Virtual Networks and Tunnels

- Virtual private networks via internet
- Use leased lines
- Establish VCs on an ATM network
- Controlled connectivity
- Using IP
  - IP Tunnels:
    - No VC
    - Concept of encapsulation router
Example

Forwarding Table **R1**

<table>
<thead>
<tr>
<th>Network Number</th>
<th>Next hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interface 0</td>
</tr>
<tr>
<td>2</td>
<td>Virtual Interface 0</td>
</tr>
<tr>
<td>Default</td>
<td>Interface 1</td>
</tr>
</tbody>
</table>
Setting up Tunnels in the Internet

R1 - Encapsulating router

- sends packet address to R2
- Packet reaches R2 as if a standard internet packet
- at R2 – strip and forward to the destination directly
Interfaces

• Router R1 –
  – Two physical interfaces 1 and 2
  – one virtual interface packet to R1 destined for N2.
  – Forwarding table – says send on Virtual interface 0

• Advantages:
  • Security: Supplement with encryption
  • A private link across a public network
Internet Control Protocols in the Network Layer

- ICMP, ARP, RARP, BOOTP
- ICMP – primarily used by routers to monitor the Internet
- Different type of ICMP messages:
  - Destination unreachable
    - No path to destination
  - DF bits set, destination on small packet Network
  - Time exceeded
    - Packet dropped – looping, congestion, timer bandwidth
  - Parameter problem
    - Illegal value in header field
Internet Control Protocols in the Network Layer (ICMP)

- Source quench
  - Throttle source sending too many packets
  - Lead to congestion

- Redirect
  - Router discover that packet routed wrongly
  - Inform sending host about problem

- Echo request
  - Determine if destination alive

- Echo reply
  - I am alive
Internet Control Protocols in the Network Layer (ICMP)

- Time stamp request:
  - Same as echo request, timestamp

- Time stamp reply
  - Same as echo reply, timestamp

- Four more messages to handle single IP address on multiple LANs, hosts can discover their Network
Address Resolution protocol (ARP): Map IP address to their physical addresses?

**Diagram:**
- **EE Ethernet**
  - 10.6.0.0
  - 10.6.0.10
  - 10.6.0.7
  - 10.6.0.1
- **CS Ethernet**
  - 10.7.0.0
  - 10.7.0.2
  - 10.7.0.3
- **FDDI ring**
  - 10.65.0.4
  - 10.65.0.0
  - 10.65.0.4
- **L1, L2, L3, L4**
  - R1
  - R2
Internet Control Protocols in the Network Layer (ARP)

- $L_1$ wants to send packet to $L_2$
- Upper layer puts IP address of $L_2$ in destination field and sends it to IP Layer.
- IP software – Realises on same LAN
- How does it find Ethernet address?
  - Configuration file?
  - updation?
Internet Control Protocols in the Network Layer (ARP)

- **L1 outputs a broadcast packet**
  - Who owns IP address 10.6.0.7?
  - Arrives at all machines on same LAN
    - Each machine checks, L2 alone responds with its Ethernet address
  - Maintain ARP cache for future
    - ARP timeout
      - Remove addresses that are old
  - Alternatively all machine broadcast their Ethernet address at boot time
Internet Control Protocols in the Network Layer (ARP)

• Machines on different LAN
  – L1 wants to send packet to L4
• send to local router R1
  – Router takes care of it
  – proxy – ARP
• alternatively sends to a default Ethernet address
• requires router - router ARP requests for other LANs
Internet Control Protocols in the Network Layer (Proxy ARP)

- Lets router answer ARP request on one of its network for a host on another of its networks!
  - Fool sender – destination router
  - Machine with two network cards can do proxy ARP
- Maintain ARP cache on each host
- Maintain recent mapping
  - expiration of an entry in cache every 20 minutes
# ARP Packet format

<table>
<thead>
<tr>
<th>Eth Dest add</th>
<th>Eth source add</th>
<th>Frame type</th>
<th>Hardware type</th>
<th>Protocol type</th>
<th>output</th>
<th>Hardware size</th>
<th>Protocol size</th>
<th>Sdr ethernet</th>
<th>Sdr IP</th>
<th>Target Ethernet</th>
<th>Target IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For ARP / ARP reply 0x0806

1 for Ethernet (type hardware address and protocol address)

0x800 for IP

Sizes in bytes hardware addresses

Size in bytes protocol addresses

Output ARP request (1) RARP request (3)

ARP reply (2) RARP reply (4)
ARP (Example)

- **arp - a** -- *empty cache*
- **telnet xyz** -- *try to connect to xyz*
- **DNS resolves xyz to IP address**
- **To monitor Ethernet packets**
- **Use tcpdump on unix machines**
ARP (Example)

- tcpdump –e
- 0:0.C0:6f:2d:40 ff:ff:ff:ff:ff:ff:ff:ff:ff:ff arp 60

- Senders Ethernet address: 0:0.C0:C2:96:26
- Target Ethernet address: 0:0:C0:6f:2d:40
- broadcast
- Length of Ethernet address: 0:0:C0:6f:2d:40
Gratitious ARP

- Host sends a request to get its own IP address
- \texttt{tcpdump} –n option
- \texttt{0:0:C0:6f:2d:C0:ff:ff:……..ff arp 60}
- \texttt{arp who has 140.252.13.35 tell 140.252.13.35}
  – enables host to determine if same IP address is in use!
ATMARP

- LAN Emulation Procedure
- Part of classical IP over ATM model
  - Depends on server to resolve addresses
  - ARP server
    - Database of IP address and ARP address
    - Machines setup VC to ARP server at boot time
    - Get address of destination
    - Setup VC to destination address
Two nodes on same Network

- Cannot communicate directly

LIS – Logical IP Subnet
ATMARP

- LIS – advantage:
  - Connect large number of routers and hosts to a big ATM Network
- ARP Server:
  - Enable nodes on LIS to resolve IP address – w/o broadcast
- LIS
  - Each node in LIS configured with ATM address of ARP server
- ARP Server
  - Table of IP and ATM addresses
- Issues:
  - h1 cannot talk to h2 directly – must go through router
Dynamic Host Configuration Protocol (DHCP)

- Host
- DHCP relay
- Other NWs
- DHCP server

IP address – unique to a given Internetwork
DHCP

• Automated configuration methods:
  • DHCP server
    – addresses handed over to hosts on demand

• Issues
  – host requires address of DHCP servers
  – host sends DHCP discover broadcast message
  – DHCP server replies to the host
  – Avoid DHCP server on every network
    • Use DHCP Relay
DHCP

- **DCHP format:**
  - **chaddr** – field in which host puts its hardware address
  - **yiaddr** – your IP address DHCP assigns address
- Hosts cannot keep IP addresses permanently
- Some mechanism for leasing IP address
- Getting IP address for duration of the call