

Network Security

Security in local-area networks

Radboud University Nijmegen, The Netherlands



Autumn 2014

Announcement

Exercise class (werkcollege) time and room changed:

Friday, 15:30-17:30, in LIN 8

A short recap

- ▶ Ethernet takes care of transporting frames on the *link layer*
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- ▶ ICMP is used for various control and administration messages

What could possibly go wrong?

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- ▶ Simplified view: all connected Ethernet cables “soldered together”

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- ▶ For > 2 computers need some joint connection
- ▶ A *hub* (active hub) repeats bits received on one port on all other ports
- ▶ Simplified view: all connected Ethernet cables “soldered together”
- ▶ joffrey plugs his computer into the hub:
 - ▶ Can listen (sniff, eavesdrop) to all communication between arya and tyrion
 - ▶ Can jam all communication between arya and tyrion (DOS)
 - ▶ Can impersonate tyrion or arya (more later)

Switched Ethernet

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- ▶ *Network switches* are aware of MAC addresses sitting behind their ports (“port” here only refers to a physical plug socket, not a TCP port)
- ▶ Forward data only to the port with the receiver MAC address
- ▶ Switched Ethernet creates separate *collision domains* for each port

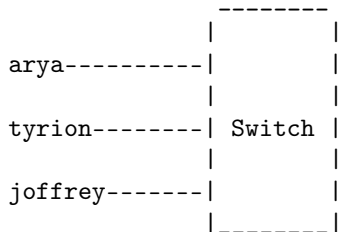
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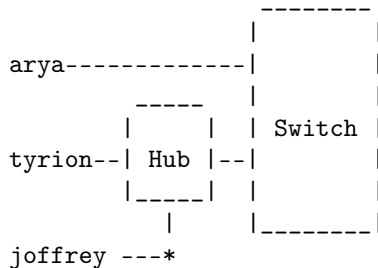
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- ▶ Switched Ethernet creates separate *collision domains* for each port
- ▶ Switched Ethernet also creates separate “sniffing domains” for each port
- ▶ How about our nice attacks, do they still work?

Put back the hub

Before the attack

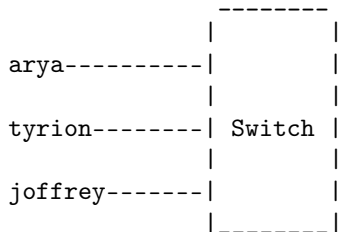


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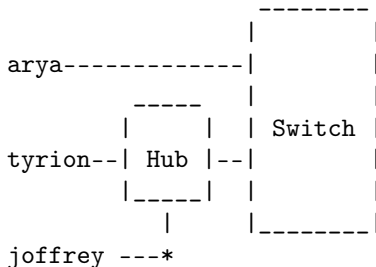


Put back the hub

Before the attack



After the attack



- ▶ Can only sniff traffic to and from tyrion, but often that's enough
- ▶ If you have an old hub, keep it!
- ▶ Could also replace the switch by a hub, but that causes all kind of problems (performance, need access to the switch, etc)

ARP Cache poisoning

- ▶ Before arya contacts tyrion, she will ask for tyrion's MAC address
- ▶ Idea: joffrey can simply answer with his MAC address
- ▶ arya will update her ARP cache entry for tyrion's IP address with joffrey's MAC address
- ▶ arya will then (unknowingly) talk to joffrey instead of tyrion
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 - ▶ *Gratuitous ARP* packets are announcements ("replies without a request")
- ▶ Various good reasons for gratuitous ARP:
 - ▶ Announce IP+MAC at boot time
 - ▶ Announce changed IP address to other hosts
 - ▶ IP-address takeover in high-performance clusters

arp spoof – convenient ARP spoofing

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root@tyrion# arpspoof -t 192.168.42.3 192.168.42.2
```
- ▶ Now use your favorite sniffer on tyrion to see traffic between 192.168.42.2 and 192.168.42.3
- ▶ Remark: arpspoof is part of the dsniff suite

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- ▶ Overflow the table
- ▶ Effects of this depend highly on the switch
- ▶ Some (many?) switches will fall back to behave like a hub

Ettercap

- ▶ Very versatile tool for various low-level (ARP related) network attacks: ettercap
- ▶ Text mode and different GUIs
- ▶ Some features of Ettercap (details in the homework):
 - ▶ ARP cache poisoning
 - ▶ MAC flooding
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 - ▶ Support for plugins
 - ▶ OS fingerprinting
- ▶ Very simple (but important) aspect: find all hosts of the network
- ▶ Simply send ARP requests for all hosts on the (sub)-network

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- ▶ Also, it's not so easy (at least on Linux):
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- ▶ Protection mechanisms on advanced switches (like “Dynamic ARP Inspection” on Cisco switches)
- ▶ Generally it's hard to defend against ARP spoofing, because

ARP does not have any authentication mechanism

VLANs

- ▶ Advanced switches support partitioning of a local-area network (LAN) into multiple *virtual LANs* (VLANs)
- ▶ You can think of a VLAN as physically separated LANs (but easier to manage)
 - ▶ VLANs are separate broadcast domains
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- ▶ This does not prevent ARP-level attacks
- ▶ Can limit the damage caused by ARP-level attacks (“students can only attack each other”)

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"A MAC address is a unique character string, and since it identifies a specific physical device – one individual NIC – the MAC address, by convention, never changes for the life of the NIC. [...] Because your NIC's MAC address is permanent, it's often referred to as the "real," or physical, address of a computer."

<http://www.watchguard.com/infocenter/editorial/135250.asp>

MAC spoofing

“It is possible to spoof the MAC address, so an attacker could potentially capture details about a MAC address from your network and pretend to be that device to connect to your network, but no casual hacker or curious snooper will go to those lengths so MAC filtering will still protect you from the majority of users.”

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- ▶ Going to "those lengths" means the following:

```
root@tyrion# ip link set dev eth0 down
root@tyrion# ip link set dev eth0 address 42:42:42:42:42:42
root@tyrion# ip link set dev eth0 up
```

- ▶ Obviously, 42:42:42:42:42:42 can be any MAC address

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 - ▶ Some proprietary software uses MAC addresses to bind a copy of the software to a fixed computer
 - ▶ In some public places each MAC address gets free WiFi for a fixed amount of time
- ▶ Summary: MAC spoofing is *easy*
- ▶ Security based on MAC uniqueness is bad

Wireless Networks

- ▶ Most important standard for wireless networks: IEEE 802.11 (released 1997)
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- ▶ Communication is physically separated by using different channels (frequencies)
- ▶ Two different modes of operation:
 - ▶ Ad-hoc mode: peer-to-peer communication between nodes
 - ▶ Infrastructure mode: communication through *access point* (AP)
- ▶ Typical (and recommended) setup for permanent installations: infrastructure mode (managed mode)

Connecting to a WiFi network

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 - ▶ If AP decides to accept the client, sends authentication OK
 - ▶ Client sends association request
 - ▶ AP sends association OK
- ▶ Other important management frames
 - ▶ Reassociate request/response frames: change the AP
 - ▶ Disassociate frame: leave the network

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- ▶ Network is not really cloaked, SSID is contained also in other frames
- ▶ Clearly *security by obscurity*, bad practice
- ▶ Not intended by the standard
- ▶ Windows XP machines always prefer access points that broadcast their SSID
- ▶ Very easy to lure those machines into a fake AP

Nice summary on hidden SSIDs

“Do you ever wonder sometimes how it is that some ideas just won't die? Like the thought that not broadcasting your wireless network's SSID will somehow make you more secure? This is a myth that needs to be forcibly dragged out behind the woodshed, strangled until it wheezes its last labored breath, then shot several times for good measure.” —Steve Riley

<http://blogs.technet.com/b/steriley/archive/2007/10/16/myth-vs-reality-wireless-ssids.aspx>

Encrypted WiFi part I

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- ▶ Weak encryption because of US export laws at the time of standardization
- ▶ Two possible authentication mechanisms:
 - ▶ Open System Authentication: no authentication
 - ▶ Challenge-Response Authentication
- ▶ WEP was optional; in the early days of WiFi most networks were not encrypted

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- ▶ Algorithm was a trade secret of RSA Security
- ▶ Posted anonymously to the cypherpunks mailing list in 1994
- ▶ Two parts of the algorithm: key schedule and pseudo-random generation
- ▶ Supports keys of length between 1 and 256 bytes
- ▶ Very small and simple C code, quickly became popular

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 - ▶ Break WEP key after 85000 frames with probability $> 95\%$

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- ▶ Tews, Weinmann, Pyshkin, 2005: tune Klein's attack for WEP
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 - ▶ Break WEP key after 85000 frames with probability $> 95\%$
- ▶ Consequence: Can break WEP in < 1 minute

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- ▶ Remark: bug in iwlwifi driver for monitor mode in kernel 3.14.2, fixed since 3.14.6

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- ▶ Available since 2003 (draft of 802.11i)
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- ▶ Reason for WPA/TKIP: No need to update hardware, “only” firmware

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Weaknesses in WPA



Jacob Appelbaum

@joerror

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@In4711 RC4 is broken in real time
by the #NSA - stop using it.

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Encrypted WiFi part III

- ▶ In 2004, IEEE announces 802.11i (WPA2)
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- ▶ Since 2006 all WiFi certified cards need to support WPA2
- ▶ Different ways of handling authentication and keys, easiest one: pre-shared-key (PSK)
- ▶ PSK is typically derived from a passphrase through a key-derivation-function (specifically, PBKDF2)

Everything fine with WPA2?

- ▶ Essentially three problems with WPA2:

- ▶ Weak passphrases (aircrack-ng has support for brute force):

“A key generated from a pass-phrase of less than about 20 characters is unlikely to deter attacks.”
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- ▶ Last bit of the PIN is a parity bit, hence, only 11000 guesses
- ▶ Brute-forcing this PIN takes < 4 hours

The cryptographer's response

- ▶ It is very hard to prevent an attacker from sniffing your communication
- ▶ It is even harder to prevent an attacker from disrupting your communication
- ▶ System administrators can do something, even harder for users
- ▶ Most of the network is typically not under your control

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- ▶ Solution for confidentiality and integrity: end-to-end encrypt/authenticate everything.