Switched environments security...
A fairy tale.

Cédric Blancher <blancher@cartel-securite.fr>

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Outline

- Network basics
  - Ethernet basics
  - ARP protocol
- Attacking LAN
  - Several ways to redirect network streams on a LAN.
- ARP cache poisoning, how and why...
  - ARP cache poisoning study
  - Exploiting
- How to protect yourself ?
  - Defending against LAN attacks

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Ethernet :

- Layer 1 and layer 2 protocol
- Different media : 10base2, 10base5, 10baseT, 100baseTX, 100baseFX, etc.

↪ Focus on star-like physical architectures such as 100baseTX or 100baseFX.

Network basics

Ethernet as layer 1 protocol :

- ▶ Relies on CSMA/CD
- ▶ Layer 1 network using hubs
- ▶ Constitutes a collision domain
- ▶ Electrical signal is sent to whole collision domain

↪ Within a collision domain, frames are sent to everyone

Ethernet as layer 2 protocol :

- Ethernet frame :

Destination MAC	Source MAC	Type	Payload	Checksum

Ethernet frame

- Layer 2 addressing : MAC addresses
- Layer 2 networks using switches

Switches : designed for bandwidth improvement

- Is able to read ethernet adresses in frames
- Associates a port to a MAC addresses list
- Reads source MAC address to keep list up to date
- Reads destination MAC address to switch frame

Consequences :

- ▶ Network is split into collision domains
- ▶ Frames are only sent to the concerned port
- ▶ Bandwidth is improved

↪ Urban legend : can't sniff a switched network

Communicating with upper layers

- Layer 2 addressing : ethernet
- Layer 3 addressing : IP
- Need to associate IP addresses to MAC addresses

↪ ARP : Address Resolution Protocol (RFC 826)

Network basics

Hardware type		Protocol type
HW addr lth	P addr lth	Opcode
Source hardware address		
Source protocol address		
Destination hardware address		
Destination protocol address		

ARP message

- HW type : ethernet (0x1)
- Proto type : IP (0x800)
- HW address length : 48 bits
- Proto address length : 32 bits
- ARP request : Opcode=1
- ARP reply : Opcode=2

Network basics

An ARP request : who has 192.168.1.11 tells 192.168.1.10

- From 00:10:A4:9B:6D:81
- To FF:FF:FF:FF:FF:FF (broadcast)

0x1		0x800
0x30	0x20	0x1
00:10:A4:9B:6D:81		
192.168.1.10		
00:00:00:00:00:00		
192.168.1.11		

ARP request

Network basics

An ARP reply : 192.168.1.11 is at 00:04:76:40:65:5E

- From 00:04:76:40:65:5E
- To 00:10:A4:9B:6D:81

<table>
<tr><td colspan="2">0x1</td><td>0x800</td></tr>
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</table>

ARP reply

ARP cache

- ▶ Need to cache ARP informations
- ▶ Need for a mecanism to keep cache up to date
- ▶ Aging timers
- ▶ Update processes
- ▶ “Keep alive” stuff

↪ According to RFC, we are very opportunist when gathering informations

Network basics

We gather informations wherever they are to keep cache up to date

- ▶ ARP requests source informations
- ▶ ARP replies informations (even unasked for !)

↪ ARP cache is a good target for attackers ;)

OK... We’re done with the basics, let’s move on to attacks now.

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LAN attacks

- Layer 1 : sniffing
- Layer 2 : MAC spoofing and “disturbing” switches
- ARP level : ARP spoofing
- ARP level : ARP cache poisoning
- Other attacks

Ethernet frames sniffing

- You can sniff all frames within your collision domain using promiscuous mode

- Pros
  - Passive if done the right way
- Cons
  - Passive
  - Acting on traffic is tricky (ACK storm)
  - Useless in full switched environments

MAC spoofing

- Use a spoofed MAC address as ethernet source
- Relies on MAC/port association table update
- Promiscuous mode to get interesting frames

↪ Pros

- Redirects traffic : we can act on it

↪ Cons

- Spoofed host is no longer reachable by anyone
- Creates port/MAC association conflicts
- Easily detectable behaviour
- Often leads to port shutdown

“Disturbing” switches

- Associations table can be flooded
- Too much conflicts can lead to strange behaviour
- When disturbed, some switches falls into repeater mode (hub-like)

↪ Pros

- Hub-like behaviours

↪ Cons

- Relies on flooding
- Easily detected
- Works on equipements with old firmware
- Often leads to port shutdown

ARP spoofing

- ARP request are sent to broadcast
- It is possible to reply to arbitrary requests, with arbitrary replies

↪ Pros

  - No need to attack switch
  - Allows traffic redirection

↪ Cons

  - Leads to conflicts

ARP cache poisoning

- ▶ We force changes into victim ARP cache
- ▶ See next part ;)

↪ Pros

- ▶ Allows traffic redirection
- ▶ Quite difficult to prevent

↪ Cons

- ▶ Not much...

Other protocols

- Spanning tree protocol (STP)
- Discovery protocols (CDP)
- Automatic VLAN exportation protocols (VTP, DTP)
- Failover protocols (HSRP, VRRP)

↪ Can lead to traffic redirection and DoS

Let’s focus on ARP cache poisoning...

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ARP cache poisoning, how and why

ARP cache updates

- ▶ Opportunistic behaviour
- ▶ Entry insertion
- ▶ Entry update
- ▶ Entry deletion

↪ Let's see how we can fool this...

ARP cache poisoning, how and why

Available parameters

- Ethernet source MAC address
- Ethernet destination MAC address
- ARP HW source address
- ARP Proto source address
- ARP HW destination address
- ARP Proto destination address

ARP cache entry creation

- ▶ When communicationg with unkown IP (ARP request is sent)
- ▶ When unknown IP wants to talk to us (ARP request is received)

↪ Acting on first case is ARP spoofing

↪ Acting on second case is OK if sent directly to target

ARP cache poisoning, how and why

ARP cache entry creation forcing using spoofed request

- Ethernet destination MAC is target address instead of broadcast
- arp-sk -w -d Target -S Spoofed -D Target

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<tr><td colspan="2">0x1</td><td>0x800</td></tr>
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<tr><td colspan="3">Spoofing MAC</td></tr>
<tr><td colspan="3">Spoofed IP</td></tr>
<tr><td colspan="3">00:00:00:00:00:00</td></tr>
<tr><td colspan="3">Target IP</td></tr>
</table>

Fooled ARP request

ARP cache poisoning, how and why

ARP cache entry creation forcing using spoofed reply

- Does not work on all OS (can’t fool Linux 2.4, Windows XP)
- arp-sk -r -d Target -S Spoofed -D Target

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Fooled ARP reply

➥ We prefer use spoofed requests to create entries

ARP cache entry update forcing

- ▶ Can be done using spoofed ARP requests
- ▶ Can be done using spoofed ARP replies
- ▶ Must be sent regularly to avoid legitimate cache update !

↪ Interesting entries are always cached : gateways, DNS servers, etc.

ARP cache poisoning, how and why

ARP cache entry deletion forcing

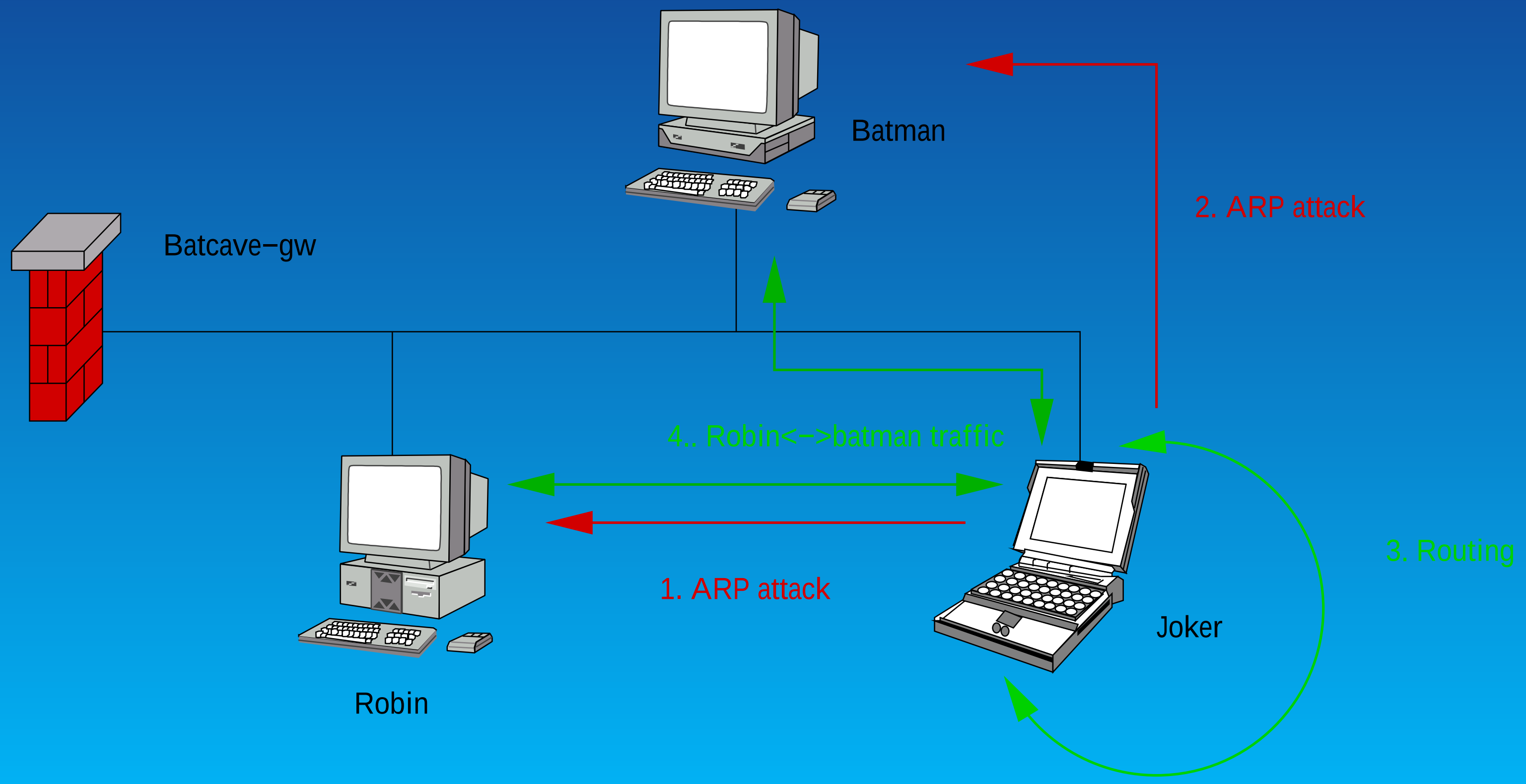
- ▶ Entries can expire
- ▶ Entries number is limited (about 500 for Linux)

↪ By creating enough entries, we force older entries deletion or ARP cache flush

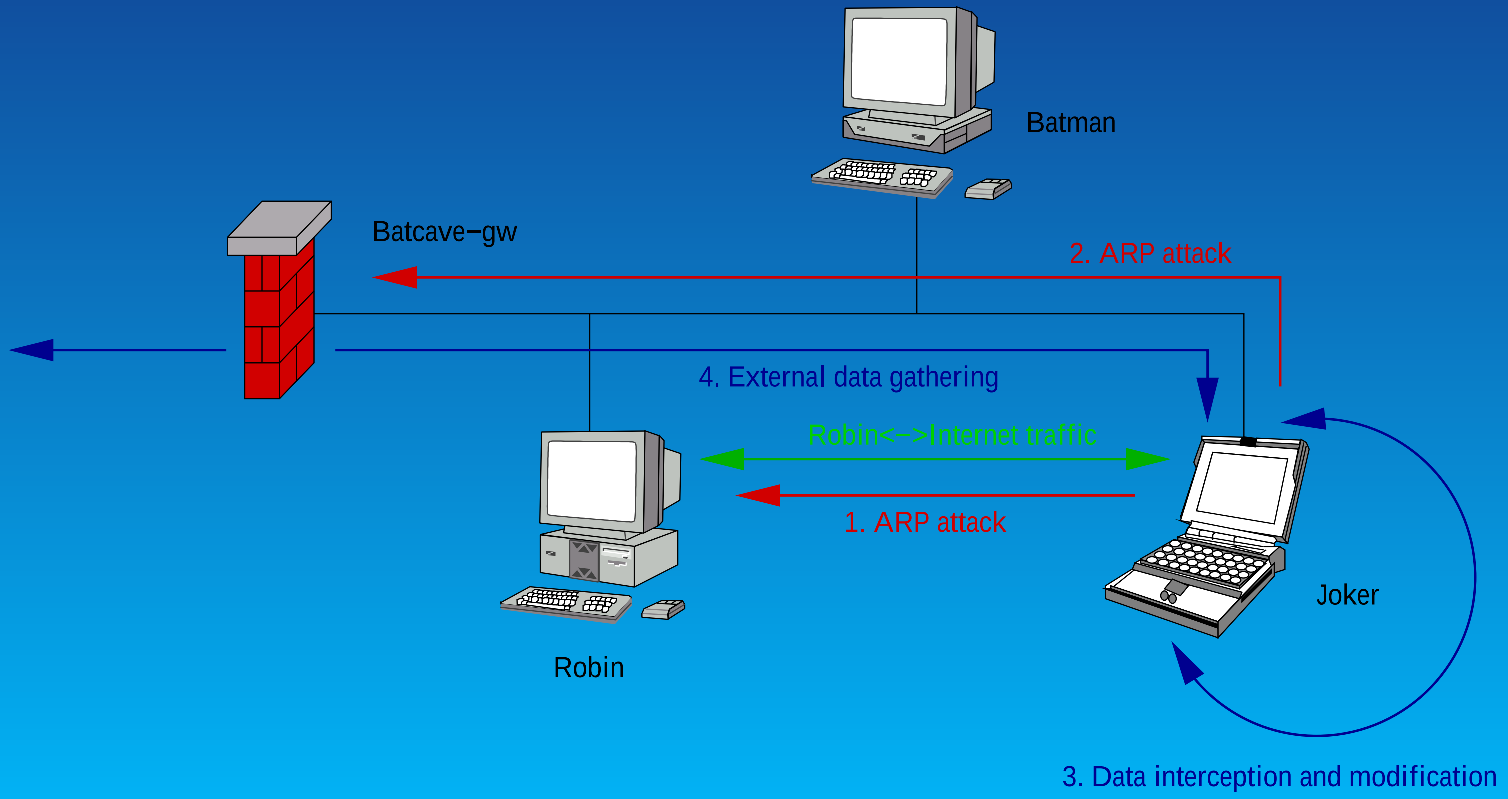
ARP cache poisoning applications

- Spying : you can read data without using promiscuous mode
- Interception : you can transparently proxy connections
- Decrypting : you can decrypt connections using Man in the Middle attack
- Hijacking : you can steal proxied connections
- Tampering : you can inject traffic into proxied connections
- Firewall bypassing : you can bypass firewalling rulesets using IP spoofing
- DoS : packets are redirect to a dead MAC

ARP MitM for spying, decrypting connections

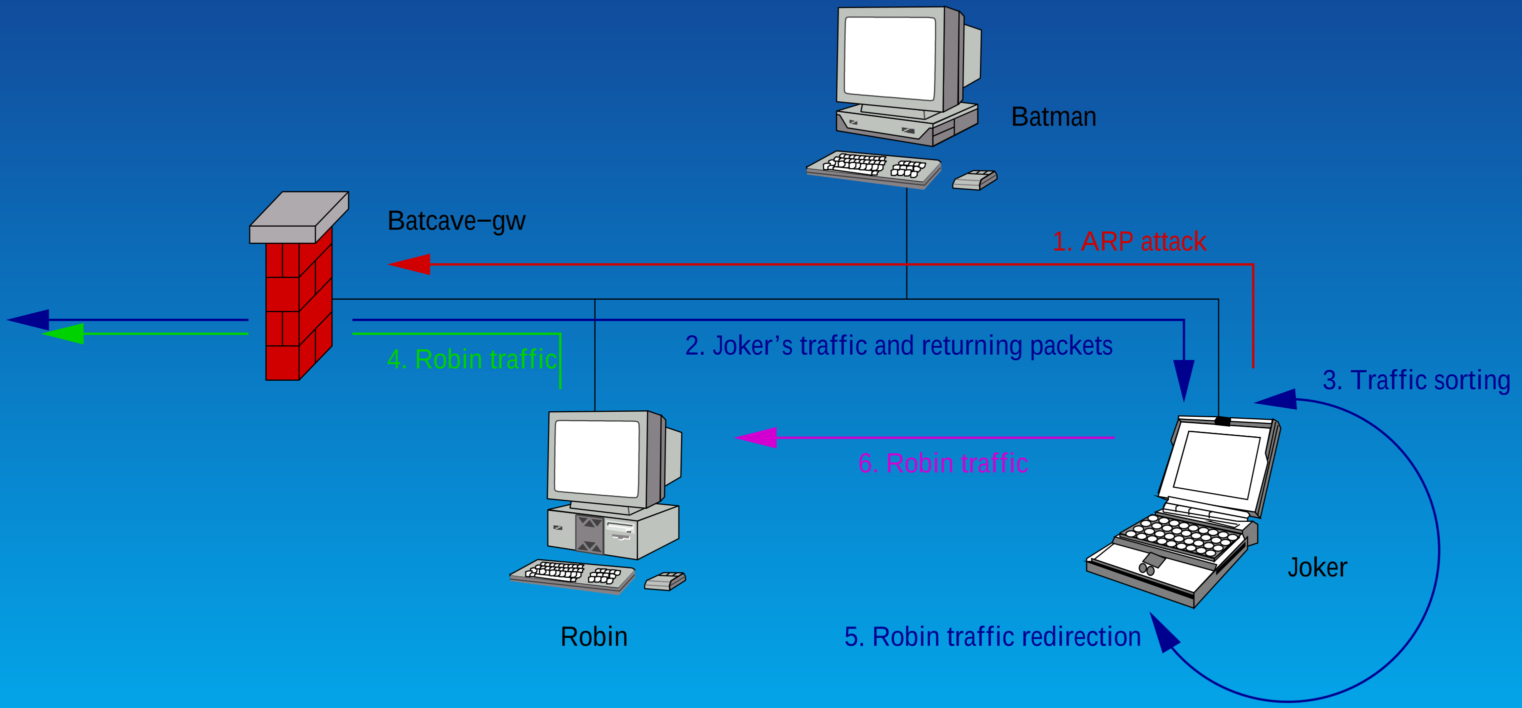


ARP proxying for traffic tampering and connection hijacking



ARP cache poisoning, how and why

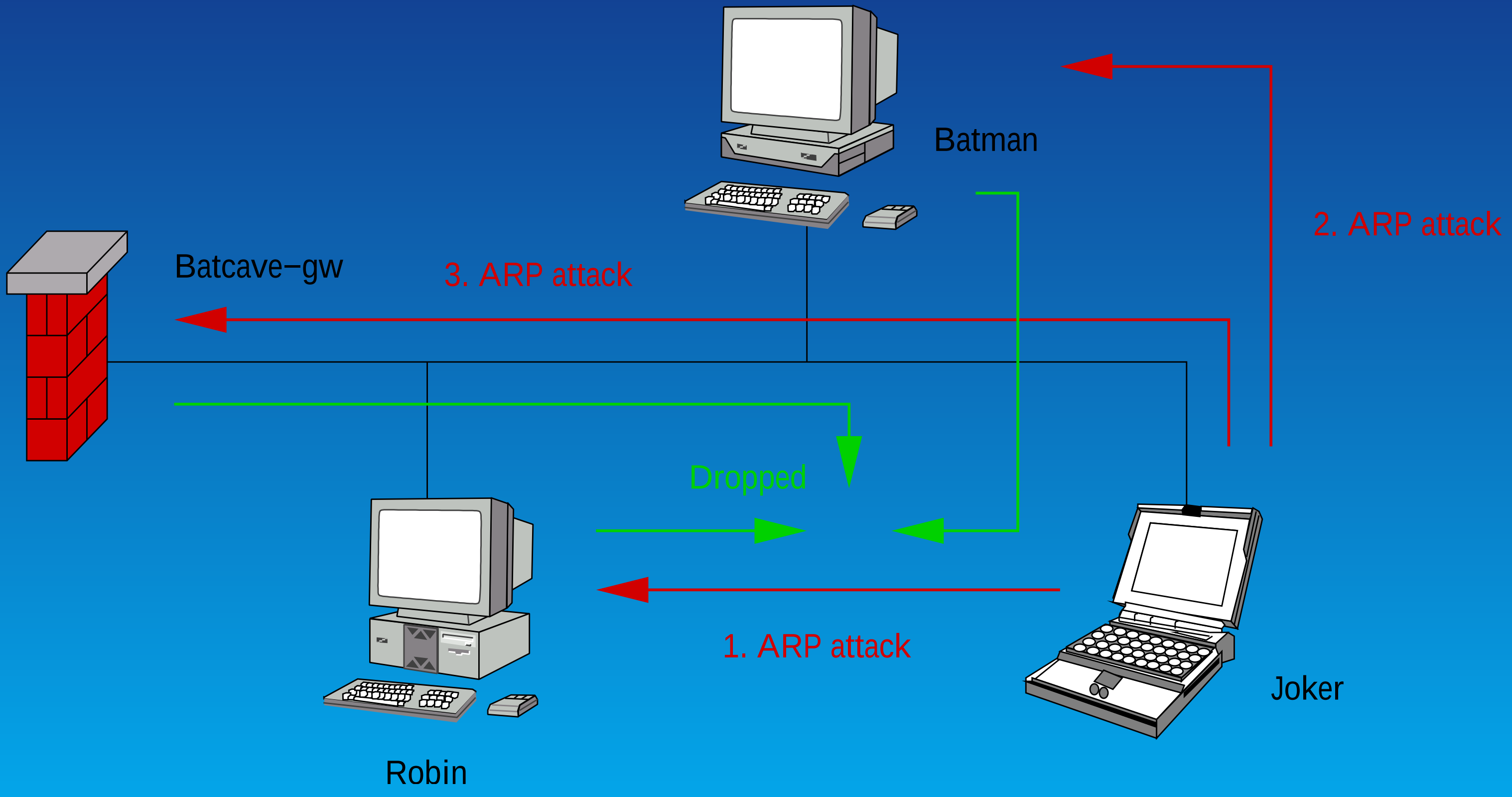
One way ARP cache poisoning for IP spoofing and firewall bypassing



➥ Can be done using MitM between robin and batcave-gw ;)

ARP cache poisoning, how and why

DoS using ARP cache poisoning



- DoSed hosts are likely to check their entries when things go wrong

Consequence

- Once an attacker is root on a network, the whole ethernet segment is no more secure

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Protections

- Maximum segmentation
- Switches security features
- Static ARP caches
- NIDS stuff
- Layer 2 and ARP filtering
- Strong authentication

↪ Theses protections are not easy to maintain, but are needed

Protections

Switches security features

- ▶ Use recent firmware to avoid strange behaviours
- ▶ Use static MAC/port associations when available
- ▶ Use administrative port shutdown when conflict occurs

↪ Prevents MAC spoofing or flooding, but not ARP attacks

↪ Some layer 3 switches feature IP/MAC/port associations

Static ARP caches

- ARP entries can be added “manually” using arp -s
- /etc/ethers like files can be loaded using arp -f
- Such entries are permanent : cannot be nor deleted nor updated

↪ Prevents ARP attacks

↪ Beware of the Windows world, in which permanent entries can be updated (except in XP)

↪ You can sometimes set ARP entries expiration time (Solaris, Linux)

↪ A lot of commercial products do not feature ARP cache tuning

NIDS stuff

- ARPWatch (and WinARPWatch) allows you to track IP/MAC associations through ARP messages
- Some NIDS feature an ARP plugin that monitors ARP messages (Prelude IDS)

↪ Allows detection, but reaction is tricky : fooled messages don't violate RFC

↪ NIDS lack ARP support : you can't specify specific rules for ARP

Layer 2 and ARP filtering

- ▶ Linux Netfilter has a MAC source address match
- ▶ Linux Netfilter will soon provide an ARP table for ARP messages filtering

↪ Lack of products that allow this kind of filtering

Protections

Strong authentication

- ▶ Relies on cryptographic authentication
- ▶ Use public keys, certificates or secure authentication protocols

↪ Reliable but quite painful to deploy

↪ Users can be fooled by well crafted false certificates

Protections

Check physical accesses to your network

- ▶ Social engineering
- ▶ Foreign computers, such as laptops
- ▶ Wireless access points (802.11b)

↪ Do not let anybody plug himself onto your network !

Conclusion

ARP is a weak protocol, easy to fool : it was not designed for security.

We need a more secure way to authenticate hosts.

Whatever, it is obvious that switches are not security tools.

<PUB>

- French security magazine MISC

</PUB>

Thanks

Thanks to :

- Frédéric "Pappy" Raynal for convincing me into looking deeper in that stuff and writing arp-sk
- Éric Detoisien for writing Win32 tools winarp-sk and winarp-mim
- Daniel "Bozo" Polombo for having performed a heavy de-obfuscating task on my slides

Links

- http://www.networksorcery.com/enp/default0402.htm
- http://www.arp-sk.org/
- http://www.monkey.org/~dugsong/dsniff/
- http://www.bitland.net/taranis/
- http://www.off.net/~jme/ols2000/html/img0.htm
- http://www.netfilter.org/
- http://letanou.linuxfr.org/arpwatch/arpwatch.html
- http://jota.sm.luth.se/~andver-8/warp/
- http://www.prelude-ids.org/
- http://www.cartel-securite.fr/