ARP and high Broadcast rates

Why it is a problem for some routers and how to solve it

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Networking Basics
DE-CIX Academy

01 - Networks, Packets, and Protocols
02 - Ethernet + 02a - VLANs
03 - Internet Protocol (IP), 03a Routing, 03b Global IP
04a - User Datagram Protocol (UDP)
04b - TCP
04c - ICMP
05 - Unicast, Broadcast, Multicast, and Anycast

ARP - Address Resolution Protocol
**Internet Model**  
Layers working together

- Interaction between Internet and Link layers
- What happens when an IP packet is sent
  - The first time to a new neighbor
  - What you know is its IPv4 address
  - But not its Ethernet MAC
I want to send packets to 192.168.1.254 and need to know the MAC address.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Application</td>
</tr>
<tr>
<td>4</td>
<td>Transport</td>
</tr>
<tr>
<td>3</td>
<td>Internet</td>
</tr>
<tr>
<td>2</td>
<td>Link</td>
</tr>
<tr>
<td>1</td>
<td>Physical</td>
</tr>
</tbody>
</table>
Requesting an unknown MAC address

IP Layer and Ethernet layer

My MAC: e0:63:da:51:ee:c8
My IPv4: 192.168.1.135
Destination IPv4: 192.168.1.254
I want: Destination MAC

Layer | Name
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Requesting an unknown MAC address

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My IPv4: 192.168.1.254
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Layer | Name
--- | ---
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Types of communication
Modes of communication

- **Unicast**
  - 1:1 communication
  - Standard in the Internet

- **Broadcast**
  - 1:all
  - Discovery

- **Anycast**
  - 1:1 but don't care which one
  - improve speed or redundancy

- **Multicast**
  - 1:group
  - address a group with something in common
Broadcast

Addressing a crowd
ARP - Address Resolution Protocol
ARP
Address Resolution Protocol

- Nearly as old as the Internet
- Introduced 1982 in RFC826
  - If you read the RFC, it is different than today’s RFCs
- What is shown here is ARP how it is used and implemented today
- ARP is a network layer protocol - just like IPv4.
  - It is **not** encapsulated in IPv4 packets!
ARP
Packet format

• We have ARP requests and replies
  • They use the same packet format
• Lets do an ARP request
  • We want to know the MAC of the host with IPv4 192.168.1.254
• Let's fill out an ARP request packet!
ARP Request
Packet format

- Hardware type is "1" for Ethernet
- Protocol type is "0x800" same as Ethertype field
- Operation is "1" for "Request"
- Sender IPv4 and MAC
- Destination IPv4 is what we know
- Destination MAC is unknown
- We put in the broadcast address
ARP Request

Sending it

- The ARP packet goes into the payload of an Ethernet frame
- Ethertype is 0x806
- Source MAC is the sender’s MAC address
- Destination MAC is the Ethernet Broadcast address

<table>
<thead>
<tr>
<th>Preamble</th>
<th>SF</th>
<th>D</th>
<th>Destination MAC Address</th>
<th>Source MAC Address</th>
<th>Ethertype</th>
<th>Payload</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ff:ff:ff:ff:ff:ff</td>
<td>e0:63:da:51:ee:c8</td>
<td>0x806</td>
<td>46-1500</td>
<td>32 Bits</td>
</tr>
</tbody>
</table>

The ARP packet goes into the payload of an Ethernet frame.
- Ethertype is 0x806.
- Source MAC is the sender’s MAC address.
- Destination MAC is the Ethernet Broadcast address.
ARP Reply
Packet format

- Hardware type is "1" for Ethernet
- Protocol type is "0x800" same as Ethertype field
- Operation is "2" for "Reply"
- Destination IPv4 is the requestors
- Destination MAC also
- Sender IPv4 is the one asked for
- Sender MAC is the requested one
What's next?
Do I have to ask every time?

• Your host has now received the MAC address to an IPv4 address
• This is stored in the *arp table*
  • With some timeout value (Cisco routers: 4 hours, Juniper routers: 25 minutes)
  • After that it gets refreshed (exact calculation is implementation specific and might be complicated)
• And another broadcast is made
Broadcast rate
Broadcast rate
High broadcast rate considered harmful

• On a normal LAN, the ARP rate is quite low
  • about 0-5 ARPs per second (measured on my home LAN)
• On a peering LAN with many routers connected it can go extremely high
  • DE-CIX Frankfurt: 700 ARPs per second and more
  • Of which each must be processed by every router connected
  • Some routers rate-limit ARP traffic
• To protect themselves against attacks
How a router works

Control Plane

Data Plane

Gig0/0

Gig0/1
How a router works

Control Plane

- OSPF
  - Neighbor Table
  - LSDB
- BGP
  - Neighbor Table
  - BGP Table
- Static Routes
- Interface Addresses

Routing Table

Data Plane

- Forwarding Table

Text:

To: 00:25:95:D1:91:29
From: E4:8D:8C:DA:D6:59

Payload From 129.13.10.90 To: 185.54.144.1 Data....
How a router works

Control Plane

- OSPF
  - Neighbor Table
  - LSDB
- BGP
  - Neighbor Table
  - BGP Table
- Static Routes
- Interface Addresses

Routing Table

Data Plane

ARP Request: Who has 80.81.196.61?

To: FF:FF:FF:FF:FF:FF
From: E4:8D:8C:DA:D6:59

Forwarding Table

Network Addresses
Protecting the control plane

Control Plane

- OSPF
  - Neighbor Table
  - LSDB
  - Routing Table

- BGP
  - Neighbor Table
  - BGP Table
  - LSDB
  - BGP Table

- Static Routes
  - Interface Addresses

Routing Table

Data Plane

Forwarding Table

Rate limited

Gig0/0

Gig0/1
Protecting the control plane

Control Plane

- OSPF
  - Neighbor Table
  - LSDB
- BGP
  - Neighbor Table
  - BGP Table
- Static Routes
- Interface Addresses

Routing Table

Rate limited

Data Plane

Forwarding Table

Gig0/0 -> Gig0/1
Solution: Adjust rate limit for DE-CIX FRA

Control Plane

Adjust rate limit for DE-CIX Frankfurt interface*

Route Plane

Forwarding Table

Data Plane

Rate limited

* see appendix for a Juniper configuration example
Conclusion
Conclusion
The ARP protocol

• The ARP protocol gives you the Ethernet address of a neighbor system
• ARP is IPv4 specific
• It works via Broadcast
• High Broadcast rates can overload a router
• Juniper polices the acceptable Broadcast rate
• This policing can be configured and adjusted to the needs of a peering LAN
Thank you!

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Links and further reading
Links and further reading

- IPv4
- IPv6
- History of Internet and IP
  - Internet Hall of Fame - [https://internethalloffame.org](https://internethalloffame.org)
  - Defense Advanced Research Projects Agency (DARPA) - [https://www.darpa.mil](https://www.darpa.mil)

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Links and further reading
ARP and Broadcast

• Wikipedia articles:
  • https://en.wikipedia.org/wiki/Broadcasting_(networking)
  • https://en.wikipedia.org/wiki/Broadcast_address
• Ethernet related:
  • https://en.wikipedia.org/wiki/Broadcast_storm
• IP related:
  • Address Resolution Protocol: RFC826, Wikipedia
Internet RFCs (Standards)

• There are too many RFCs dealing with IPv4 and IPv6 to be listed here
• Just go to https://tools.ietf.org/html/ and use the search field
• How does something become RFC? https://www.rfc-editor.org/pubprocess/
• The IETF - Internet Engineering Task Force
Juniper configuration example

- You need to define a "policer" first (in the firewall context):

```plaintext
policer DECIX-arp {
  if-exceeding {
    bandwidth-limit 2m;
    burst-size-limit 2m;
  }
  then discard;
}
```

- Then you apply the policer to your DE-CIX interface:

```plaintext
interface ae5 {
  unit 2800 {
    description "DE-CIX Peering Interface";
    vlan-id 2800;
    family inet {
      policer {
        arp DECIX-arp;
      }
    }
  }
}
```