

# Network Security

## Security in local-area networks

Radboud University, The Netherlands



Autumn 2015

# Announcement

Exercise class (werkcollege) room changed:

**Thursday, 8:30–10:30, in LIN 8**

More room changes ahead (for both lecture and exercise class)

## A short recap

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- ▶ UDP much more lightweight, essentially only implements endpoints (ports)
- ▶ ICMP is used for various control and administration messages



What could possibly go wrong?

[this slide intentionally left empty]

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- ▶ 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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- ▶ Forward data only to the port with the receiver MAC address
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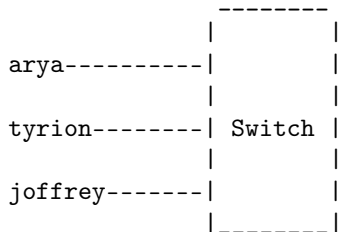
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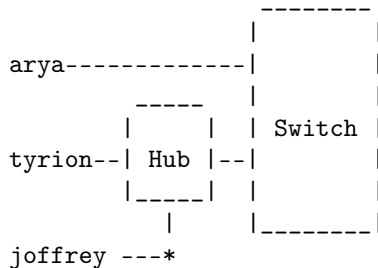
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- ▶ Switched Ethernet also creates separate “sniffing domains” for each port
- ▶ How about our nice attacks, do they still work?

# Put back the hub

Before the attack



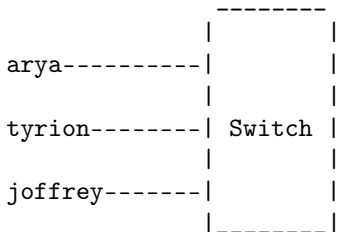
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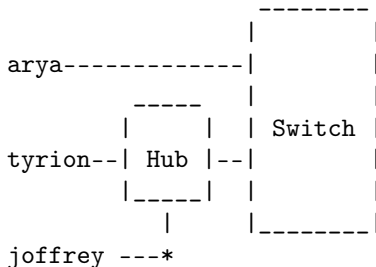


# Put back the hub

## 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

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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

# Ettercap

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

# RFCs

- ▶ RFC stands for *Request for Comments*
- ▶ Publications by the Internet Engineering Taskforce (IETF)
- ▶ Typically describes methods to operate the Internet
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- ▶ Not all RFCs are entirely serious, e.g., [RFC 1149](#) “A Standard for the Transmission of IP Datagrams on Avian Carriers”
- ▶ This RFC has actually been implemented, see <http://web-blog.rhcloud.com/rfc1149/writeup/>

# From RFC 826 – An Ethernet Address Resolution Protocol

?Do I have the hardware type in ar\$hrd?

Yes: (almost definitely)

[optionally check the hardware length ar\$hlen]

?Do I speak the protocol in ar\$pro?

Yes:

[optionally check the protocol length ar\$pln]

Merge\_flag := false

If the pair <protocol type, sender protocol address> is already in my translation table, update the sender hardware address field of the entry with the new information in the packet and set Merge\_flag to true.

?Am I the target protocol address?

Yes:

If Merge\_flag is false, add the triplet <protocol type, sender protocol address, sender hardware address> to the translation table.

?Is the opcode ares\_op\$REQUEST? (NOW look at the opcode!!)

Yes:

Swap hardware and protocol fields, putting the local hardware and protocol addresses in the sender fields.

Set the ar\$op field to ares\_op\$REPLY

Send the packet to the (new) target hardware address on the same hardware on which the request was received.

## Another kind of ARP spoofing ctd.

- ▶ First a clarification of terms:
  - ▶ ar\$hrd: Hardware address space, e.g., Ethernet
  - ▶ ar\$pro: Protocol address space
  - ▶ ar\$hln: byte length of each hardware address
  - ▶ ar\$pln: byte length of each protocol address
  - ▶ ares\_op\$REQUEST/REPLY: Distinguish type (opcode)



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- ▶ Ettercap supports this: `set arp_poison_request = 1` in `/etc/ettercap/etter.conf`

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- ▶ Attack idea: send many Ethernet frames with different source MAC addresses
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- ▶ Effects of this depend highly on the switch
- ▶ Some (many?) switches will fall back to behave like a hub

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- ▶ Disable gratuitous ARP (this may break things)
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  - ▶ Disables gratuitous ARP only for *new* IP addresses!

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- ▶ 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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- ▶ Example use:
  - ▶ Logical network for staff of university institute
  - ▶ Logical network containing computers with student access
- ▶ This does not prevent ARP-level attacks
- ▶ Can limit the damage caused by ARP-level attacks (“students can only attack each other”)

# MAC address filtering

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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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- ▶ Various “security” concepts rely on the fact that you cannot spoof MAC addresses:
  - ▶ 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)
- ▶ Designed to behave in many ways like a wired network
- ▶ Uses the same kind of MAC addresses as Ethernet
- ▶ *Association* with a network corresponds to plugging in the network cable



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- ▶ Networks in vicinity are logically separated by their *network names* (service set identification, SSID)
- ▶ 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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  - ▶ AP sends association OK
- ▶ Other important management frames
  - ▶ Reassociate request/response frames: change the AP
  - ▶ Disassociate frame: leave the network

# Hidden SSID

- ▶ Clients need to know the SSID to authenticate/associate
- ▶ Idea: Don't send this SSID in beacon frames (legitimate users know it anyway)
- ▶ Advertise this as “network cloaking”

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- ▶ 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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- ▶ Two possible authentication mechanisms:
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  - ▶ Challenge-Response Authentication
- ▶ WEP was optional; in the early days of WiFi most networks were not encrypted

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- ▶ 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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- ▶ Consequence: Can break WEP-104 in  $< 1$  minute

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- ▶ The aircrack suite has various filters and switches that influence performance
- ▶ Generally a very powerful tool to break WiFi encryption (see homework)

## Encrypted WiFi part II

- ▶ Drop-in replacement for WEP: WiFi Protected Access (WPA)
- ▶ Available since 2003 (draft of 802.11i)
- ▶ Uses Temporal Key Integrity Protocol (TKIP) for encryption
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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)
- ▶ Most important change compared to WEP and WPA: get rid of RC4
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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.