

PCP Interoperability Test Report

Apple Airport Extreme

IETF-89

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V0.2

Summary

- Apple's Airport Extreme implementation is a feature parity upgrade from NAT-PMP
 - <http://www.ietf.org/proceedings/88/slides/slides-88-pcp-5.pdf>
- Solid, no major issues
- Some interesting results
- Tests still on-going

Logistics

- PCP Client: <https://github.com/libpcp/pcp>
- PCP Server:
<http://www.apple.com/airport-extreme/>
- Port Scanner:
<http://www.whatsmyip.org/port-scanner/>

First Test

- MAP Add
- Outside->In connection
- MAP Delete

MAP Add, Out->In Connection

The image shows a Wireshark capture of PCP v2 traffic. The left pane displays the details of a 'Map Request' packet (Frame 19), and the right pane displays the details of a 'Map Response' packet (Frame 21). The packet list at the bottom shows the corresponding request and response packets.

Map Request Packet Details:

- Version: 2
- 0... .. = R: Response
- .000 0001 = Opcode: Map (1)
- Reserved: 0
- Requested Lifetime: 240
- Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23)
- Map Request
 - Mapping Nonce: 42d2e2955e4fbd043e794e89
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 2004
 - Suggested External Port: 20004
 - Suggested External IP Address: :: (::)

Map Response Packet Details:

- Version: 2
- 1... .. = R: Request
- .000 0001 = Opcode: Map (1)
- Reserved: 0
- Result Code: Success (0)
- Lifetime: 240
- Epoch Time: 42879
- Reserved: 00000000000000000000000000000000
- Map Response
 - Mapping Nonce: 42d2e2955e4fbd043e794e89
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 2004
 - Assigned External Port: 20004
 - Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218)

Packet List:

No.	Time	Source	Destination	Protocol	Length	Info
96	71.215139000	204.11.33.59	10.0.1.23	TCP	78	58138 > mailbox [SYN] Seq=0
97	71.215160000	10.0.1.23	204.11.33.59	TCP	54	mailbox > 58138 [RST, ACK]

MAP Delete

The image displays two side-by-side Wireshark packet capture windows. The left window shows a 'Map Request' packet (Frame 38) and the right window shows a 'Map Response' packet (Frame 40). Both packets are PCP v2 102. The request packet has a client IP of 10.0.1.23 and a destination of 10.0.1.1. The response packet has a source IP of 10.0.1.1 and a destination of 10.0.1.23. The response packet includes a 'Result Code: Success (0)' and an 'Epoch Time: 42898'.

Left Window: 38 26.370106000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request

- Frame 38: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
- Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)
- Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)
- User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)
- Port Control Protocol, Map Request
 - Version: 2
 - 0... .. = R: Response
 - .000 0001 = Opcode: Map (1)
 - Reserved: 0
 - Requested Lifetime: 0
 - Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23)
 - Map Request
 - Mapping Nonce: 11884299692d832e469659b7
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 2004
 - Suggested External Port: 20004
 - Suggested External IP Address: :: (::)

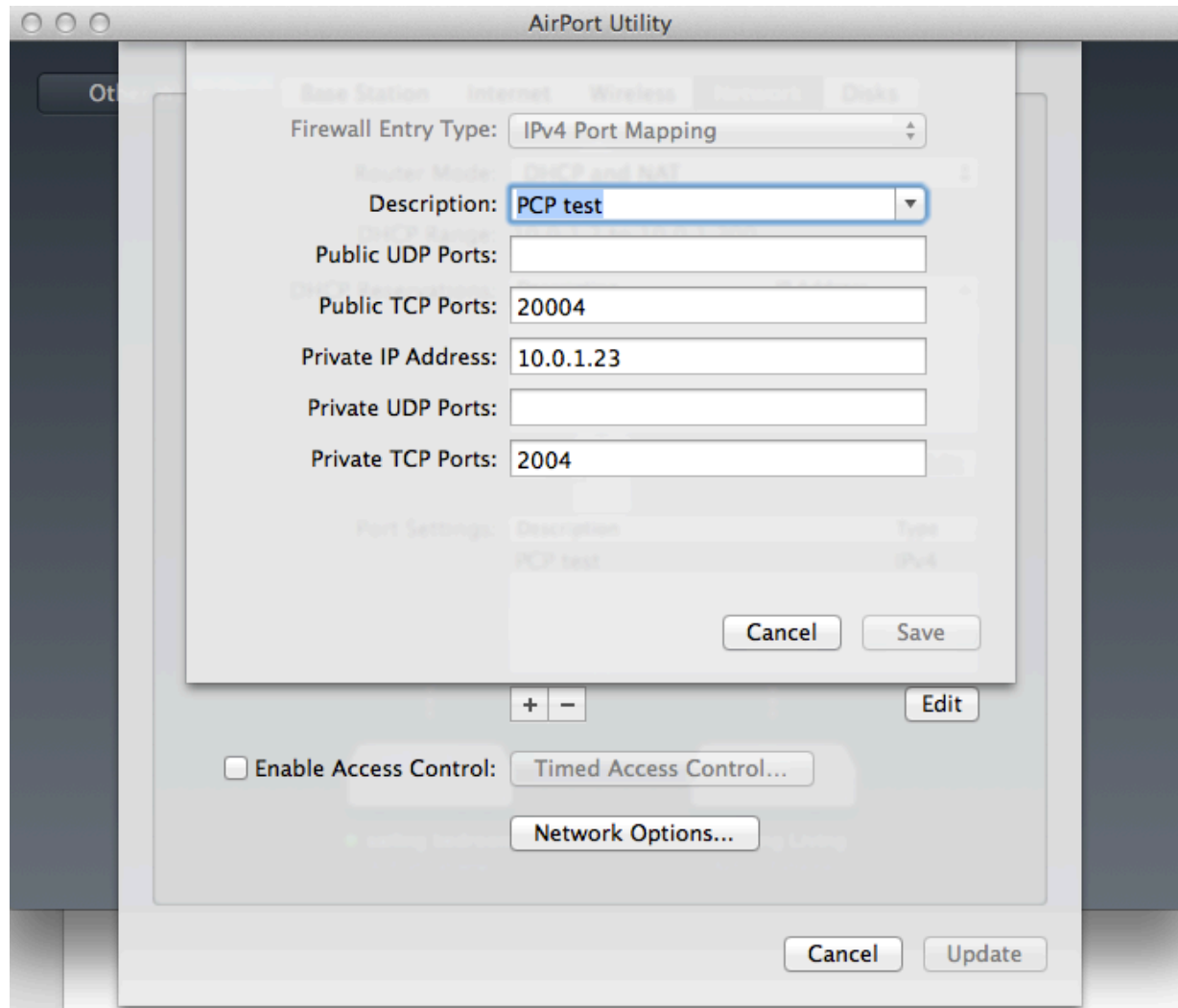
Right Window: 40 26.372670000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response

- Frame 40: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
- Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IntelCor_c6:10:70 (00:26:c7:c6:10:70)
- Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)
- User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
- Port Control Protocol, Map Response
 - Version: 2
 - 1... .. = R: Request
 - .000 0001 = Opcode: Map (1)
 - Reserved: 0
 - Result Code: Success (0)
 - Lifetime: 0
 - Epoch Time: 42898
 - Reserved: 000000000000000000000000
 - Map Response
 - Mapping Nonce: 11884299692d832e469659b7
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 2004

Second Test

- Create Manual Mapping
- MAP ADD
 - Same internal port, different external ports. Two external ports pointing to same internal port.
 - Possible when one of them is manual
- Rotate PCP mapping
 - Same external port, another internal port.
 - Not possible, automatically allocates another external port.

Airport Extreme Configuration



MAP Add, MAP Rotate

```
606 437.548341000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request
Frame 606: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)
Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)
User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)
Port Control Protocol, Map Request
  Version: 2
  0... .... = R: Response
  .000 0001 = Opcode: Map (1)
  Reserved: 0
  Requested Lifetime: 240
  Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23)
  Map Request
    Mapping Nonce: 6739371715d785150834a1d5
    Protocol: 6
    Reserved: 0
    Internal Port: 2004
    Suggested External Port: 20005
    Suggested External IP Address: :: (::)
```

```
608 437.553520000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response
Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IntelCor_c6:10:70 (00:26:c7:c6:10:70)
Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)
User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
Port Control Protocol, Map Response
  Version: 2
  1... .... = R: Request
  .000 0001 = Opcode: Map (1)
  Reserved: 0
  Result Code: Success (0)
  Lifetime: 240
  Epoch Time: 615
  Reserved: 00000000000000000000000000000000
  Map Response
    Mapping Nonce: 6739371715d785150834a1d5
    Protocol: 6
    Reserved: 0
    Internal Port: 2004
    Assigned External Port: 20005
    Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218)
```

```
822 641.239315000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request
Frame 822: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)
Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)
User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)
Port Control Protocol, Map Request
  Version: 2
  0... .... = R: Response
  .000 0001 = Opcode: Map (1)
  Reserved: 0
  Requested Lifetime: 240
  Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23)
  Map Request
    Mapping Nonce: 50fa7e906bad535361f64b29
    Protocol: 6
    Reserved: 0
    Internal Port: 2005
    Suggested External Port: 20005
    Suggested External IP Address: :: (::)
```

```
824 641.249547000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response
Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IntelCor_c6:10:70 (00:26:c7:c6:10:70)
Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)
User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
Port Control Protocol, Map Response
  Version: 2
  1... .... = R: Request
  .000 0001 = Opcode: Map (1)
  Reserved: 0
  Result Code: Success (0)
  Lifetime: 240
  Epoch Time: 819
  Reserved: 00000000000000000000000000000000
  Map Response
    Mapping Nonce: 50fa7e906bad535361f64b29
    Protocol: 6
    Reserved: 0
    Internal Port: 2005
    Assigned External Port: 32769
    Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218)
```

Third Test

- MAP ADD
 - Same internal port, different external ports. Two external ports pointing to same internal port.
 - **Not** Possible when both mappings are dynamic (PCP)
 - First External 30005-> Internal: 3005 (OK)
 - Then External 30006-> Internal: 3005 (OK, but was assigned 30005 as above)

Third Test

The image displays four Wireshark packet capture windows, arranged in a 2x2 grid, showing PCP v2 Map Request and Map Response packets. Each window has a title bar with a close button, a maximize button, and a window title. The windows are:

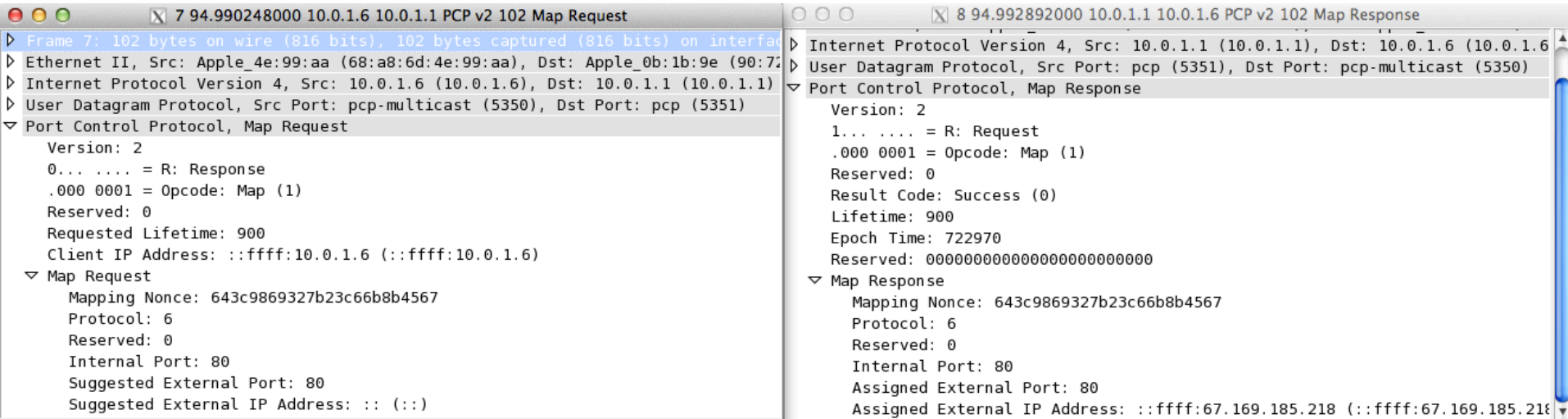
- Top Left:** Title: 986 790.718935000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request. Content: Frame 986: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface... Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)... Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)... User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)... Port Control Protocol, Map Request. Version: 2. 0... .. = R: Response. .000 0001 = Opcode: Map (1). Reserved: 0. Requested Lifetime: 240. Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23). Map Request. Mapping Nonce: 077041ff0a68919f4fa29b98. Protocol: 6. Reserved: 0. Internal Port: 3005. Suggested External Port: 30005. Suggested External IP Address: :: (::).
- Top Right:** Title: 988 790.726403000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response. Content: Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)... User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)... Port Control Protocol, Map Response. Version: 2. 1... .. = R: Request. .000 0001 = Opcode: Map (1). Reserved: 0. Result Code: Success (0). Lifetime: 240. Epoch Time: 968. Reserved: 00000000000000000000000000000000. Map Response. Mapping Nonce: 077041ff0a68919f4fa29b98. Protocol: 6. Reserved: 0. Internal Port: 3005. Assigned External Port: 30005. Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218).
- Bottom Left:** Title: 998 797.209015000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request. Content: Frame 998: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface... Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)... Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)... User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)... Port Control Protocol, Map Request. Version: 2. 0... .. = R: Response. .000 0001 = Opcode: Map (1). Reserved: 0. Requested Lifetime: 240. Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23). Map Request. Mapping Nonce: 53b07747054b5b4902e7c299. Protocol: 6. Reserved: 0. Internal Port: 3005. Suggested External Port: 30006. Suggested External IP Address: :: (::).
- Bottom Right:** Title: 1000 797.211660000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response. Content: Frame 1000: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface... Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IntelCor_c6:10:70 (00:26:c7:c6:10:70)... Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)... User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)... Port Control Protocol, Map Response. Version: 2. 1... .. = R: Request. .000 0001 = Opcode: Map (1). Reserved: 0. Result Code: Success (0). Lifetime: 240. Epoch Time: 975. Reserved: 00000000000000000000000000000000. Map Response. Mapping Nonce: 53b07747054b5b4902e7c299. Protocol: 6. Reserved: 0. Internal Port: 3005. Assigned External Port: 30005. Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218).

Test 4-5

- PREFER_FAILURE Option (not supported)
- PEER Opcode (unsupported, Wireshark complains PCP response malformed)

Test 6

- Port 80 (OK, had to sudo)



The image displays two side-by-side screenshots of a network traffic analysis tool, likely Wireshark, showing PCP v2 protocol details. The left window shows a 'Map Request' packet, and the right window shows the corresponding 'Map Response' packet.

Left Window: 7 94.990248000 10.0.1.6 10.0.1.1 PCP v2 102 Map Request

- Frame 7: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
- Ethernet II, Src: Apple_4e:99:aa (68:a8:6d:4e:99:aa), Dst: Apple_0b:1b:9e (90:72:4d:0b:1b:9e)
- Internet Protocol Version 4, Src: 10.0.1.6 (10.0.1.6), Dst: 10.0.1.1 (10.0.1.1)
- User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)
- Port Control Protocol, Map Request
 - Version: 2
 - 0... .. = R: Response
 - .000 0001 = Opcode: Map (1)
 - Reserved: 0
 - Requested Lifetime: 900
 - Client IP Address: ::ffff:10.0.1.6 (::ffff:10.0.1.6)
 - Map Request
 - Mapping Nonce: 643c9869327b23c66b8b4567
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 80
 - Suggested External Port: 80
 - Suggested External IP Address: :: (::)

Right Window: 8 94.992892000 10.0.1.1 10.0.1.6 PCP v2 102 Map Response

- Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.6 (10.0.1.6)
- User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
- Port Control Protocol, Map Response
 - Version: 2
 - 1... .. = R: Request
 - .000 0001 = Opcode: Map (1)
 - Reserved: 0
 - Result Code: Success (0)
 - Lifetime: 900
 - Epoch Time: 722970
 - Reserved: 00000000000000000000000000000000
 - Map Response
 - Mapping Nonce: 643c9869327b23c66b8b4567
 - Protocol: 6
 - Reserved: 0
 - Internal Port: 80
 - Assigned External Port: 80
 - Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218)

Test 7 - Announce

The image displays two side-by-side network traffic capture windows. The left window shows a PCP v2 66 Announce Response, and the right window shows a NAT-PMP 54 External Address Response. Both responses are captured on interface 0 and are sent from 10.0.1.1 to 224.0.0.1.

Left Window: 13 861.893934000 10.0.1.1 224.0.0.1 PCP v2 66 Announce Response

- Frame 13: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0
- Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IPv4mcast_00:00:01 (01:00:5e:00:00:01)
- Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.1 (224.0.0.1)
- User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
- Port Control Protocol, Announce Response
 - Version: 2
 - 1... = R: Request
 - .000 0000 = Opcode: Announce (0)
 - Reserved: 0
 - Result Code: Success (0)
 - Lifetime: 0
 - Epoch Time: 21
 - Reserved: 00000000000000000000000000000000
 - Announce Response

Right Window: 14 861.893985000 10.0.1.1 224.0.0.1 NAT-PMP 54 External Address Response

- Frame 14: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0
- Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IPv4mcast_00:00:01 (01:00:5e:00:00:01)
- Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.1 (224.0.0.1)
- User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
- NAT Port Mapping Protocol, External Address Response
 - Version: 0
 - Opcode: External Address Response (128)
 - Result Code: Success (0)
 - Seconds Since Start of Epoch: 21
 - External IP Address: 67.169.185.218 (67.169.185.218)

Both PCP and NAT-PMP Announce messages on reboot

Test 8

- Shorten Lifetime
- Allowed. Very good for testing, otherwise need to keep guessing how many seconds really need between tests until mapping expires.

Test 9

- PCP Interception.
- PCP message to Server on the Internet is intercepted by Airport Extreme

```
4 16.762335000 10.0.1.6 98.138.253.109 PCP v2 102 Map Request
  Frame 4: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface 0
  Ethernet II, Src: Apple_4e:99:aa (68:a8:6d:4e:99:aa), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)
  Internet Protocol Version 4, Src: 10.0.1.6 (10.0.1.6), Dst: 98.138.253.109 (98.138.253.109)
  User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)
  Port Control Protocol, Map Request
    Version: 2
    0... .... = R: Response
    .000 0001 = Opcode: Map (1)
    Reserved: 0
    Requested Lifetime: 900
    Client IP Address: ::ffff:10.0.1.6 (::ffff:10.0.1.6)
  Map Request
    Mapping Nonce: 19495cff74b0dc5166334873
    Protocol: 6
    Reserved: 0
    Internal Port: 2004
    Suggested External Port: 20004
    Suggested External IP Address: :: (:)

5 16.765306000 10.0.1.1 10.0.1.6 PCP v2 102 Map Response
  Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.6 (10.0.1.6)
  User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)
  Port Control Protocol, Map Response
    Version: 2
    1... .... = R: Request
    .000 0001 = Opcode: Map (1)
    Reserved: 0
    Result Code: Success (0)
    Lifetime: 900
    Epoch Time: 7901
    Reserved: 00000000000000000000000000000000
  Map Response
    Mapping Nonce: 643c9869327b23c66b8b4567
    Protocol: 6
    Reserved: 0
    Internal Port: 2004
    Assigned External Port: 32768
    Assigned External IP Address: ::ffff:67.169.185.218 (::ffff:67.169.185.218)
```