the hacker's choice

presents:

Attacking the IPv6 Protocol Suite

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Contents

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Very short and fast Introduction to IPv6

- Goals of IPv6:
  - Enough IP addresses for the next decades
    - 2^{128}=340.282.366.920.938.463.463.374.607.431.768.211.456
  - Autoconfiguration of IP addresses and networking
  - Hierarchical address structure
    - Reduces operational costs
  - Integrated security features

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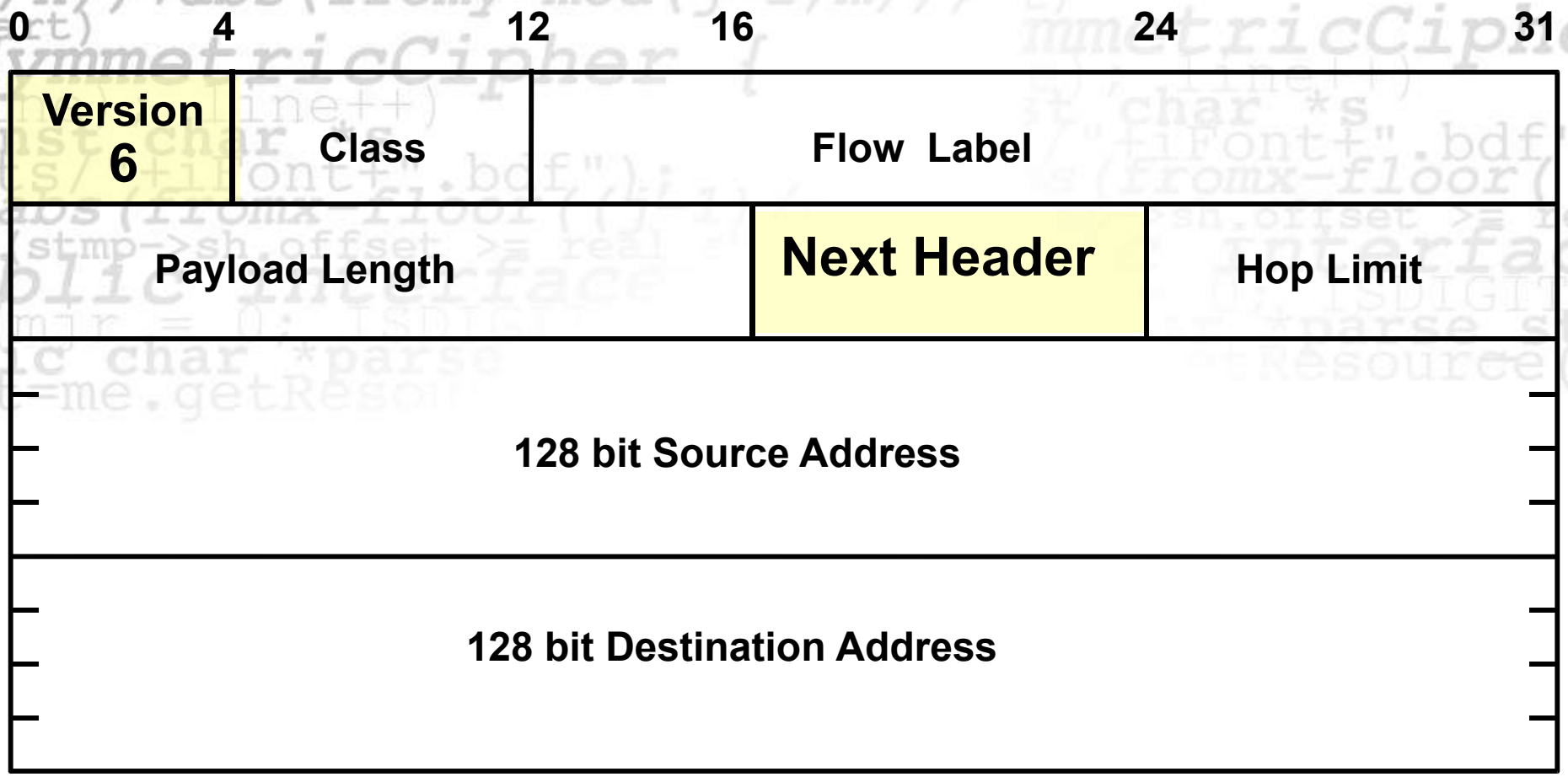
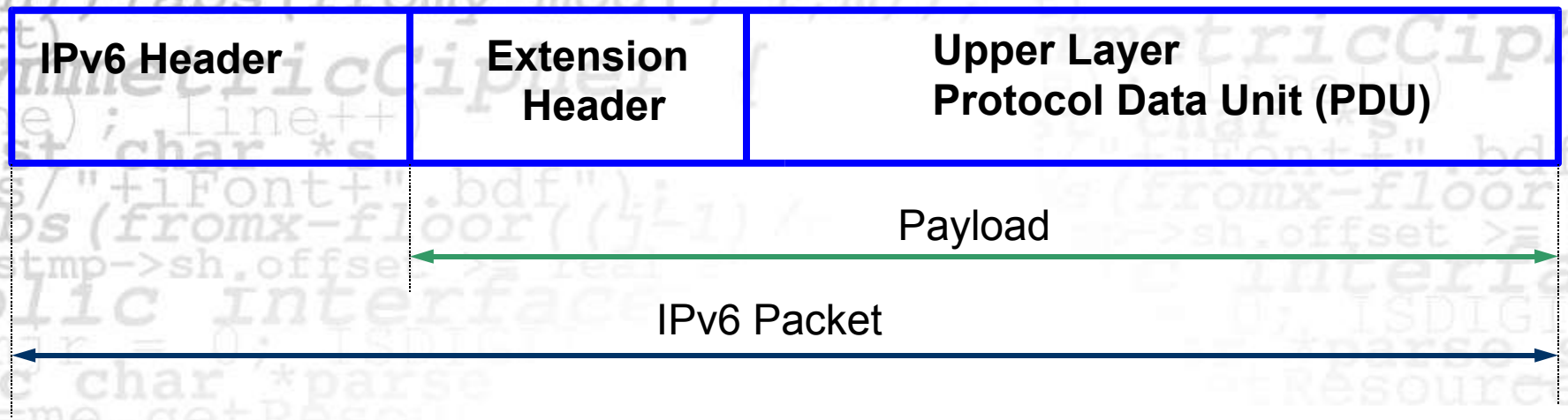
IPv6 Header Structure



IPv6 Layer Structure



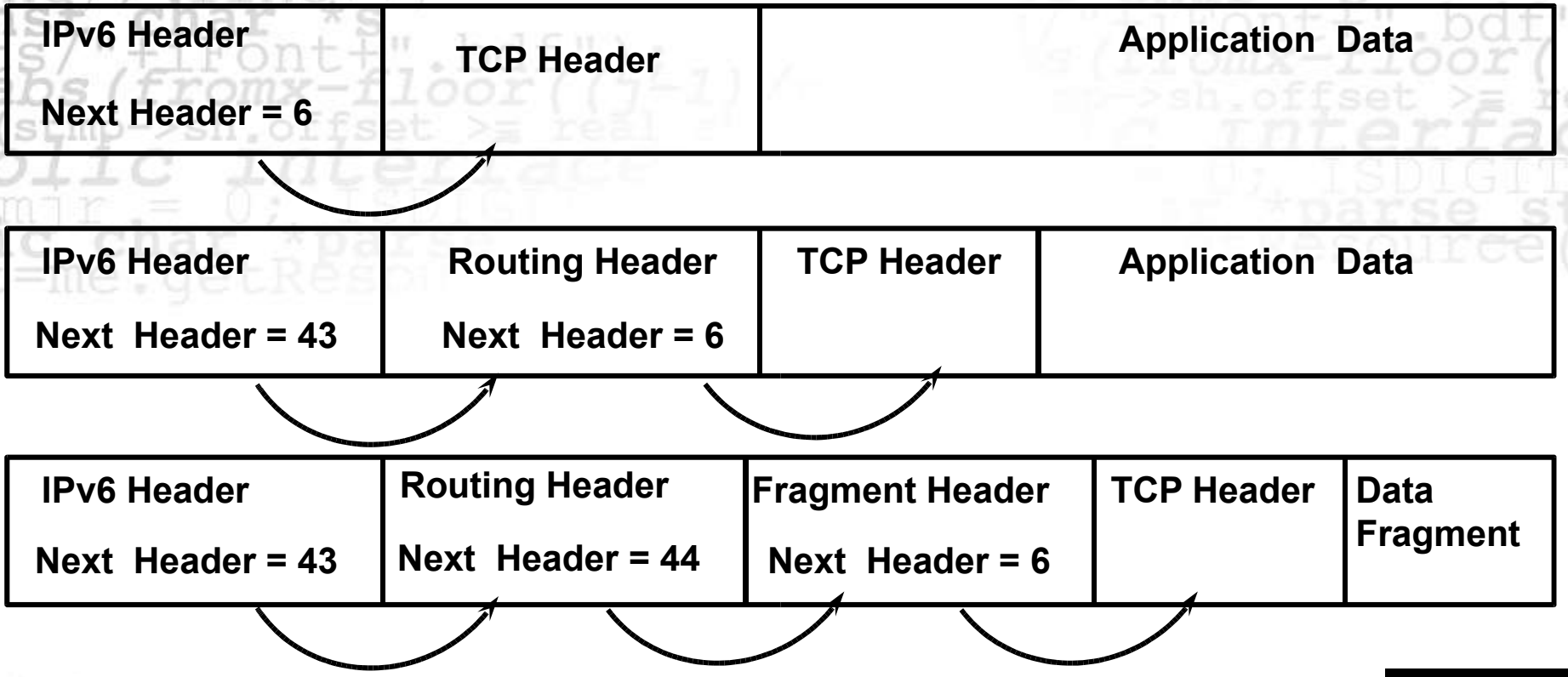
IPv6 Header **40 Bytes**

Upper Layer PDU 65535 Bytes

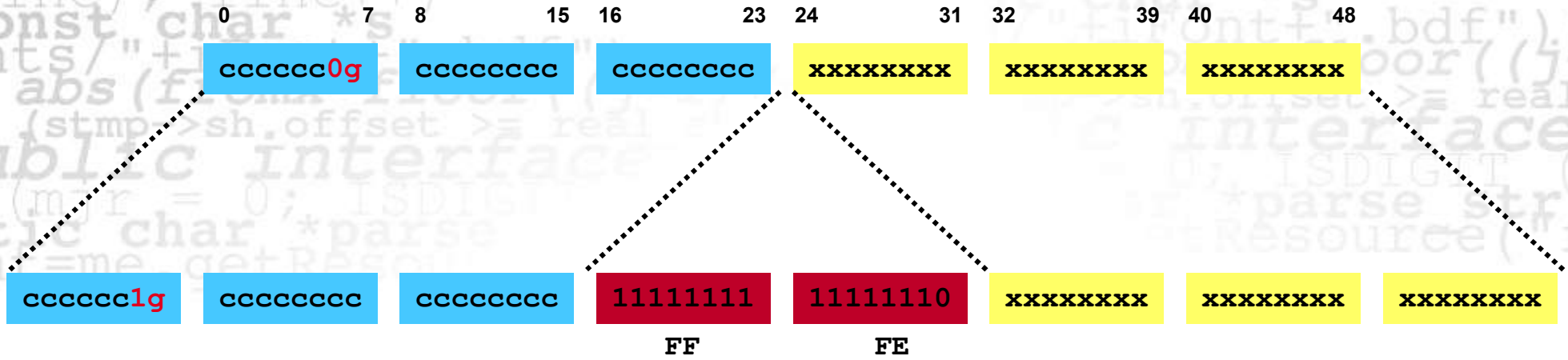
Upper Layer PDU 65535 Bytes = Jumbo Payload

IPv6 Header Structure

Examples for Extension Headers: Hop-by-Hop = 0; UDP = 17; Encapsulated Header = 41; RSVP = 46; IPSEC (Encapsulating Security Payload = 50; Authentication Header = 51;) ICMPv6 = 58; No Next Header = 59; Destination Options = 60; OSPFv3 = 98



IPv6 Interface Identifier (EUI-64 Format) Mapping



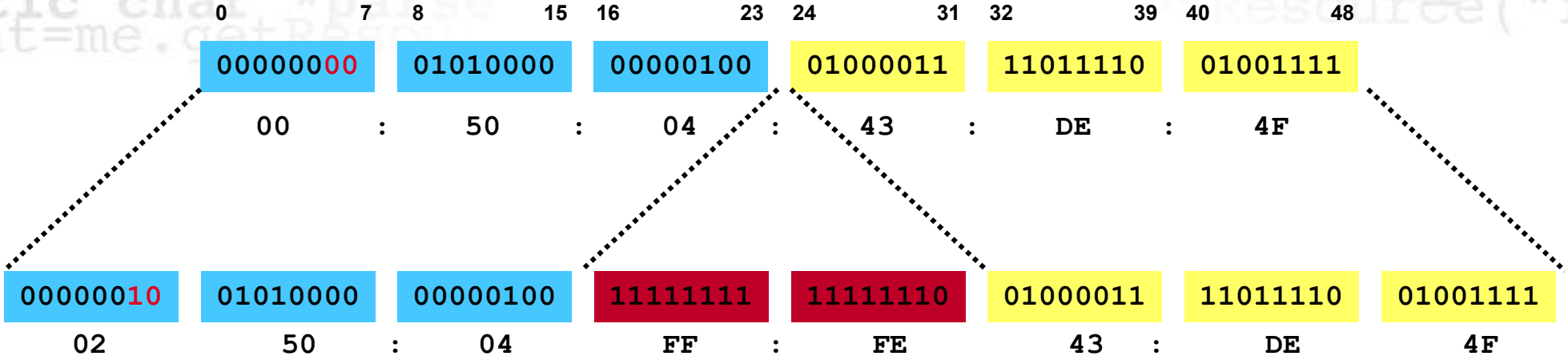
IPv6 Interface Identifier im EUI-64 Format

EUI: Extended Unique Identifier

c = company id
x = extension identifier
g = Individual/Group (G): 0 - unicast 1 - multicast

Example

```
# ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:50:04:43:DE:4F
          inet addr:10.2.1.1  Bcast:10.2.1.255  Mask:255.255.255.0
          inet6 addr: 3ffe:ffff:100:f101:250:4ff:fe43:de4f/64 Scope:Global
          inet6 addr: fe80::250:4ff:fe43:de4f/64 Scope:Link
          ...
```



Blackhat usage of IPv6 today

Backdoor deployment

- Enable IPv6 (6to4)
- Run Backdoor on IPv6
- No chance to detect by port scanning
- Hard to analyze if backdoor traffic is detected

Inter-Communication

- Establishing of IPv6 interconnections (via 6to4) for warez exchange, IRC and bouncing

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Availability of Hacker Tools so far …

The following Hacker tools exist:

- Port Scanning: nmap, halfscan6, …
- Port Bouncers: relay6, 6tunnel, nt6tunnel, asybo, …
- Denial-of-Service (connection flooding): 6tunneldos
- Packet fun: isic6, libnet (partially implemented only)

No IPv6 specific attack tools exist so far!

This will change when IPv6 deployment is wider

… but you do not want to wait, right?

The THC IPV6 Attack Suite

- THC has developed an easy-to-use IPv6 packet factory library
- Numerous IPv6 protocol exploits tools can be coded in just 5-10 lines
- Lots of powerful protocol exploits already included
- Caveat of current code state:
  - Linux only
  - Little Endian
  - 32-Bit
  - Ethernet

The THC IPV6 Attack Suite

- Implementation is simple!
- Two slides for 90% of the source for the Redirector redir6.c:
- Sending an ICMP6 Echo Request:
  - pkt = thc_create_ipv6(interface, PREFER_GLOBAL, &pkt_len, *src6*, ***target6***, 0, 0, 0, 0, 0);
  - thc_add_icmp6(pkt, &pkt_len, ICMP6_PINGREQUEST, 0, 0xdeadbeef, NULL, 0, 0);
  - thc_generate_and_send_pkt(interface, NULL, NULL, pkt, &pkt_len);
- Target6 will answer with an ICMP6 Echo Reply

The THC IPV6 Attack Suite

- Sending an ICMP6 Redirect after the ping:
  - ipv6 = (thc_ipv6_hdr *) pkt;
  - thc_inverse_packet(ipv6->pkt + 14, ipv6->pkt_len - 14);
    - This function inverses the Echo Request Packet to an Echo Reply Packet
  - thc_redir6(interface, *oldrouter6*, fakemac, NULL, ***newrouter6***, mac6, ipv6->pkt + 14, ipv6->pkt_len - 14);
    - This functions sends an ICMP Redirect, implanting ***newrouter6*** instead of the old default router *oldrouter6* for *src6*
- That's all – traffic will now be sent to newrouter instead!

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The THC IPV6 Attack Suite – The Tools

- PARSITE6
  - ICMP Neighbor Spoofer for Man-In-The-Middle attacks
- DOS-NEW-IPV6
  - Denial any new IPv6 system access on the LAN (DAD Spoofing)
- REDIR6
  - Redirect traffic to your system on a LAN
- FAKE_ROUTER
  - Fake a router, implant routes, become the default router, …
- SMURF6
  - Local Smurf Tool (attack you own LAN)
- RSMURF6
  - Remote Smurf Tool (attack a remote LAN)

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The THC IPV6 Attack Suite – The Tools

- TOOBIG6
  - Reduce the MTU of a target
- Alive6-Local
  - Find all local IPv6 systems
- Alive6-Remote
  - Find alive IP6 systems in a remote LAN
- Protocol Implementation Tester:
  - Fragmentation + Routing Header
  - Mass Headers
  - Invalid Pointers
  - …

>> By the time of this presentation: *NEW TOOLS* ☺ <<

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Security relevant changes from IPv4 to IPv6

- Executive Summary:
  - IPv6 and IPv4 security is quite similar
  - Basic mechanisms are the same
  - Application layers are unaffected
  - IPv6 includes IPSec but currently not used
  - IPSec would not prevent attacks on application level in Internet applications

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Overview of security relevant changes

1. Protocol Changes
2. Reconnaissance
3. Local Attacks: ARP, DHCP
4. Smurfing (Traffic Amplification)
5. Routing & Fragmentation Attacks
6. IPv4 and IPv6 coexistence

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1. Protocol Changes

- Few IP header content and options were removed:
  - No IP ID field
    - Nice uptime check not possible anymore ☹
  - No IP Record Route Option
    - No traceroute alternative anymore ☹
- No Broadcast addresses exist
- Multicast addresses can not be destined from remote
  - Big problem for alive scanning!

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2. Reconnaissance IPv4

Network size in a subnet usually 2^8 = 256

Usual attack methodology:

1. Ping sweeps to a target remote class C (takes 5-30 seconds)
2. Port scans to an alive host
3. Vulnerability test to active ports

Wide range of tools available

- Nmap
- Amap
- Nessus
- ...

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2. Reconnaissance IPv6 (1/2)

Network size increased to 2^64 *(varies)* in a subnet

- 18.446.744.073.709.551.616 possible hosts in a subnet
- Ping sweeps will consume too much time
  - Brute force: ***500 millions years***
  - Being clever + technology advances: still some months
- Public servers need to be in the public DNS
- All hosts need to be in a private DNS for admin purposes

>> DNS Servers will become primary <<
>> sources of information – and primary targets! <<

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2. Reconnaissance IPv6 (2/2)

- New opportunities are standardized multicast addresses to identify key servers within the local Network (routers, DHCP, Time, etc.)
- Local multicasts will ensure that one compromised host can find all other hosts in a subnet
- Techniques to a single host remain the same (port scan, attacking active ports, exploitation, etc.)
- Remote alive scans (ping scans) on networks will become impossible

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2. Reconnaissance with the THC-IPV6 Attack Toolkit

- alive6-local – for local/remote unicast targets, and local multicast addresses
  - Sends three different type of packets:
    - ICMP6 Echo Request
    - IP6 packet with unknown header
    - IP6 packet with unknown hop-by-hop option
    - IP6 fragment (first fragment)
- alive6-remote – remote multicast addresses
  - Same as above but sends all packets in two fragments and a routing header for a router in the target network
  - Will only work if the target router allows routing header entries to multicast addresses – requires bad implementation! (see: Research)

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3. DHCP IPv4

- DHCP uses broadcast messages
- Rouge device can respond instead of a legal one
- Feed the host with new DNS and routing information in order to perform “Man in the middle” Attacks

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3. ARP IPv4

- ARP uses layer 2 broadcast to perform the IP > MAC lookup on the local network
- Attackers will respond in order to perform “Man in the middle” Attacks

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3. ARP/DHCP IPv6

- No security added to both protocol variations
- ICMPv6 Stateless auto configuration = DHCP light
- ICMP6 Neighbor Discovery and Neighbor Solicitation = ARP replacement
- Duplicate Address Detection based on NS allows DoS against a host by responding to requests

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3. ICMPv6 Stateless Auto-Configuration

1. RS:
ICMP Type = 133
Src = ::
Dst = FF02::2
query= please send RA

***fake_router6*:**
Sets any IP as default router ☺

2. RA:
ICMP Type = 134
Src = Router Link-local Address
Dst = FF02::1
Data= options, prefix, lifetime, *autoconfig* flag

Routers send periodic as well as soliticated Router Advertisements (RA) to the all-nodes multicast address FF02::1

Clients configure their routing tables and network prefix from advertisements. => Like a DHCP-light in IPv4

But anyone can send Router Advertisements! => *fake_router6*

3. ICMPv6 Neighbor Discovery

1. NS:
ICMP Type = 135
Src = **A**
Dst = All-Nodes Mulitcast Address
query= Who-has IP **B**?

***parasite6*:**
Answer to every NS, claim to be every system on the LAN ☺

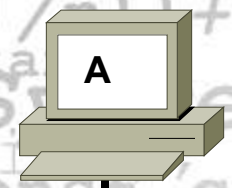
2. NA:
ICMP Type = 136
Src = **B**
Dst = **A**
Data= Link Layer Address

If A needs the MAC address of B, it sends an ICMP6 Neighbor Discovery to the All-Nodes multicast address

B sees the request and responds to A with its MAC address => Like ARP in IPv4

But everybody can respond to the request… => *parasite6*

3. ICMPv6 Duplicate Address Detection (DAD)



1. ND

1. NS:
ICMP Type = 135
Src = :: (unspecified)
Dst = All-Nodes Mulitcast Address
query= Who-has IP **A**?

***dos-new-ipv6*: Answer to every NS, claim to be every system on the LAN ☺**

2.
No reply if nobody owns the IP address.

If A sets a new IP address, it makes the Duplicate Address Detection check, to see if anybody owns the address already.

Anybody can respond to the DAD checks… => *dos-new-ipv6* prevents new systems on the LAN

4. Smurf IPv4

- Sending a packet to a broadcast address with spoofed source will force response to on single target, e.g. with ICMP echo request/reply
- Traffic amplification
- DoS for target link

4. Smurf IPv6

- No broadcast addresses
- Replaced with various multicast addresses
- RFC 2463 states that no ICMP response should be sent when destination was a multicast address. However, exceptions are made.
  - Cisco Security Research got it all wrong ☺
- Exploitable?
  - Locally: YES!
  - Remote: Depends on Implementation of Routing Headers, Fragmentation etc.

4. Smurfing IPv6 with the THC-IPV6 Attack Toolkit

- smurf6 – for local initiated smurfs
  - Source is target, destination is local multicast address
  - Generates lots of local traffic that is sent to source
- rsmurf6 – reverse smurf, exploits mis-implementations (e.g. Linux)
  - Source is all-nodes multicast address (*255.255.255.255 in IPv6 speak*), destination is target
  - If target has mis-implemented IPv6 (e.g. linux), it responds with Echo Reply to the all-nodes multicast address, generating lots of traffic
  - In the local LAN, 1 packet in a network with 100 Linux servers generated 10000 processed packets altogether!

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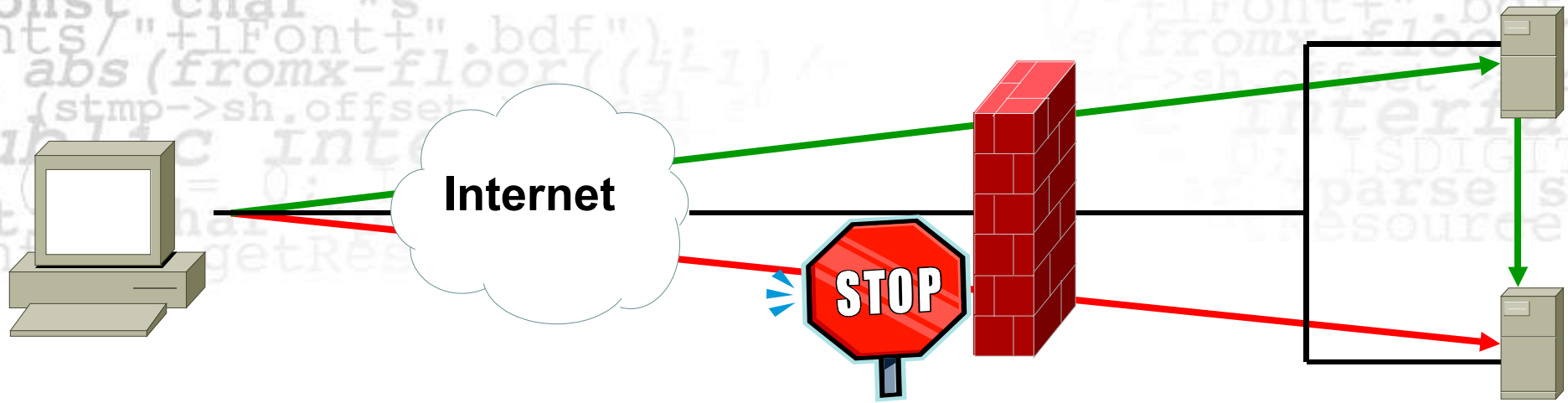
5. Routing Protocols

- Most Routing protocols provide their own security mechanisms
- This does not change with IPv6
- With the exception of OSPFv3, which has ***no*** security properties and relies on IPSEC usage

5. Routing Header Manipulation

Routing header attack (like IPv4 Source Routing)



Use alive6-remote for checking if routing headers are allowed to target

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5. Route Implanting with ICMP6 Redirects

- If a system is choosing a wrong router for a packet, the router tells this to the sender with an ICMP6 Redirect packet.
- To prevent evil systems implanting bad routes, the router has to send the offending packet with the redirect.
- If we are able to guess the full packet the system is sending to a target for which we want to re-route, we can implement any route we want! But how?
- Easy – if we fake an Echo Request, we know exactly the reply! ☺

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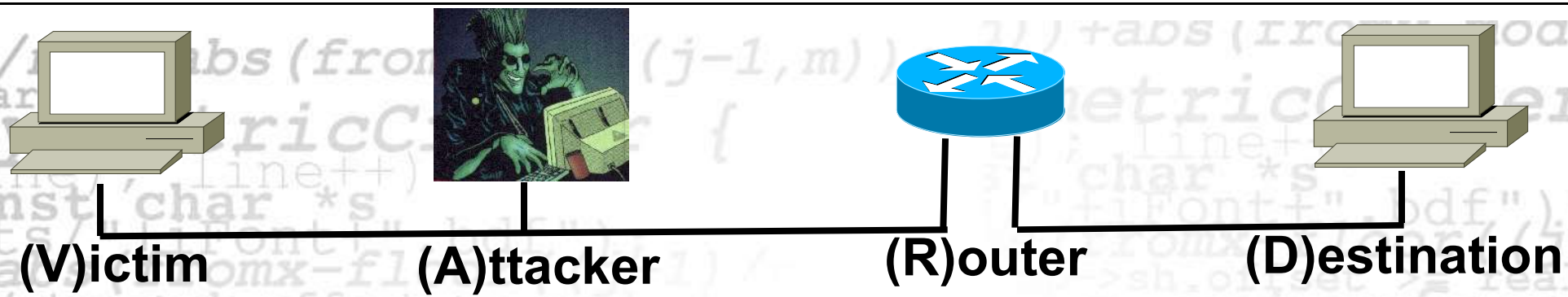
5. Route Implanting with ICMP6 Redirects



1. (A)ttacker sends Echo Request:
   Source: (D)estination, Destination: (V)ictim
2. (V)ictim received Echo Request, and send a Reply to (D)
3. (A)ttacker crafts Redirect,
   Source: (R)outer, Destination: (V)ictim,
   redirects all traffic for (D) to (A)

Performed by ***redir6*** in the THC-IPV6 Attack Toolkit ☺

Same concept for ***toobig6*** to reduce the MTU of a (V)i

5. Fragmentation

- Fragmentation is performed by source, not routers; reassembling performed by destination only
- Routers in path will not be able to drop packets with routing header if fragmentation comes first and routing header afterwards, after reassembling.

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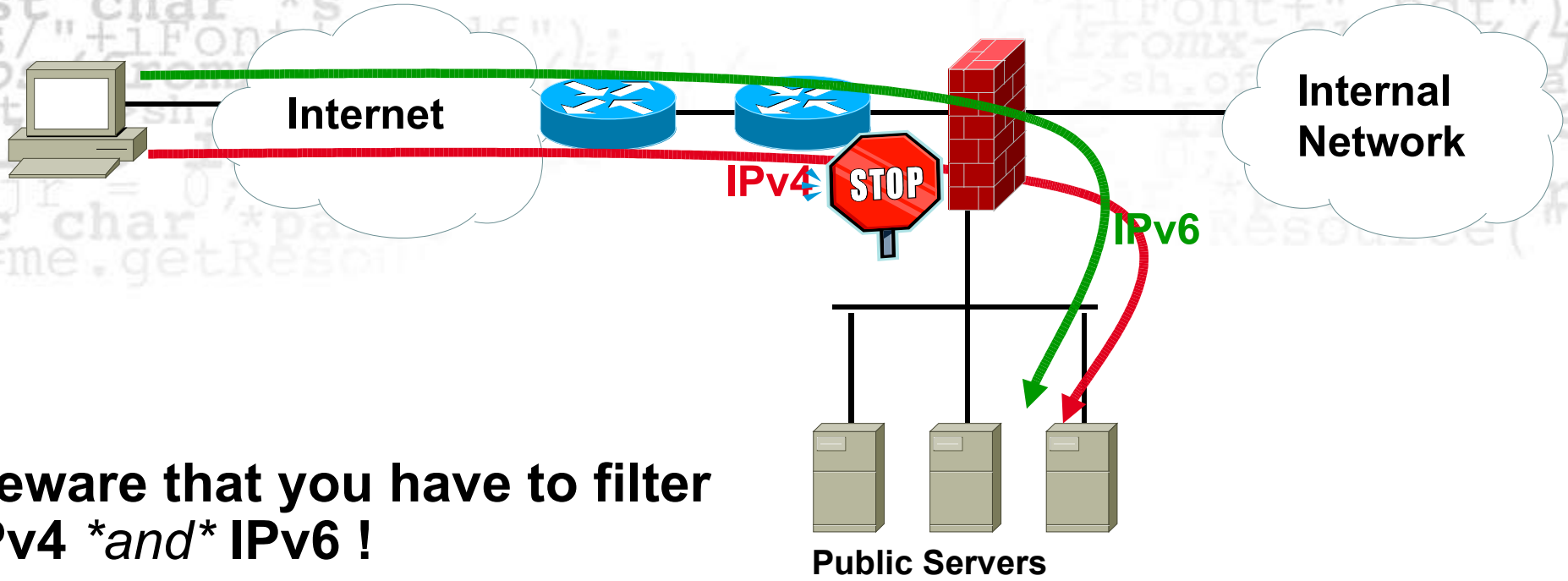
6. Dual stack attack



Beware that you have to filter IPv4 *and* IPv6 !

Implementation Vulnerabilities in IPv6 so far

- Python 03/2004 (when compiled without IPv6)
  - Crash when sending DNS replies with IPv6 addresses
- Ethereal 03/2004
  - Parsing bug, remote exploitable
- Apache 09/2004
  - URI parsing bug, remote crash, maybe exploitable
- Exim (MTA) 01/2005
  - Buffer overflow, local privileges escalation
- Cisco IOS 01/2005
  - Remote crash when receiving several malformed packets
- Postfix 02/2005
  - Allows spamming if a IPv6 config file is not present
- Linux Kernel 02/2005
  - Length validation bug, remote crash, maybe exploitable

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Research and Implementation Tests

- Responding to packets to multicast destinations
- Responding to packets from multicast address sources
- Routing header to multicast address
- Fragmentation and following Routing Header
- Cross border routing of Multicast Listener Discovery (ttl > 1)

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Upcoming IPv6 Security Research from THC

- Multicast Fun
  - Global Multicast FF:0E exploitation
- IPv4 <> IPv6 co-existance solutions
  - Security weaknesses in Tunneling

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Upcoming IPv6 Threats and Chances

1. **Specific attack tool development for IPv6**
   - No special difference to existing IPv4 attack tools
2. **Worms**
   - TCP/IP Worms (e.g. Slammer types) will die out
   - E-Mail Worms will stay
   - Messenger and P2P Worms will come
3. **DNS Server will become primary targets**
4. **Attacks will move to attack Clients from compromised servers in a LAN**
5. **When IPSEC is widely deployed, certificate stealing will be primary security concern**

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Conclusion Internet Security with IPv6

So far no known new risks with IPv6, but some security improvements against IPv4:

- Alive-Scanning and TCP/IP Worming very hard
- IP Record Route Option removed, no uptime check
- Easier network filtering and attack tracing

Introduction of IPSEC will not make IPv6 secure, but will make attack tracing easy, and sniffing + Man-in-the-Middle very difficult

Some implications unclear yet, research needed

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Questions?

Have fun!

Thank you very much!

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