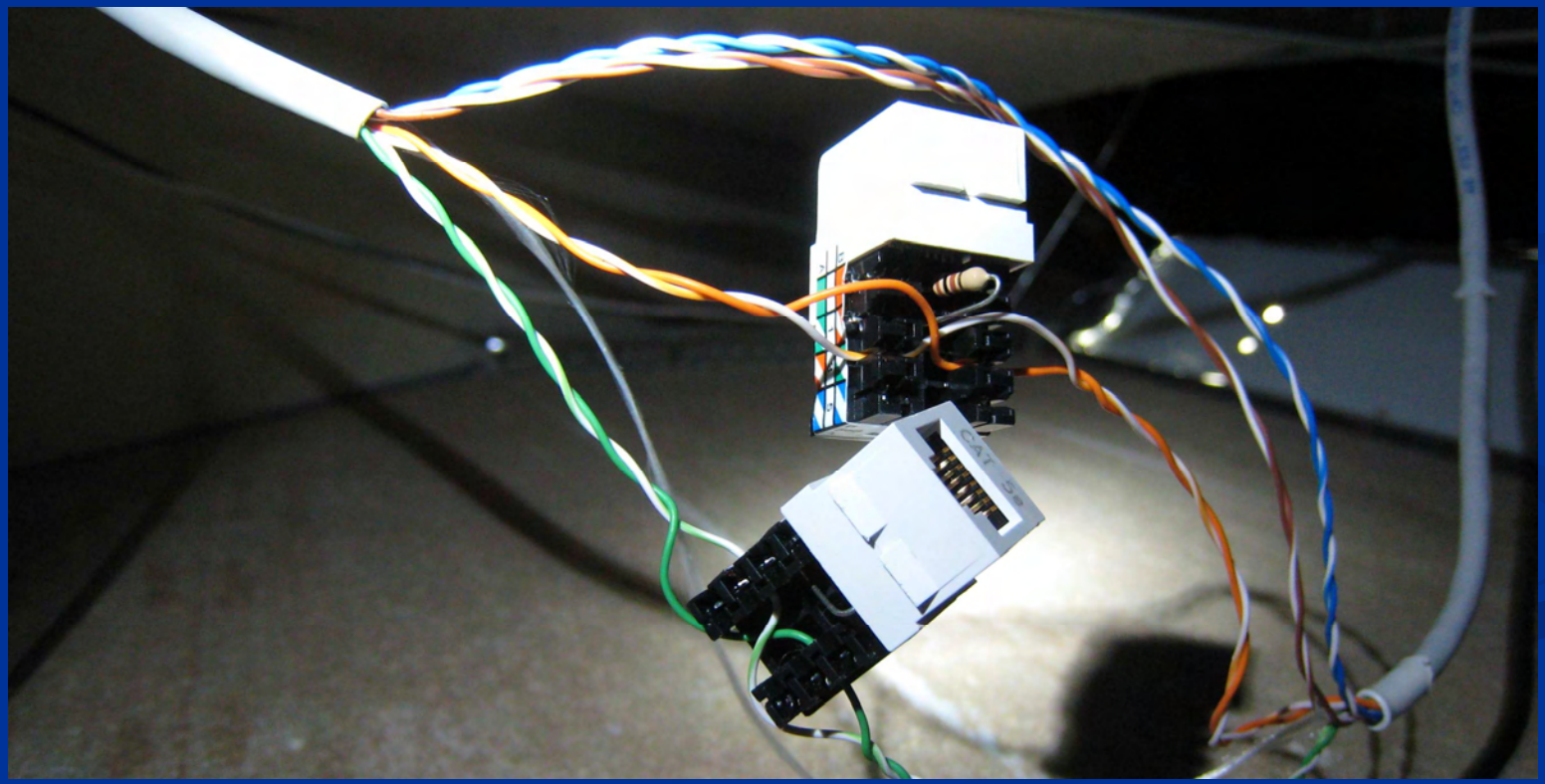
http://en.wikipedia.org/wiki/Linear_feedback_shift_register

# Tapping methods

- DC coupling
- Inductive coupling

# Tapping Methods: DC coupling

- A direct copper connection between the wires being monitored and the monitoring device.

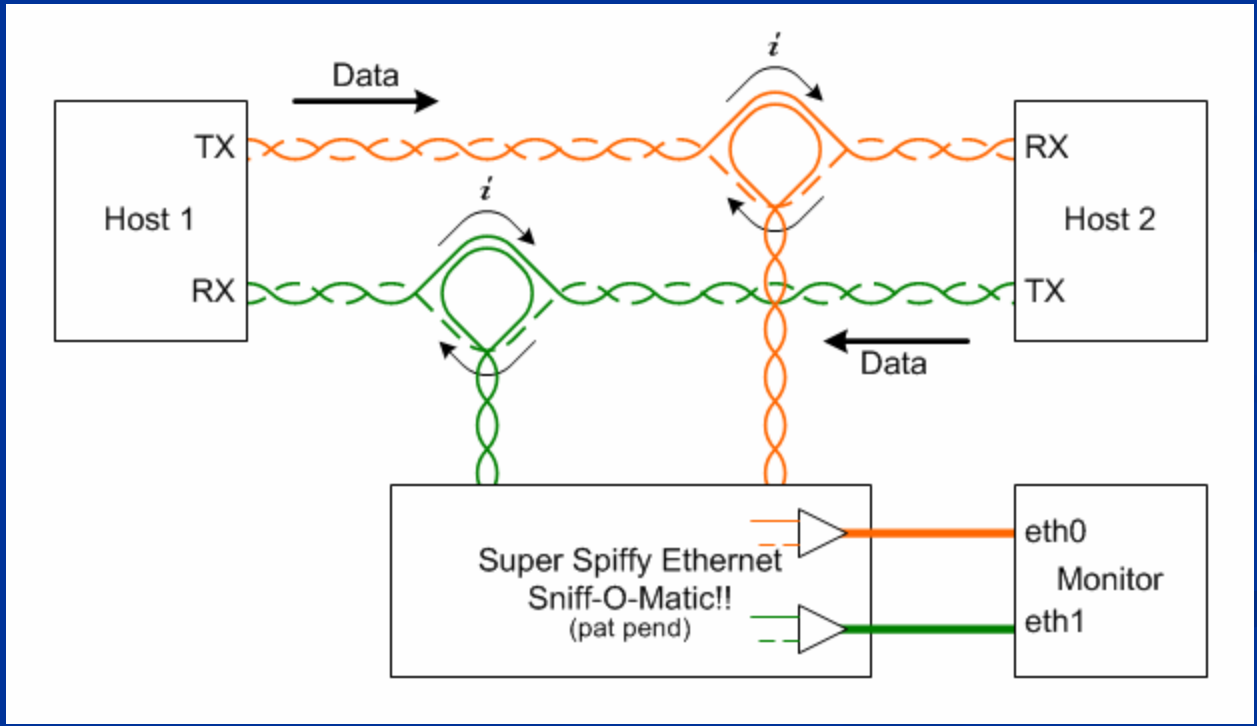


# Tapping Methods: DC coupling

- Pros:
  - Easy to construct and connect.
  - Hardware is cheap and passive; no power required.
- Cons:
  - Accidental DC short, could break link.
  - Tap and branch cause reflections, could break link.
  - Accidental reversal of TX/RX, or auto-negotiation of MDI state will transmit, could break link.

# Tapping Methods: Inductive Coupling

- Build a small transformer with the pair being monitored, pull a bit of the power.



# Tapping Methods: Inductive Coupling

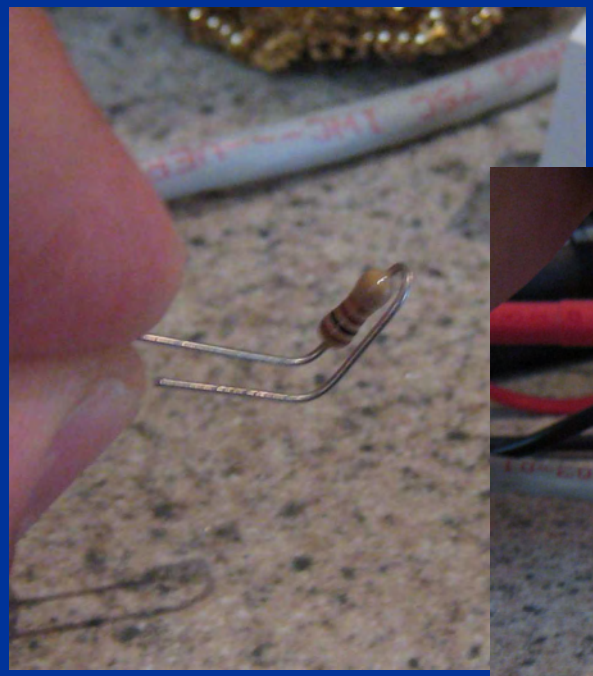
- Pros:
  - Minimal impedance change, hard to detect.
  - Insulation intact, won't accidentally DC short.
  - The receiver amplifier acts as a buffer, prevents accidental transmission.
- Cons:
  - Inductively coupled signal is high impedance; requires amplifier.
  - Transformers are finicky, hard to get right.

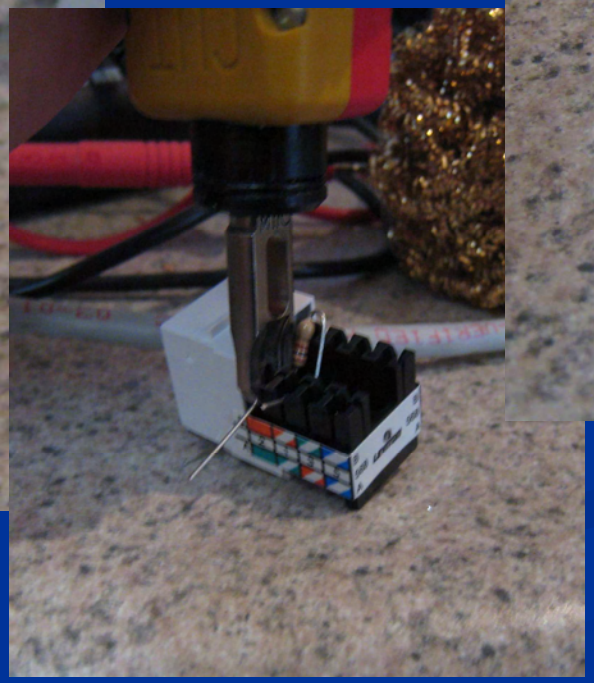
# Hardware Assembly

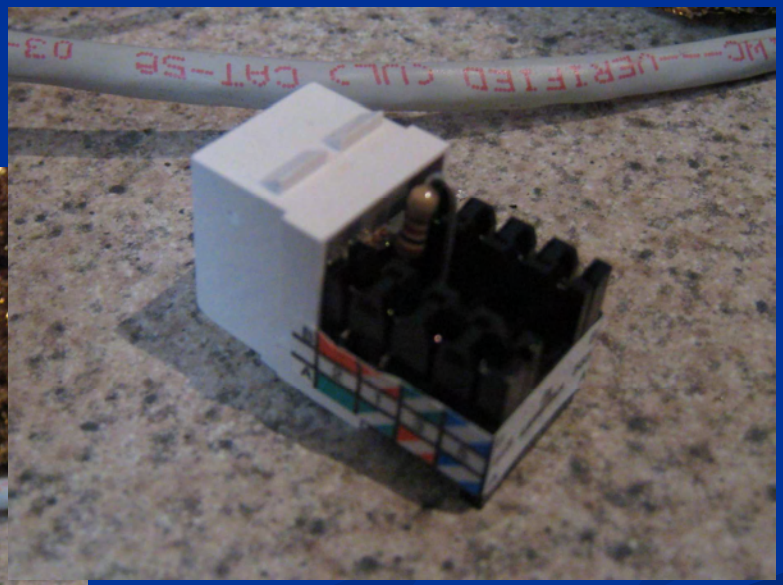
- Because of its simplicity, we'll be using a DC coupled system for today's demonstration.

# Hardware Assembly: DC Coupled

- Punch a 100 ohm resistor across Orange pair of two 568B RJ-45 wall jacks.

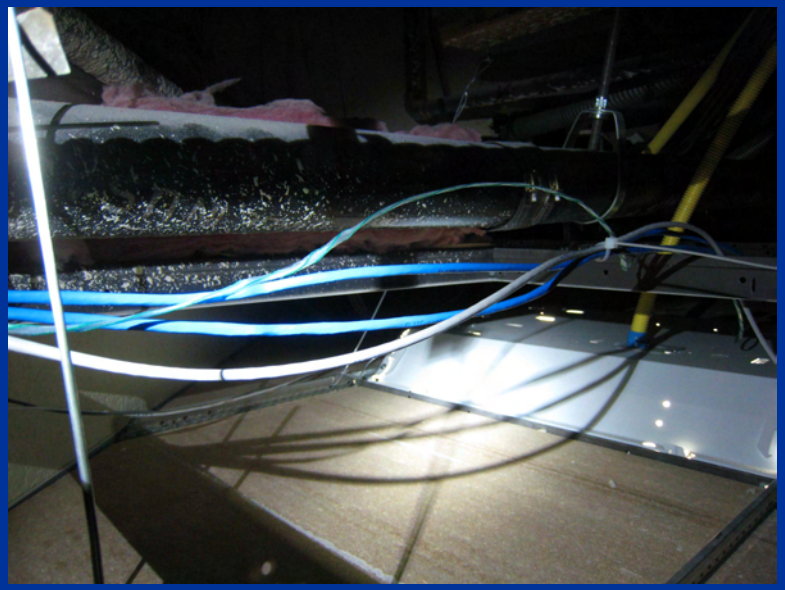


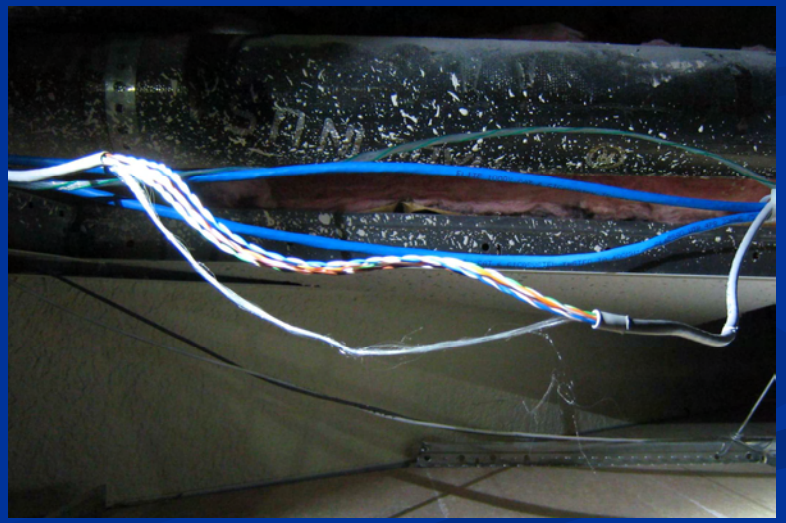




# Hardware Assembly: DC Coupled

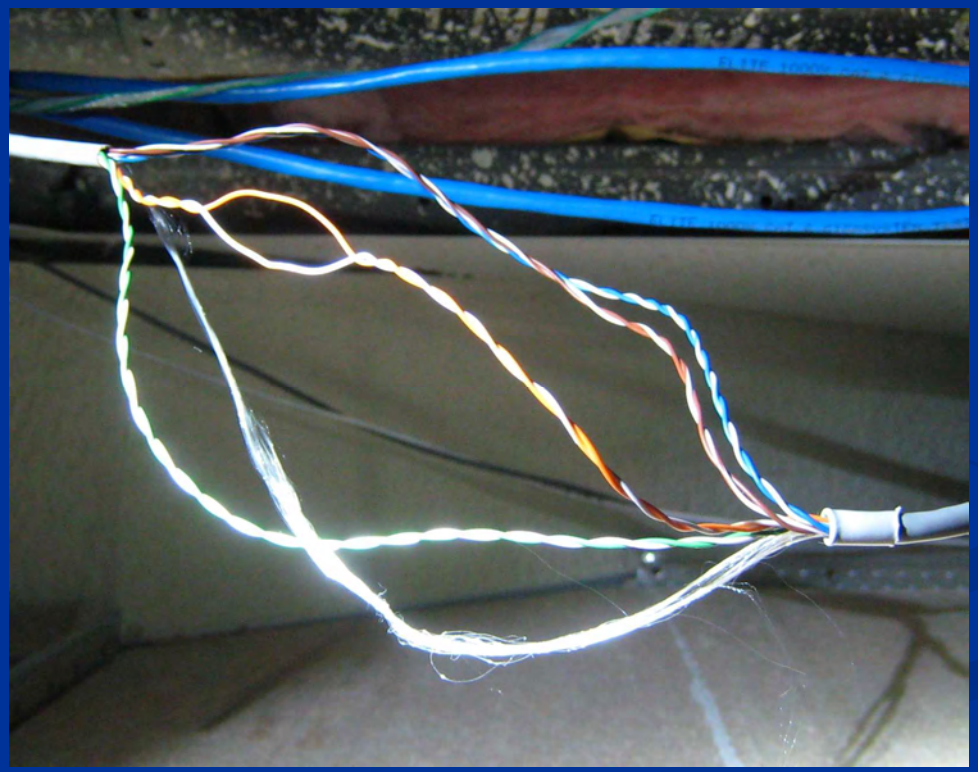
- Carefully cut about 12 inches of the **outer jacket** off the Ethernet cable to be monitored.





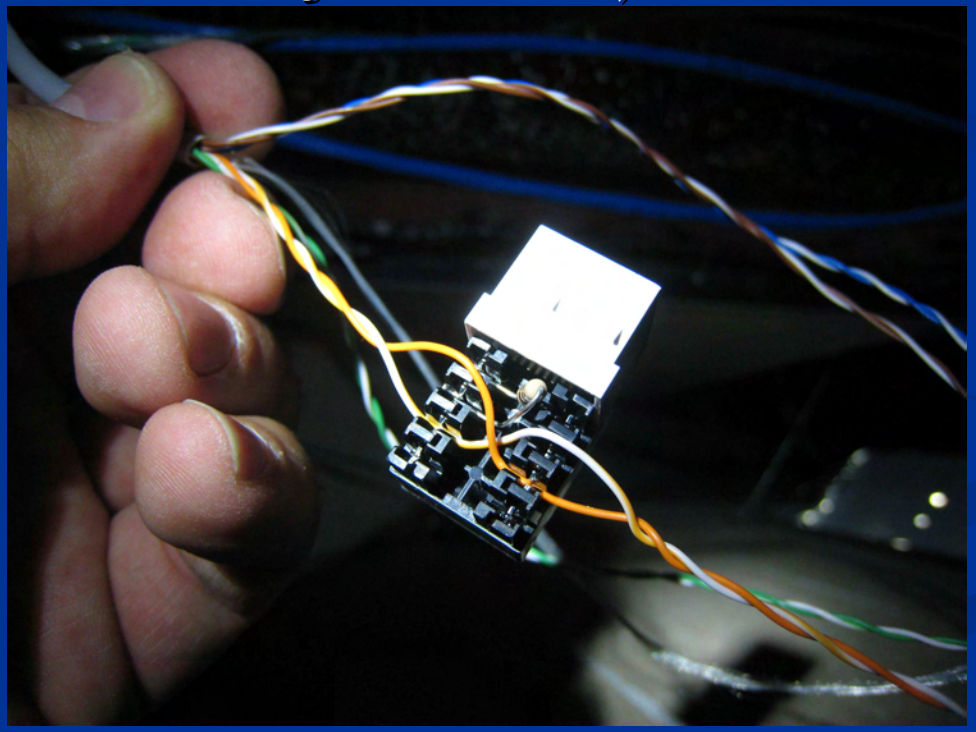
# Hardware Assembly: DC Coupled

- Untwist the Orange pair a bit to give yourself about an inch of straight wires.



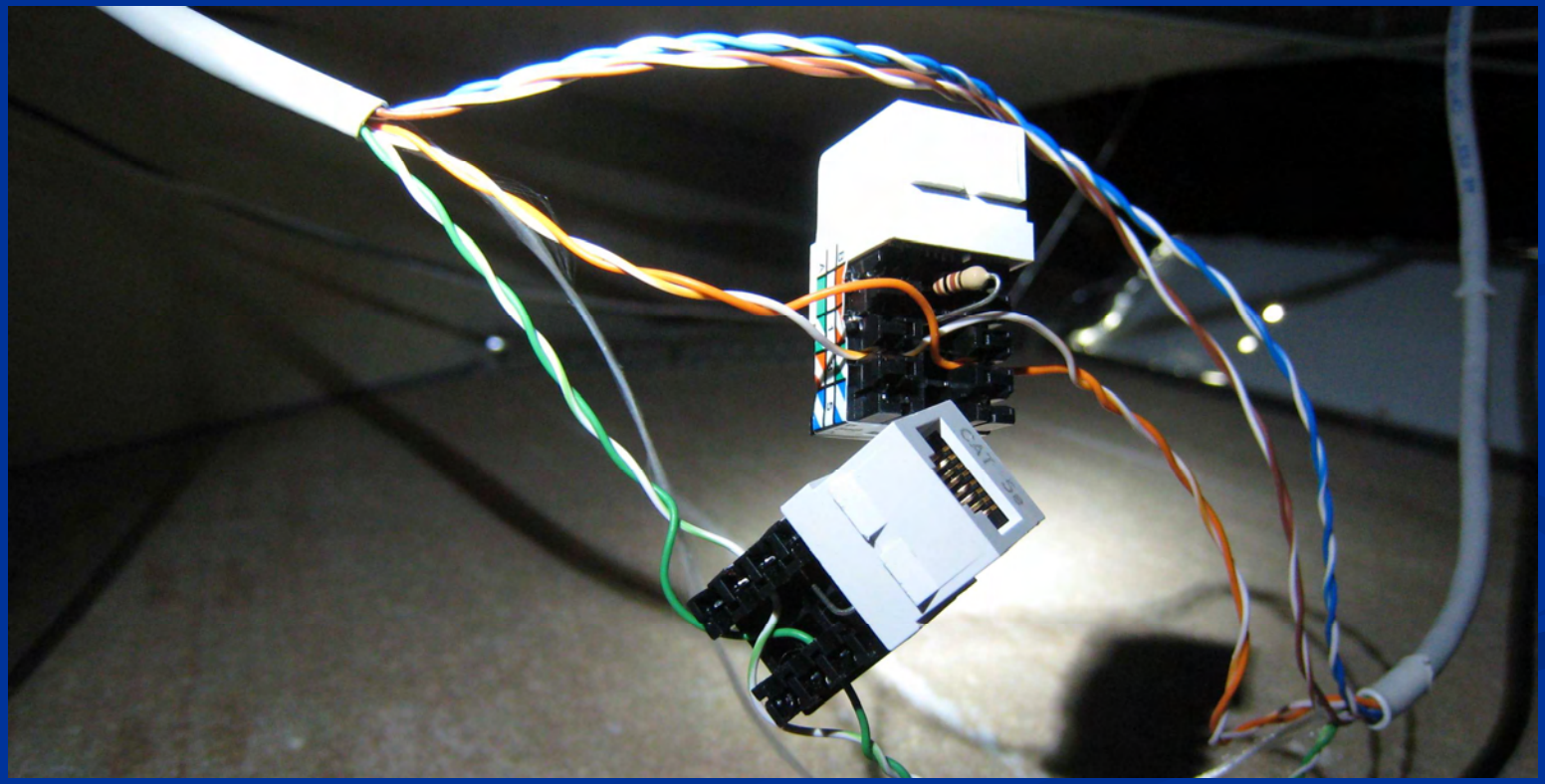
# Hardware Assembly: DC Coupled

- Using the non-cutting side of a punch tool, punch the Orange wire into the Green pair of one of the 568B RJ-45 wall jacks.



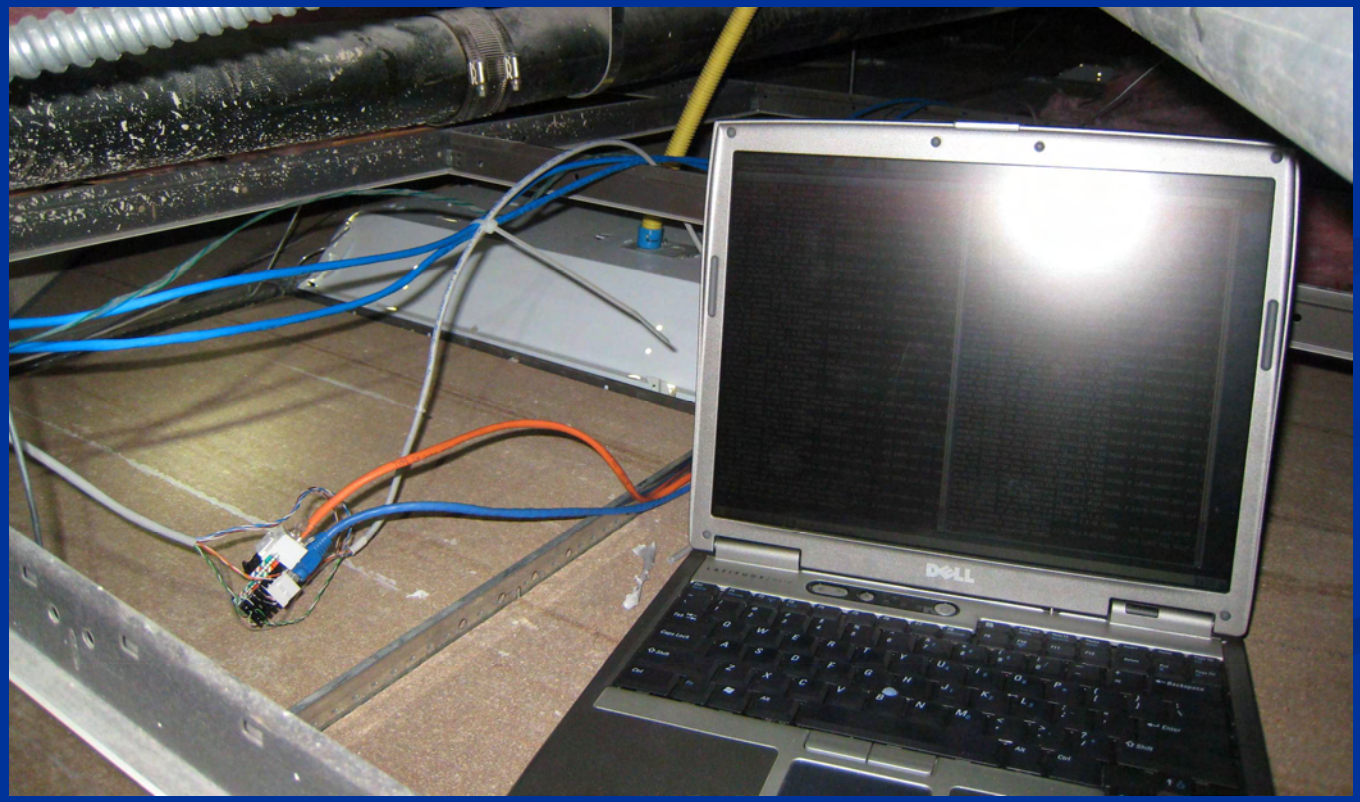
# Hardware Assembly: DC Coupled

- Repeat last two steps with the Green pair.



# Hardware Assembly: DC Coupled

- Connect two standard Ethernet cables from the RJ-45 wall jacks to your monitoring system.



# Hardware Assembly: DC Coupled

- eth0 sees traffic one way, eth1 sees traffic the other way.
- Use tcpdump, WireShark or similar to capture and display the data.
- Capture with precise timestamps, add a bit of scripting, and you can have a single combined data flow.

# Hardware Assembly: Inductively Coupled

- …come see me next year…

# Thinking Black Hat

- Shared phone rooms and wiring closets
- Drop ceilings
- "Protected" conduits (got a pipe cutter from Home Depot?)
- Man holes, J-Boxes, etc.

# Thinking White Hat

- Physical Security. (See other presentations here at DefCon.)
- Encryption. IPSec, TLS, etc.
- Heck, encrypt everything anyway; CPU is cheap.
- Periodic TDR measurements.
- Gigabit Ethernet (stick around…)

# The Holy Grail: Gigabit Ethernet
## …and why it's *REALLY* hard to sniff…

- 10baseT and 100baseT are easy to monitor:
  - Simple line coding techniques.
  - Relatively low signal rates (20MHz and 31.25MHz)
  - Individual TX and RX pairs (each pair is simplex.)
  - Auto-negotiation can be disabled and line settings configured manually.

# The Holy Grail: Gigabit Ethernet
## …and why it's *REALLY* hard to sniff…

- Gigabit Ethernet is none of those things:
  - Auto-negotiation is a requirement of the spec.
  - All four pairs are used *simultaneously* for TX and RX. Two unknowns, only one equation.
  - 1000baseT is far more susceptible to reflections and changes in impedance.

# The Holy Grail: Gigabit Ethernet

## …and why it's *REALLY* hard to sniff…

- Nothing public exists for this yet, but its not impossible.
- A more motivated and better funded organization has probably already figured this out.

# Conclusion

- We've shown that:
  - A careful attacker with no budget can easily tap into unprotected 10baseT and 100baseT.
  - A decently funded attacker can probably do the same thing with 1000baseT.
- If you can't physically secure your network links, encrypt your traffic (IPSec, TLS, etc.)

# Thanks!

- Thanks for listening!
  - Mark Smith, aka Smitty
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http://www.halibut.com/~mark/EtherSniff-v1.0.pdf