Supporting Protocols
ARP and ICMP

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Recap

- Forwarding needs IP to MAC address mapping
  - Service provided by ARP protocol
- Network layer needs to provide means for debugging (error signaling) and for router-host communication (determine MTU size, indicate better routes, provide netmask info etc)
  - Service provided by ICMP protocol

Problem Statement

- IP layer forwarding is based on IP addresses
- Next-hop delivery based on Link addresses (MAC)
- Need to perform IP to MAC address translation
- Answer: Address Resolution Protocol (ARP)

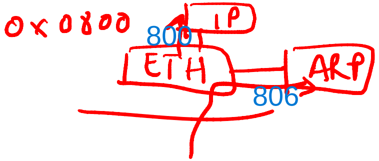
- what layer?
- How do you ensure ARP process gets the relevant packets? -> demux
- what address should the frame carry?
- what messages would you send & how do you act on a ~~message~~ received message?

Address Resolution Protocol (ARP)

- Operates at Link layer (Frame type = 0x0806)

butit deosn nto do any framing/MAC, it is hanfdkled by eherhet.
so ARP is liek a compaion protocol

- Based on broadcast: What is the MAC address corresponding to given IP address?



  - Host with matching IP address replies

- Each host maintains a cache with IP to MAC translations

  - Entries in cache timed out periodically (15 min)

to account for changes in ip-MAC mappings

ARP Packet Format

hardware : ethernet
Protocol : ip

<table>
<tr><th colspan="2">0 8</th><th colspan="2">16 31</th></tr>
<tr><td colspan="2">Hardware Type (=1)</td><td colspan="2">Protocol Type (=0x0800)</td></tr>
<tr><td>HLEN (=48) MAC
hardware len</td><td>PLEN (=32) IP
protocol len</td><td colspan="2">Operation request, reply</td></tr>
<tr><td colspan="4">Source Hardware Address (Bytes 0-3)</td></tr>
<tr><td colspan="2">Source Hardware Address (Bytes 4-5)</td><td colspan="2">Source Protocol Address (Bytes 0-1)</td></tr>
<tr><td colspan="2">Source Protocol Address (Bytes 2-3)</td><td colspan="2">Target Hardware Address (Bytes 0-1)</td></tr>
<tr><td colspan="4">Target Hardware Address (Bytes 2-5) - ?</td></tr>
<tr><td colspan="4">Target Protocol Address (Bytes 0-3)</td></tr>
</table>

Numbers in brackets capture mapping
IP addresses to Ethernet addresses

Address Resolution Protocol (ARP)

- Originator: Add entry to cache corresponding to target ↳ ARP Request
- ARP Reply
  Target: Add entry to cache corresponding to the originator (sender)
- Intermediate hosts: Refresh existing entries
- When forwarding a datagram, check cache, if no mapping, invoke ARP

Example

(A): MAC corresponding to IP of B

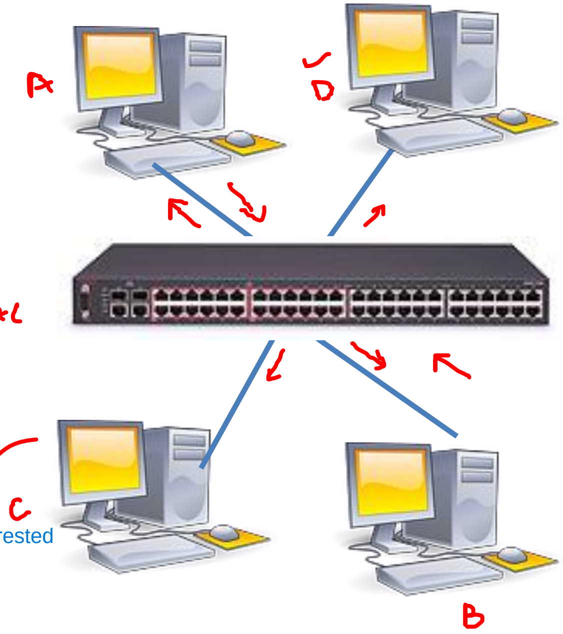
ARP request → MAC header: src add, dst add → ff:ff: . . .

↓ broadcast → Payload

Src MAC	Src IP	Target MAC	Target IP
A	A	?	B

Cache' A

B IP → B MAC



ARP reply from B ↓ "uni cast" → MAC → src add B, dst add: A

no reson that other hosts would be interested inB's addres

→ Payload

Src MAC	Src IP	Target MAC	Target IP
B ← B		A	A

Cache' B

A IP → A MAC

C, D ARP request

↳ A → refresh (reset timer)

no entry A , ignore ARP request

C,D wont have anything to do with ARP reply

C, D

Address Resolution Protocol (ARP)

- Originator: Add entry to cache corresponding to target

IP addr , MAC

- Target: Add entry to cache corresponding to the originator (sender)
- Intermediate hosts: Refresh existing entries
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ARP

Gratuitous ARPs

- Generated by a host to inform others of its IP to MAC mapping

→ broadcast

MAC header — src MAC ↑ host — dest ff:ff . . . — own

ARP

- Could be a request or reply

Ethernet payload ..... i.e, ARP data

ARP data

src , Target

IP = ? IP = ?

src MAC = MAC

  - If request, no reply will occur
  - If reply, there was no preceding request
  - Source IP = destination IP = IP of machine generating gratuitous ARP
  - Target MAC = ?

ff:ff → request } window

MAC → reply

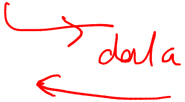
Uses of Gratuitous ARPs

- Issued whenever IP or MAC address of an interface changes or brought up from down state
  - Help rectify cached ARP entries
  - Report IP address conflicts (duplicate IP)

    if u manually configure a dup ip, then a grat ARP, will reach the host with that ip, and it replies that u have used a dup ip... so u better change it.
  - Inform bridges of the location of new host

ICMP: Internet Control Message Protocol

- Used by hosts & routers to communicate network-level information
  - Error reporting: unreachable host, network, port, protocol
  - Diagnostic purposes: Echo request/reply (used by ping)
  - Routing: Source quench



if sourse sends too much data rate than it can handle.

ICMP Packet Format

ICMP protocol operates at Network Layer,,,

demux TCP = 6

IP → ICMP

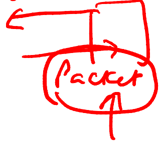
demux key : 1

if demux key is 1, then pass packet to the ICMP protocol

- ICMP messages carried in IP datagrams
- 8 bytes of header followed by data.
- Data field in error messages carry

not all ICMP msgs contain data, it is contained only in the error messages

ICMP mes Route



  - entire IP header and first 8 bytes of data of IP packet that caused the error

entire ICMP message

0	8	16	31
Type //	Code //	Checksum	
Type/Code defined information			
Data			

8 byte

Select ICMP Messages

Type	Code	Description
0	0	Echo Reply (Ping)
3	0	Destination network unreachable
3	1	Destination host unreachable
3	3	Destination port unreachable
3	4	Fragmentation required, DF flag set
3	6	Destination network unknown
3	7	Destination host unknown

if wesend a large packet, and still say DontFragment ... then it drops the packet and sends tus error message

Select ICMP Messages

Type	Code	Description
4	0	Source Quench
5	0	Redirect datagram for the network
8	0	Echo request (Ping)
11	0	TTL expired
12	0	Bad IP header
13	0	Timestamp
14	0	Timestamp reply
17	0	Address mask request
18	0	Address mask reply

these not error messages

Example: Fragmentation Required

0	8	16	31
Type=3	**Code=4**	**Checksum**	
Unused		**Next hop MTU**	
IP header and first 8 bytes of original datagram’s payload			

Traceroute

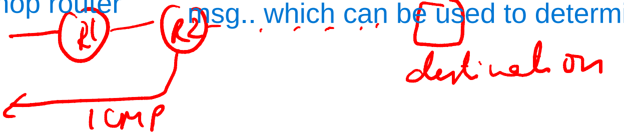
- Source sends series of UDP segments to destination one after another

it keeps on sending till it gets a reply.

  - First has TTL =1

The packet is dropped by the very next-hop router

and the next-hop-router sends back an ICMP msg.. which can be used to determine the route



  - Second has TTL=2, etc.
  - Destination port is set to an unlikely number

Traceroute

- When n^th datagram arrives to nth router:
  - Router discards datagram
  - Sends to source an ICMP message (type 11, code 0)
  - Message includes name of router& IP address
- For each ICMP message, sending host notes router id and RTT time ← UDP ICMP error message
- Sending host stops when it gets ICMP message (type 3, code 3) → destination port

Summary

- Studied two useful protocols: ARP and ICMP
- ARP is needed for forwarding
  - Performs IP to MAC address translation
- ICMP helps with error reporting and host signaling