

# PCP Interoperability Test Report

## Apple Airport Extreme

### IETF-89

[Reinaldo Penno : repenno@cisco.com](mailto:repenno@cisco.com)

[Peter Tatrai : ptatrai@cisco.com](mailto:ptatrai@cisco.com)

v0.1

# 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 displays a Wireshark packet capture of a PCP v2 102 Map Request and its corresponding Map Response. The interface shows the packet list, packet details, and packet bytes panes.

**Packet 19: 19 7.460926000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request**

- Frame 19: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface 0
- Ethernet II, Src: IntelCor\_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple\_0b:1b:9e (90:0b:1b:9e:00:00)
- 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: 42d2e2955e4fbd043e794e89
    - Protocol: 6
    - Reserved: 0
    - Internal Port: 2004
    - Suggested External Port: 20004
    - Suggested External IP Address: :: (::)

**Packet 21: 21 7.465801000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response**

- Frame 21: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface 0
- Ethernet II, Src: Apple\_0b:1b:9e (90:0b:1b:9e:00:00), 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: 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)

**Filter:** tcp.stream eq 3

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]

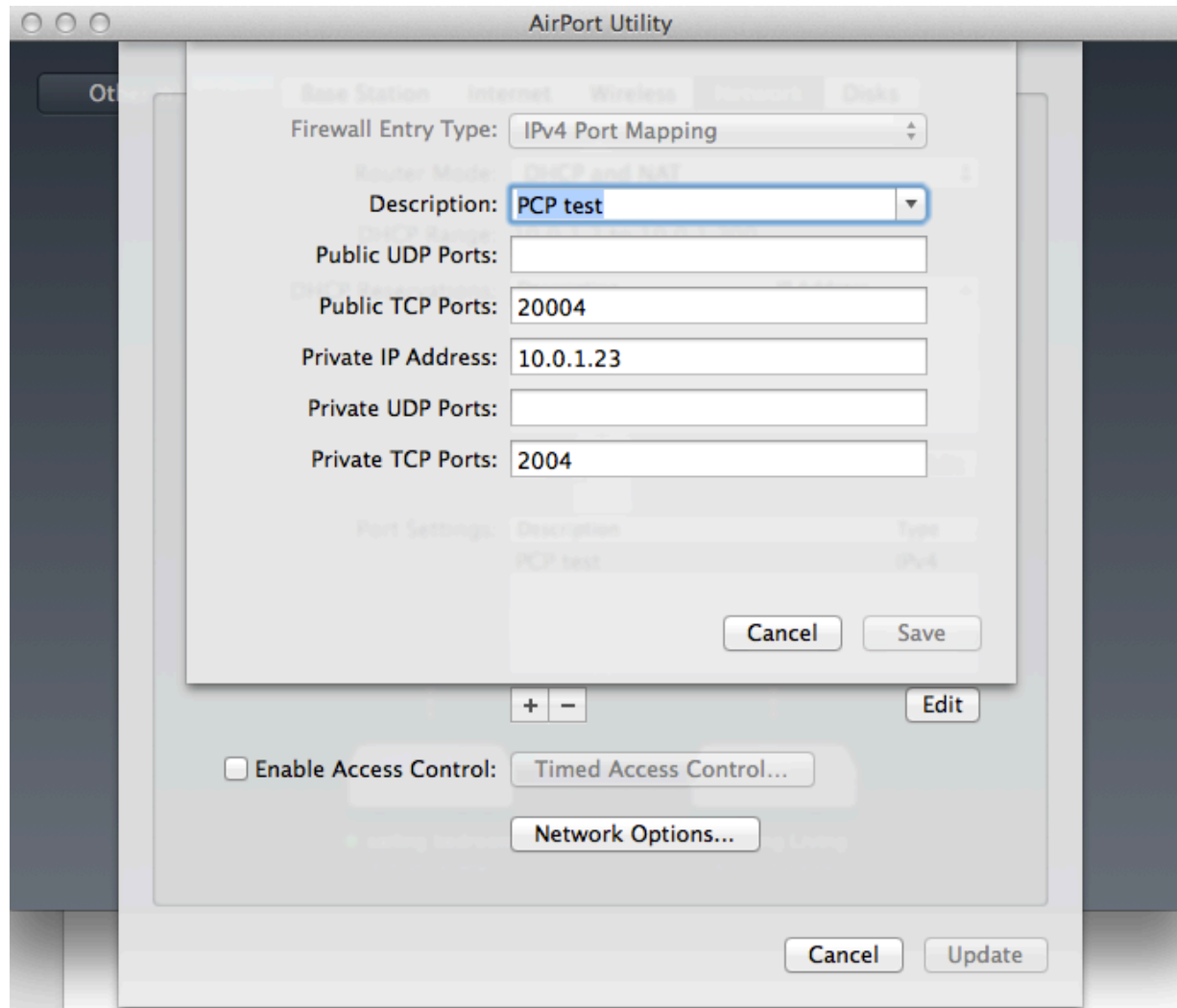
# MAP Delete

<p>38 26.370106000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request</p> <p>Frame 38: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface</p> <p>Ethernet II, Src: IntelCor_c6:10:70 (00:26:c7:c6:10:70), Dst: Apple_0b:1b:9e (90:72:40:0b:1b:9e)</p> <p>Internet Protocol Version 4, Src: 10.0.1.23 (10.0.1.23), Dst: 10.0.1.1 (10.0.1.1)</p> <p>User Datagram Protocol, Src Port: pcp-multicast (5350), Dst Port: pcp (5351)</p> <p>Port Control Protocol, Map Request</p> <p>Version: 2</p> <p>0... .... = R: Response</p> <p>.000 0001 = Opcode: Map (1)</p> <p>Reserved: 0</p> <p>Requested Lifetime: 0</p> <p>Client IP Address: ::ffff:10.0.1.23 (::ffff:10.0.1.23)</p> <p>Map Request</p> <p>Mapping Nonce: 11884299692d832e469659b7</p> <p>Protocol: 6</p> <p>Reserved: 0</p> <p>Internal Port: 2004</p> <p>Suggested External Port: 20004</p> <p>Suggested External IP Address: :: (::)</p>	<p>40 26.372670000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response</p> <p>Frame 40: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface</p> <p>Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IntelCor_c6:10:70 (00:26:c7:c6:10:70)</p> <p>Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 10.0.1.23 (10.0.1.23)</p> <p>User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)</p> <p>Port Control Protocol, Map Response</p> <p>Version: 2</p> <p>1... .... = R: Request</p> <p>.000 0001 = Opcode: Map (1)</p> <p>Reserved: 0</p> <p>Result Code: Success (0)</p> <p>Lifetime: 0</p> <p>Epoch Time: 42898</p> <p>Reserved: 000000000000000000000000</p> <p>Map Response</p> <p>Mapping Nonce: 11884299692d832e469659b7</p> <p>Protocol: 6</p> <p>Reserved: 0</p> <p>Internal Port: 2004</p>
--	---

# 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 network traffic for a PCP v2 protocol test. Each window has a title bar with standard macOS window controls and a packet list on the left.

**Top Left Window: 986 790.718935000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request**

- 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 (90:0b:1b:9e:00:00)
- 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 Window: 988 790.726403000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response**

- 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 Window: 998 797.209015000 10.0.1.23 10.0.1.1 PCP v2 102 Map Request**

- 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 (90:0b:1b:9e:00:00)
- 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 Window: 1000 797.211660000 10.0.1.1 10.0.1.23 PCP v2 102 Map Response**

- Frame 1000: 102 bytes on wire (816 bits), 102 bytes captured (816 bits) on interface
- Ethernet II, Src: Apple\_0b:1b:9e (90:0b:1b:9e:00:00), 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 Wireshark packet capture windows side-by-side. The left window, titled '7 94.990248000 10.0.1.6 10.0.1.1 PCP v2 102 Map Request', shows a packet list with the following details:

- 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: :: (::)

The right window, titled '8 94.992892000 10.0.1.1 10.0.1.6 PCP v2 102 Map Response', shows the corresponding response packet with the following details:

- 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

<div>13 861.893934000 10.0.1.1 224.0.0.1 PCP v2 66 Announce Response</div> <div>▶ Frame 13: 66 bytes on wire (528 bits), 66 bytes captured (528 bits) on interface 0</div> <div>▶ Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IPv4mcast_00:00:01 (01:00:00:00:00:01)</div> <div>▶ Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.1 (224.0.0.1)</div> <div>▶ User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)</div> <div>▼ Port Control Protocol, Announce Response</div> <div>Version: 2</div> <div>1... .... = R: Request</div> <div>.000 0000 = Opcode: Announce (0)</div> <div>Reserved: 0</div> <div>Result Code: Success (0)</div> <div>Lifetime: 0</div> <div>Epoch Time: 21</div> <div>Reserved: 00000000000000000000000000000000</div> <div>Announce Response</div>	<div>14 861.893985000 10.0.1.1 224.0.0.1 NAT-PMP 54 External Address Response</div> <div>▶ Frame 14: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0</div> <div>▶ Ethernet II, Src: Apple_0b:1b:9e (90:72:40:0b:1b:9e), Dst: IPv4mcast_00:00:01 (01:00:00:00:00:01)</div> <div>▶ Internet Protocol Version 4, Src: 10.0.1.1 (10.0.1.1), Dst: 224.0.0.1 (224.0.0.1)</div> <div>▶ User Datagram Protocol, Src Port: pcp (5351), Dst Port: pcp-multicast (5350)</div> <div>▼ NAT Port Mapping Protocol, External Address Response</div> <div>Version: 0</div> <div>Opcode: External Address Response (128)</div> <div>Result Code: Success (0)</div> <div>Seconds Since Start of Epoch: 21</div> <div>External IP Address: 67.169.185.218 (67.169.185.218)</div>
---	--

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.