

Appendix B

Analysis of IPv6 Packets

B.1 Introduction

This appendix presents some IPv6 packets captured on the 6bone network of Politecnico di Torino (see Section 12.3.1) by the protocol analyzer Radcom RC-100 WL¹. For each packet, first its hexadecimal format is shown, and then its decoding is shown.

Packets have been captured on an IEEE 802.3 network, and they have an Ethernet v.2.0 encapsulation, according to the description in Section 2.9. In particular, the encapsulation used is shown in Figure 2-6a.

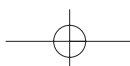
The hexadecimal format consists of a certain number of lines containing 16 couples of hexadecimal digits. Each couple of digits represents an octet; therefore, a line represents 128 bits. The last line typically contains a number of couples lower than 16 to take into account the real length of the IPv6 packet. The hexadecimal format ends with the IPv6 PDU; the Ethernet FCS is not shown.

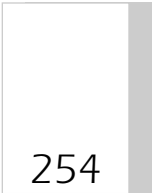
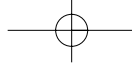
B.2 Example of Decoding

Figure B-1 shows an example of decoding of the hexadecimal format.

The Ethernet header must be decoded with reference to Figure 6-2a and begins with source and destination addresses both on 6 octets, followed by the Protocol Type field on 2 octets that contain the value 86DD (hexadecimal). This value indicates that an IPv6 header follows, which must be decoded with reference to Figure 3-1. In the IPv6 header, the second word and the destination IPv6 address are highlighted in gray.

¹The protocol analyzer RC-100 WL is manufactured by RADCOM Ltd. (Israel). See <http://www.radcom-inc.com/> or send e-mail to: info@radcom.co.il. The author thanks this company for its collaboration.

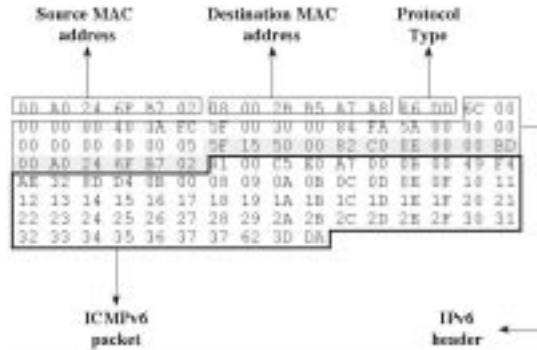




254

Appendix B: Analysis of IPv6 Packets

Figure B-1
Example of decoding



In the second part, we find the value 3A (hexadecimal) in the third octet—that is, 58 (decimal)—that indicates that the Next Header is ICMPv6.

The destination IPv6 address is followed by the ICMPv6 packet, which must be decoded with reference to Figure 5-1. It presents a Type = 81 (hexadecimal)—that is, 129 (decimal)—that classifies it like an Echo Reply packet, that is, as a reply to the ping.

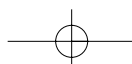
Figure B-2 shows the complete decoding of the packet made by the analyzer Radcom RC-100 WL.

Figure B-2
Complete decoding of the packet

```

Captured at: 50.227925
Length: 122 Status: Ok
Ethernet: Destination Address 00A0246FB702 <00A0246FB702>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Source Address DecNetB5A7A8 <08002BB5A7A8>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <6C>
IPv6: Priority: 12
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry) <000000>
Pv6: Payload Length: 64 <0040>
IPv6: Next Header: 58 Internet Control Message Protocol <3A>
IPv6: Hop Limit: 252 <FC>
IPv6: Source Address: 5F00:3000:84FA:5A00::5
IPv6: Destination Address: 5F15:5000:82C0:E00:BD:A0:246F:B702
ICMPv6: Type: 129 Echo Reply (IPv6 Ping Message) <81>
ICMPv6: Code: 0 <00>

ICMPv6: Checksum: 0xC5E0 <C5E0>
ICMPv6: Identifier: 42752 <A700>
ICMPv6: Sequence Number: 2816 <0B00>
User Data
OFFST DATA ASCII
003E: 49 F4 AE 32 8D D4 0B 00 08 09 0A 0B 0C 0D 0E 0F I..2.....
004E: 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F .....
005E: 20 21 22 23 24 25 26 27 28 29 2A 2B 2C 2D 2E 2F !"#%&'()*+,-./
006E: 30 31 32 33 34 35 36 37 01234567
Frame Tail
OFFST DATA ASCII
0076: 37 62 3D DA 7b=.
    
```



Appendix B: Analysis of IPv6 Packets

B.3 TCP Packet

This section shows an IPv6 packet containing a TCP packet. To better understand the decoding, please refer to Section 3.1. (See Figures B-3 and B-4.)

Figure B-3
TCP packet in
hexadecimal

```
Captured at: 08.116772
Length: 261 From: Network Status: Ok
OFFST DATA ASCII
0000: 00 A0 24 6F B6 A3 00 A0 24 6F B7 02 86 DD 60 00 ..$.....$.o...`.
0010: 00 00 00 CB 06 40 5F 15 50 00 82 C0 0E 00 00 BD .....@.P.....
0020: 00 A0 24 6F B7 02 5F 15 50 00 82 C0 0E 00 00 BD ..$._.P.....
0030: 00 A0 24 6F B6 A3 23 3F 04 06 63 A9 BC 4A 1E 41 ..$..#?.c..J.A
0040: B0 80 80 18 43 80 74 8A 00 00 01 01 08 0A 00 0A .....C.t.....
0050: 96 D9 00 00 14 D5 4C 61 73 74 20 6C 6F 67 69 6E .....Last login
0060: 3A 20 54 75 65 20 4A 61 6E 20 20 37 20 31 37 3A : Tue Jan 7 17:
0070: 30 33 3A 34 36 20 66 72 6F 6D 20 61 6C 69 63 65 03:46 from alice
0080: 2D 76 36 2E 69 70 76 36 0D 0A 57 61 72 6E 69 6E -v6.ipv6..Warnin
0090: 67 3A 20 6E 6F 20 4B 65 72 62 65 72 6F 73 20 74 g: no Kerberos t
00A0: 69 63 6B 65 74 73 20 69 73 73 75 65 64 2E 0D 0A ickets issued...
00B0: 4F 70 65 6E 42 53 44 20 31 2E 32 20 28 49 50 4E OpenBSD 1.2 (IPN
00C0: 47 4B 45 52 29 20 23 31 3A 20 46 72 69 20 4E 6F GKER) #1: Fri No
00D0: 76 20 31 35 20 30 38 3A 30 33 3A 34 32 20 50 53 v 15 08:03:42 PS
00E0: 54 20 31 39 39 36 0D 0A 0D 0A 57 65 6C 63 6F 6D T 1996...Welcom
00F0: 65 20 74 6F 20 4F 70 65 6E 42 53 44 2E 0D 0A 0D e to OpenBSD....
0100: 0A A3 5F 44 A9 .._D.
```

Figure B-4
Decoded TCP packet

```
Captured at: 08.116772
Length: 261 Status: Ok
Ethernet: Destination Address 00A0246FB6A3 <00A0246FB6A3>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Source Address 00A0246FB702 <00A0246FB702>
Ethernet: Individual Address

Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <60>
IPv6: Priority: 0 Uncharacterized Traffic
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry)
<000000>
IPv6: Payload Length: 203 <00CB>
IPv6: Next Header: 6 Transmission Control Protocol <06>
IPv6: Hop Limit: 64 <40>
IPv6: Source Address: 5F15:5000:82C0:E00:BD:A0:246F:B702
IPv6: Destination Address: 5F15:5000:82C0:E00:BD:A0:246F:B6A3
TCP: Source Port = 9023 <233F>
TCP: Destination Port = 1030 <0406>
TCP: Sequence Number = 1672068170 <63A9BC4A>
TCP: Acknowledgement Number = 507621504 <1E41B080>
TCP: HLEN = 32 [Bytes] <80>
TCP: Flags: 0x18 ACK PSH <18>
```

Figure B-4
Continued

```

TCP: Window = 17280                <4380>
TCP: CheckSum = 0x748A             <748A>
TCP: Option = 1 [No Operation]     <01>
TCP: Option = 1 [No Operation]     <01>
TCP: Option = 8
TCP: Padding = 100101502170020213 <0A000A96D9000014D5>
User Data
OFFST DATA                        ASCII
0056: 4C 61 73 74 20 6C 6F 67 69 6E 3A 20 54 75 65 20 Last login: Tue
0066: 4A 61 6E 20 20 37 20 31 37 3A 30 33 3A 34 36 20 Jan  7 17:03:46
0076: 66 72 6F 6D 20 61 6C 69 63 65 2D 76 36 2E 69 70 from alice-v6.ip
0086: 76 36 0D 0A 57 61 72 6E 69 6E 67 3A 20 6E 6F 20 v6..Warning: no
0096: 4B 65 72 62 65 72 6F 73 20 74 69 63 6B 65 74 73 Kerberos tickets
00A6: 20 69 73 73 75 65 64 2E 0D 0A 4F 70 65 6E 42 53 issued...OpenBS
00B6: 44 20 31 2E 32 20 28 49 50 4E 47 4B 45 52 29 20 D 1.2 (IPNGKER)
00C6: 23 31 3A 20 46 72 69 20 4E 6F 76 20 31 35 20 30 #1:  Fri Nov 15 0
00D6: 38 3A 30 33 3A 34 32 20 50 53 54 20 31 39 39 36 8:03:42 PST 1996
00E6: 0D 0A 0D 0A 57 65 6C 63 6F 6D 65 20 74 6F 20 4F ...Welcome to O
00F6: 70 65 6E 42 53 44 2E 0D 0A 0D 0A penBSD.....

Frame Tail
OFFST DATA                        ASCII
0101: A3 5F 44 A9                    ._D.

```

B.4 UDP Packet

This section shows an IPv6 packet containing an UDP packet. To better understand the decoding, please refer to Section 3.1. (See Figures B-5 and B-6.)

Figure B-5
UDP packet in
hexadecimal

```

Captured at:  50.024340
Length: 90     Status: Ok
OFFST DATA                        ASCII
0000: 33 33 00 00 00 09 08 00 2B B5 A7 A8 86 DD 67 00 33.....+.....g.
0010: 00 00 00 20 11 FF FE 80 00 00 00 00 00 00 00 00 ... ..
0020: 08 00 2B B5 A7 A8 FF 02 00 00 00 00 00 00 00 00 ..+.....
0030: 00 00 00 00 00 09 02 09 02 09 00 20 21 A1 01 01 .....!...
0040: 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 .....
0050: 00 00 00 00 00 10 F2 9B F3 73                .....s

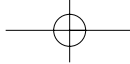
```

Figure B-6
Decoded UDP packet

```

Captured at:  50.024340
Length: 90     Status: Ok
Ethernet: Destination Address 333300000009 <333300000009>
Ethernet: Multicast Address
Ethernet: Local Address
Ethernet: Source Address DecNetB5A7A8 <08002BB5A7A8>
Ethernet: Individual Address
Ethernet: Universal Address

```



Appendix B: Analysis of IPv6 Packets

Figure B-6
Continued

```

Ethernet: Ethernet V.2, Type IPv6      <86DD>
IPv6: Version: 6                       <67>
IPv6: Priority: 7 Internet Control Traffic
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry)
<000000>
IPv6: Payload Length: 32                <0020>
IPv6: Next Header: 17 User Datagram Protocol <11>
IPv6: Hop Limit: 255                    <FF>
IPv6: Source Address: FE80::800:2BB5:A7A8
IPv6: Destination Address: FF02::9
UDP: Source Port = RIPng                <0209>
UDP: Destination Port = RIPng           <0209>
UDP: Length = 32                        <0020>
UDP: CheckSum = 0x21A1                  <21A1>
RIPng: Command:1 Request                 <01>
RIPng: Version No.:1                    <01>
RIPng: Must Be Zero:0x0000              <0000>
RIPng: Entry No. :1
RIPng: IPv6 Prefix:0x00000000000000000000000000000000 [Default Route]
<00000000000000000000000000000000>
RIPng: Route Tag:0x0000                 <0000>
RIPng: Prefix Length:0                  <00>
RIPng: Metric:16                        <10>
Frame Tail
OFFST DATA                             ASCII
0056: F2 9B F3 73                       ...S

```

B.5 Router Solicitation Packet

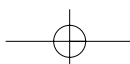
This section shows an IPv6 packet containing a Router Solicitation ICMP packet. To better understand the decoding, please refer to Section 5.5.4. (See Figures B-7 and B-8.)

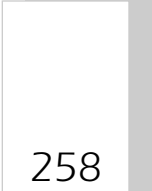
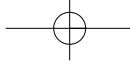
Figure B-7
Router Solicitation
in hexadecimal

```

Captured at: 15.017728
Length: 66 Status: Ok
OFFST DATA                             ASCII
0000: 33 33 00 00 00 02 00 A0 24 6F B7 02 86 DD 6F 00 33.....$o.....
0010: 00 00 00 08 3A FF FE 80 00 00 00 00 00 00 00 00 00 .....
0020: 00 A0 24 6F B7 02 FF 02 00 00 00 00 00 00 00 00 00 ..$.
0030: 00 00 00 00 00 02 85 00 A1 25 00 00 00 00 3D BE .....%.
0040: 4C 0B                                     L.

```





Appendix B: Analysis of IPv6 Packets

B.6 Router Advertisement Packet

This section shows an IPv6 packet containing a Router Advertisement ICMP packet. To better understand the decoding, please refer to Section 5.5.5. (See Figures B-9 and B-10.)

Figure B-8
Decoded Router Solicitation

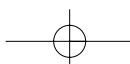
```

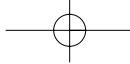
Captured at: 15.017728
Length: 66 Status: Ok
Ethernet: Destination Address 333300000002 <333300000002>
Ethernet: Multicast Address
Ethernet: Local Address
Ethernet: Source Address 00A0246FB702 <00A0246FB702>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <6F>
IPv6: Priority: 15
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry) <000000>
IPv6: Payload Length: 8 <0008>
IPv6: Next Header: 58 Internet Control Message Protocol <3A>
IPv6: Hop Limit: 255 <FF>
IPv6: Source Address: FE80::A0:246F:B702
IPv6: Destination Address: FF02::2
ICMPv6: Type: 133 Router Solicitation <85>
ICMPv6: Code: 0 <00>
ICMPv6: Checksum: 0xA125 <A125>
ICMPv6: Reserved: 0x00000000 <00000000>
Frame Tail
OFFST DATA ASCII
003E: 3D BE 4C 0B =.L.
    
```

Figure B-9
Router Advertisement in hexadecimal

```

Captured at: 15.500171
Length: 122 Status: Ok
OFFST DATA ASCII
0000: 33 33 00 00 00 01 08 00 2B B5 A7 A8 86 DD 6F 00 33.....+.....o.
0010: 00 00 00 40 3A FF FE 80 00 00 00 00 00 00 00 00 ...@:.....
0020: 08 00 2B B5 A7 A8 FF 02 00 00 00 00 00 00 00 00 ..+.....
0030: 00 00 00 00 00 01 86 00 07 BD 40 00 07 08 00 00 .....@.....
0040: 75 30 00 00 27 10 01 01 08 00 2B B5 A7 A8 05 01 u0..'.....+.....
0050: 00 00 00 00 05 DC 03 04 50 40 FF FF FF FF 00 09 .....P@.....
0060: 3A 80 00 00 00 00 5F 15 50 00 82 C0 0E 00 00 BD :....._P.....
0070: 00 00 00 00 00 00 19 10 05 C0 .....
    
```





Appendix B: Analysis of IPv6 Packets

Figure B-10
Decoded Router
Advertisement

```

Captured at: 15.500171
Length: 122 Status: Ok
Ethernet: Destination Address 333300000001 <333300000001>
Ethernet: Multicast Address
Ethernet: Local Address
Ethernet: Source Address DecNetB5A7A8 <08002BB5A7A8>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <6F>
IPv6: Priority: 15
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry)
<000000>
IPv6: Payload Length: 64 <0040>
IPv6: Next Header: 58 Internet Control Message Protocol <3A>
IPv6: Hop Limit: 255 <FF>
IPv6: Source Address: FE80::800:2BB5:A7A8
IPv6: Destination Address: FF02::1
ICMPv6: Type: 134 Router Advertisement <86>
ICMPv6: Code: 0 <00>
ICMPv6: Checksum: 0x07BD <07BD>
ICMPv6: Cur Hop Limit: 64 <40>
ICMPv6: M Flag: 0 <00>
ICMPv6: O Flag: 0
ICMPv6: Reserved: 0
ICMPv6: Router Lifetime (sec) : 1800 <0708>
ICMPv6: Reachable Time (millisec): 0:0:30:0
ICMPv6: Retrans Timer (millisec): 0:0:10:0
ICMPv6: Option Type: 1 Source Link-Layer Address <01>
ICMPv6: Option Length: 1 (8*bytes) <01>
ICMPv6: Link-Layer Address: DecNetB5A7A8 <08002BB5A7A8>
ICMPv6: Option Type: 5 MTU <05>
ICMPv6: Option Length: 1 (8*bytes) <01>
ICMPv6: Reserved: 0 <0000>
ICMPv6: MTU: 0x000005DC <000005DC>
ICMPv6: Option Type: 3 Prefix Information <03>
ICMPv6: Option Length: 4 (8*bytes) <04>
ICMPv6: Prefix Length: 80 <50>
ICMPv6: L Flag: 0 <40>
ICMPv6: A Flag: 1 Prefix Can Be Use For Autonomous Address Configuration
ICMPv6: Reserved(1): 0
ICMPv6: Valid Lifetime (sec): 4294967295 <FFFFFFFF>
ICMPv6: Preferred Lifetime (sec): 604800 <00093A80>
ICMPv6: Reserved(2): 0x00000000 <00000000>
ICMPv6: Prefix: 0x5F15500082C00E0000BD <5F15500082C00E0000BD>
ICMPv6: Pad: 0x000000000000 <000000000000>
Frame Tail
OFFST DATA ASCII
0076: 19 10 05 C0 ....

```

B.7 Neighbor Solicitation Packet

This section shows an IPv6 packet containing a Neighbor Solicitation ICMP packet. To better understand the decoding, please refer to Section 5.5.6. (See Figures B-11 and B-12.)

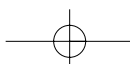


Figure B-11
Neighbor Solicitation
in hexadecimal

```

Captured at: 40.244537
Length: 90 Status: Ok
OFFST DATA ASCII
0000: 33 33 24 6F B7 02 08 00 2B B5 A7 A8 86 DD 6F 00 33$o.....+.o.
0010: 00 00 00 20 3A FF FE 80 00 00 00 00 00 00 00 00 ... :.....
0020: 08 00 2B B5 A7 A8 FF 02 00 00 00 00 00 00 00 00 ..+.....
0030: 00 01 24 6F B7 02 87 00 CB 4C 00 00 00 00 00 5F 15 ..$o.....L.....
0040: 50 00 82 C0 0E 00 00 BD 00 A0 24 6F B7 02 01 01 P.....$o....
0050: 08 00 2B B5 A7 A8 95 8F 01 B1 ..+.....

```

Figure B-12
Decoded Neighbor
Solicitation

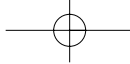
```

Captured at: 40.244537
Length: 90 Status: Ok
Ethernet: Destination Address 3333246FB702 <3333246FB702>
Ethernet: Multicast Address
Ethernet: Local Address
Ethernet: Source Address DecNetB5A7A8 <08002BB5A7A8>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <6F>
IPv6: Priority: 15
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry) <000000>
IPv6: Payload Length: 32 <0020>
IPv6: Next Header: 58 Internet Control Message Protocol <3A>
IPv6: Hop Limit: 255 <FF>
IPv6: Source Address: FE80::800:2BB5:A7A8
IPv6: Destination Address: FF02::1:246F:B702
ICMPv6: Type: 135 Neighbor Solicitation <87>
ICMPv6: Code: 0 <00>
ICMPv6: Checksum: 0xCB4C <CB4C>
ICMPv6: Reserved: 0x00000000 <00000000>
ICMPv6: Target Address: 5F15:5000:82C0:E00:BD:A0:246F:B702
ICMPv6: Option Type: 1 Source Link-Layer Address <01>
ICMPv6: Option Length: 1 (8*bytes) <01>
ICMPv6: Link-Layer Address: DecNetB5A7A8 <08002BB5A7A8>
Frame Tail
OFFST DATA ASCII
0056: 95 8F 01 B1 .....

```

B.8 Neighbor Advertisement Packet

This section shows an IPv6 packet containing a Neighbor Advertisement ICMP packet. To better understand the decoding, please refer to Section 5.5.7. (See Figures B-13 and B-14.)



Appendix B: Analysis of IPv6 Packets

Figure B-13

Neighbor Advertisement in hexadecimal

```
Captured at: 40.244896
Length: 90 Status: Ok
OFFST DATA ASCII
0000: 08 00 2B B5 A7 A8 00 A0 24 6F B7 02 86 DD 6F 00 ..+.....$o....o.
0010: 00 00 00 20 3A FF 5F 15 50 00 82 C0 0E 00 00 BD ... :_.P.....
0020: 00 A0 24 6F B7 02 FE 80 00 00 00 00 00 00 00 00 ..$o.....
0030: 08 00 2B B5 A7 A8 88 00 26 69 60 00 00 00 5F 15 ..+.....&i`..._
0040: 50 00 82 C0 0E 00 00 BD 00 A0 24 6F B7 02 02 01 P.....$o....
0050: 00 A0 24 6F B7 02 BE 3E 40 51 ..$o...>@Q
```

Figure B-14

Decoded Neighbor Advertisement

```
Captured at: 40.244896
Length: 90 Status: Ok
Ethernet: Destination Address DecNetB5A7A8 <08002BB5A7A8>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Source Address 00A0246FB702 <00A0246FB702>
Ethernet: Individual Address
Ethernet: Universal Address
Ethernet: Ethernet V.2, Type IPv6 <86DD>
IPv6: Version: 6 <6F>
IPv6: Priority: 15
IPv6: Flow Label: 0x000000 (Packet Do Not Belong To a Flow Carry)
<000000>
IPv6: Payload Length: 32 <0020>
IPv6: Next Header: 58 Internet Control Message Protocol <3A>
IPv6: Hop Limit: 255 <FF>
IPv6: Source Address: 5F15:5000:82C0:E00:BD:A0:246F:B702
IPv6: Destination Address: FE80::800:2BB5:A7A8
ICMPv6: Type: 136 Neighbor Advertisement <88>
ICMPv6: Code: 0 <00>
ICMPv6: Checksum: 0x2669 <2669>
ICMPv6: R Flag: 0 <60000000>
ICMPv6: S Flag: 1 Advertisement is Response to Neighbor Solicitation From
Des.Add
ICMPv6: O Flag: 1 Advertisement Override Existing Cache Entry And Update
Cached Linl
ICMPv6: Reserved: 0x0
ICMPv6: Target Address: 5F15:5000:82C0:E00:BD:A0:246F:B702
ICMPv6: Option Type: 2 Target Link-Layer Address <02>
ICMPv6: Option Length: 1 (8*bytes) <01>
ICMPv6: Link-Layer Address: 00A0246FB702 <00A0246FB702>
Frame Tail
OFFST DATA ASCII
0056: BE 3E 40 51 .>@Q
```

