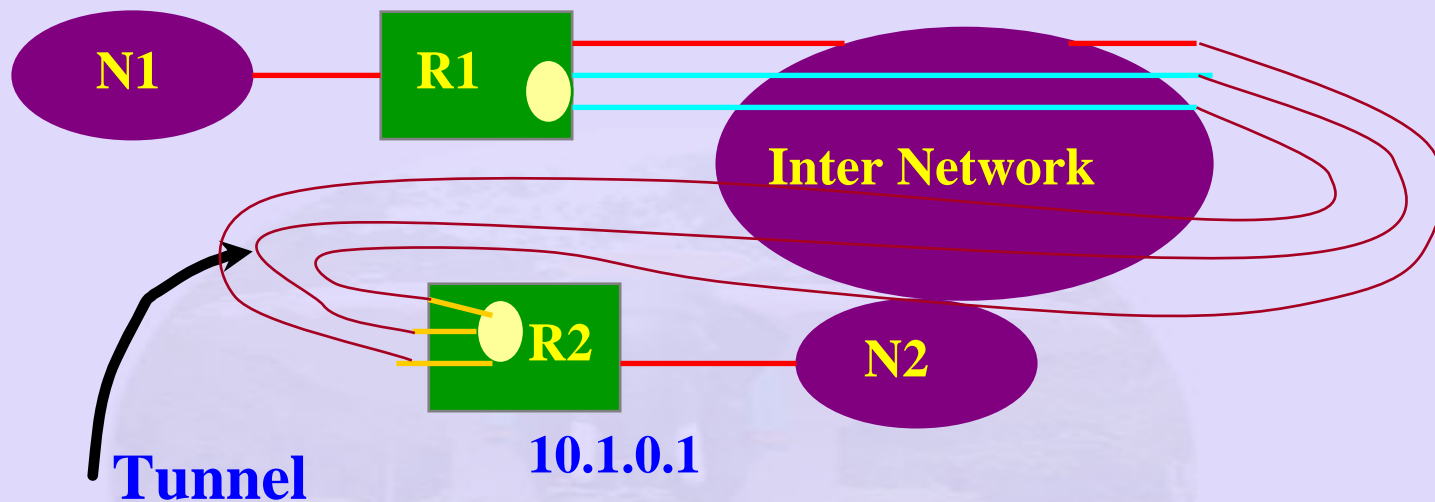# Virtual Networks and Tunnels

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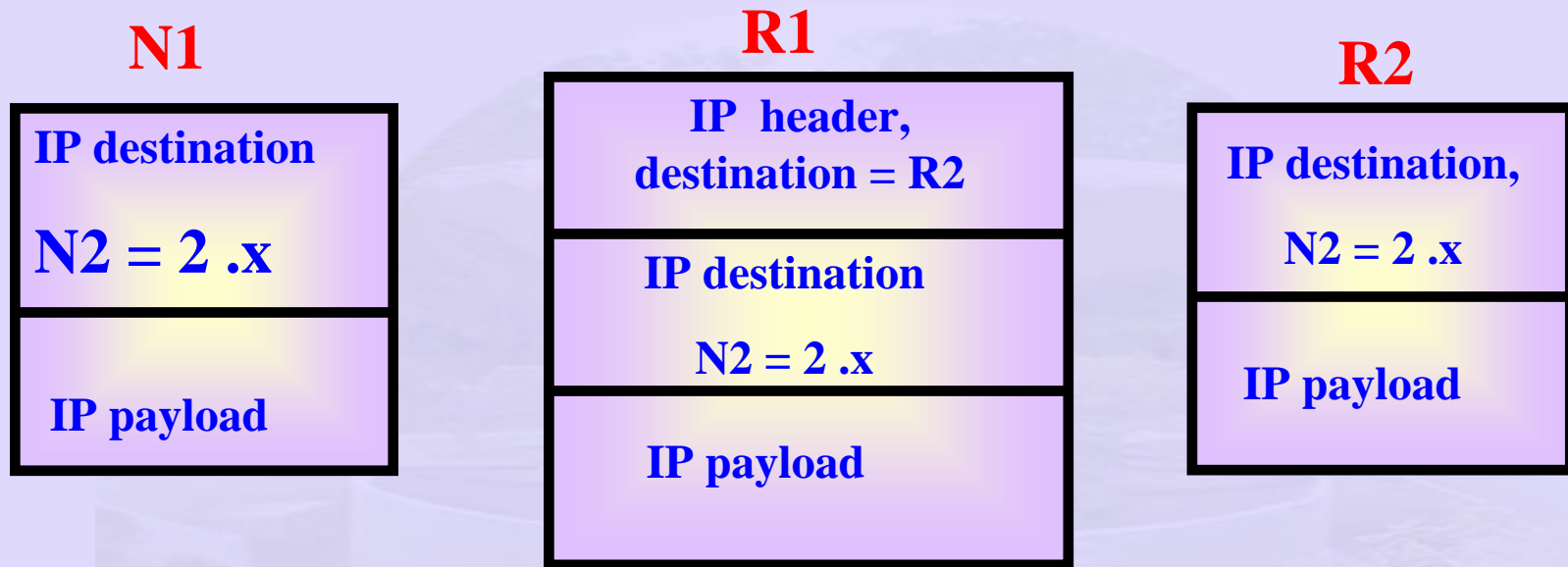   - No VC
    - Concept of encapsulation router

Example

N1 — **R1** — **Inter Network**

R2

N2

10.1.0.1

Tunnel

Forwarding Table R1

Network Number	Next hop
1	Interface 0
2	Virtual Interface 0
Default	Interface 1

Setting up Tunnels in the Internet

N1

R1

R2

IP destination
$N2 = 2 .x$
IP payload

IP header, destination = R2
IP destination N2 = 2 .x
IP payload

IP destination, N2 = 2 .x
IP payload

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

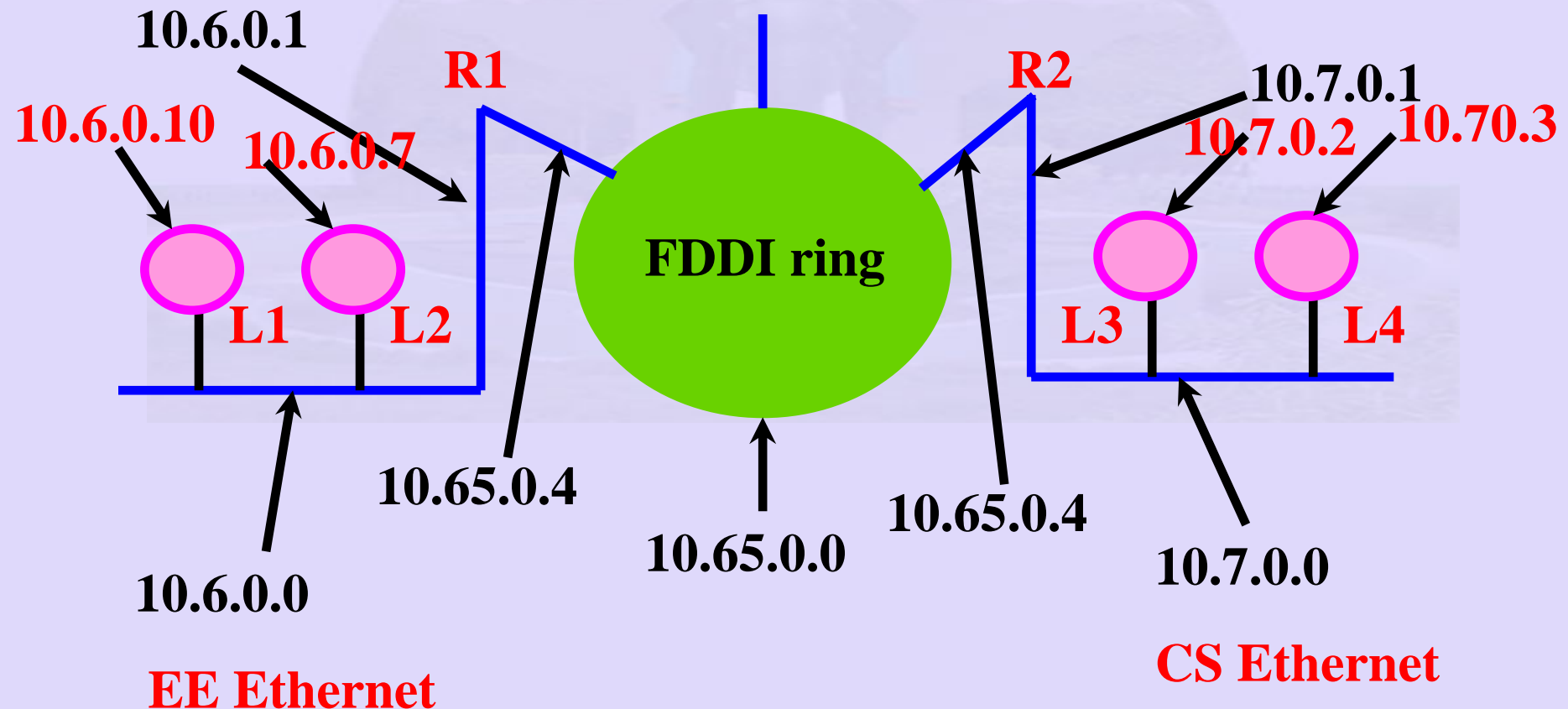# Internet Control Protocols in the Network Layer (ICMP)

- 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 LAN, hosts can discover their Network

Internet Control Protocols in the Network Layer (ARP)

Address Resolution protocol (ARP): Map IP address to their physical addresses?

10.6.0.1

R1

R2

10.7.0.1

10.6.0.10

10.6.0.7

10.7.0.2

10.70.3

FDDI ring

L1   **L2**

L3   **L4**

10.65.0.4

10.65.0.4

10.6.0.0

10.65.0.0

10.7.0.0

EE Ethernet

CS Ethernet

Internet Control Protocols in the Network Layer (ARP)

- *L1* wants to send packet to *L2*

- Upper layer puts IP address of *L2* 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

Eth Dest add	Eth source add	Frame type	Hard ware type	Proto col type	output	Hard ware size	Proto col size	Sdr ethernet	Sdr IP	Target Ether net	Target IP

6   6   2   2   2   2

For ARP / ARP reply 0 x 0806

Sizes in bytes hardware addresses

1 for Ethernet (type hardware address and protocol address)

Size in bytes protocol addresses

0 x 800 for IP

Output ARP request (1)   **RARP request (3)**
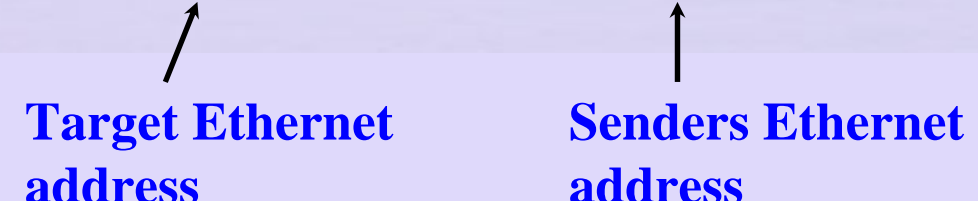
ARP reply (2)   **RARP reply (4)**

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 arp 60

Senders Ethernet address   **broadcast**   **Length of Ethernet address**
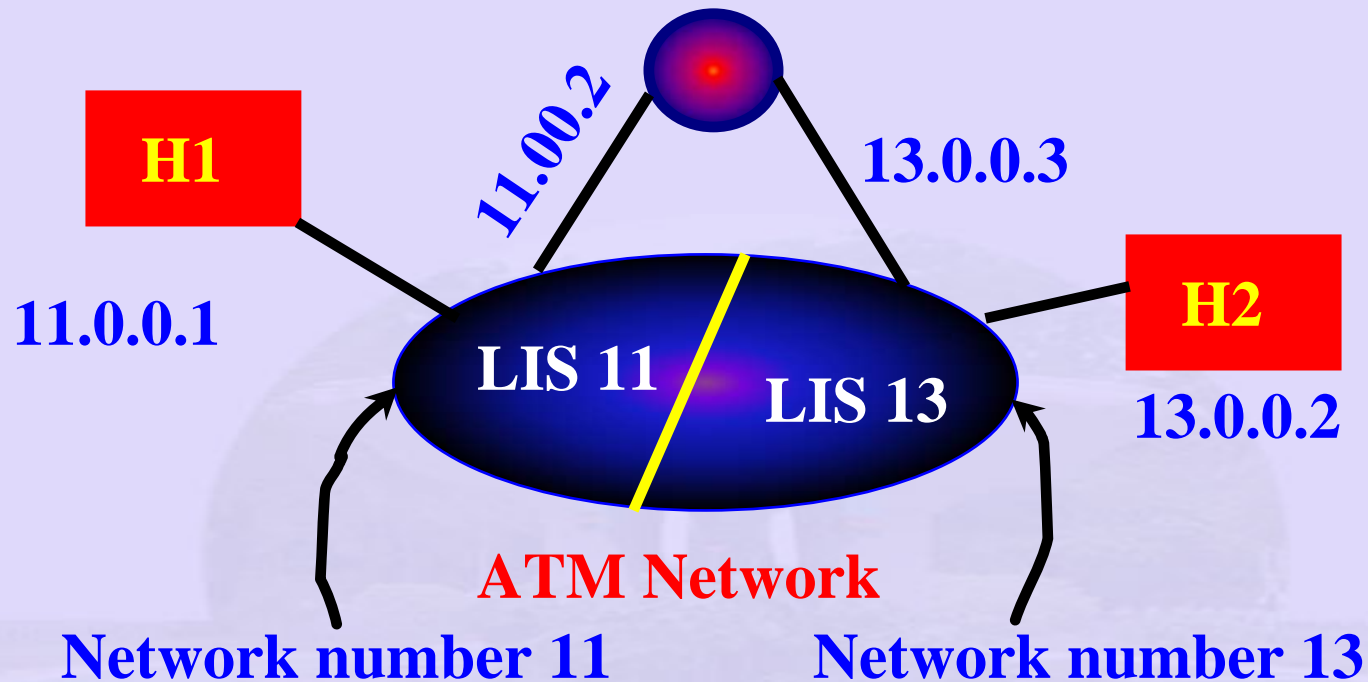
0:0.C0:C2:96:26   0:0.C0:6f:2d:40

Target Ethernet address   **Senders Ethernet address**

Gratitious ARP

- Host sends a request to get its own IP address

- tcpdump –n option

- 0:0:C0:6f:2d:C0:ff:ff:…….ff arp 60

- 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

H1

11.00.2

13.0.0.3

11.0.0.1

H2

LIS 11   **LIS 13**

13.0.0.2

ATM Network

Network number 11   **Network number 13**

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)

Unicast to server

broadcast

DHCP relay

Other NWs
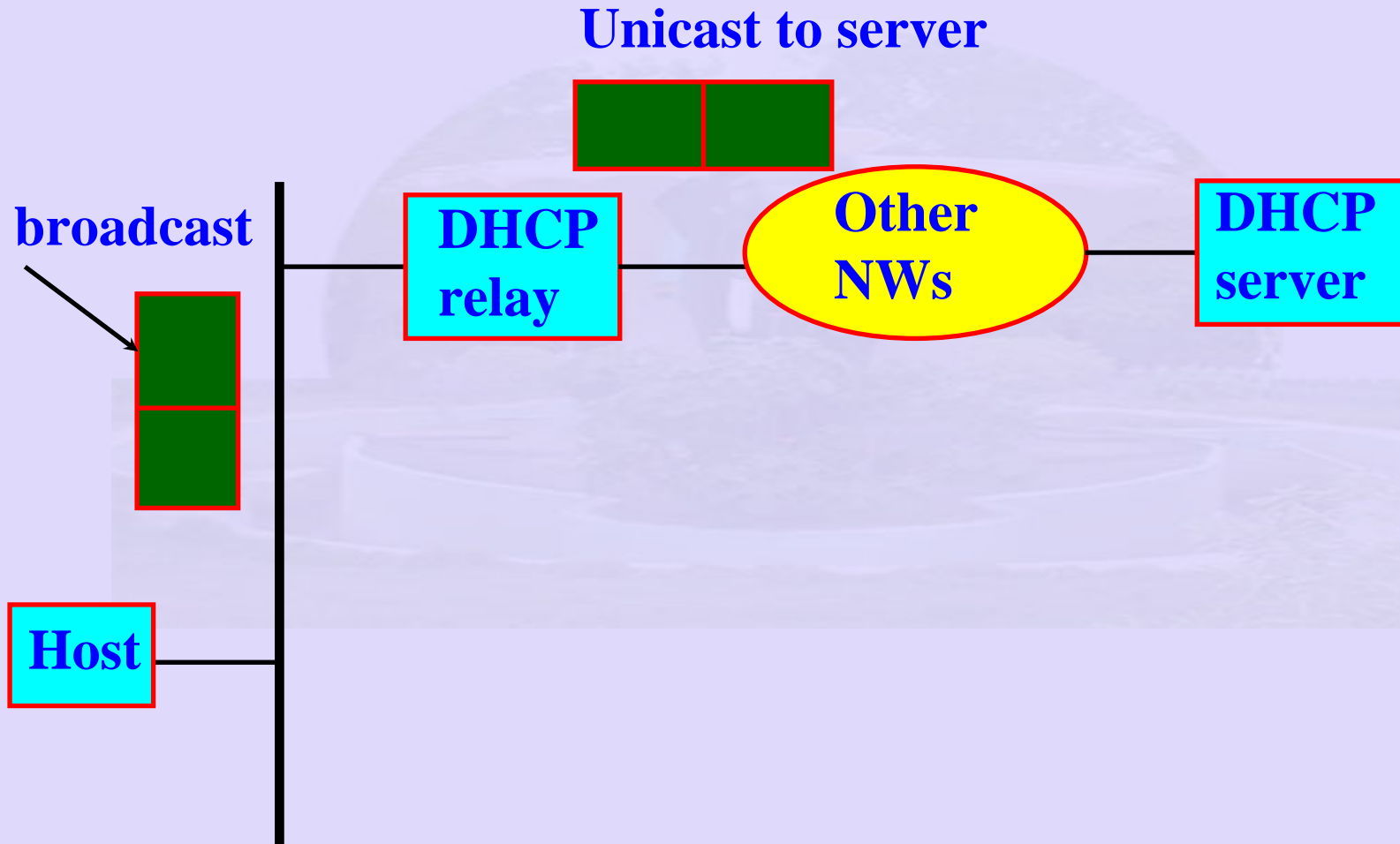
DHCP server

Host

IP address – unique to a given Internetwork

DHCP

- Automated configuration methods:
- DCHP server
  - addresses handed over to hosts on demand
- Issues
  - host requires address of DCHP servers
  - host sends DCHP 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