CS 348: Computer Networks

- IP addressing; 21st Aug 2012

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Think-Pair-Share: IP addressing

• What is the need for IP addresses?
  • Why not have only MAC addresses?

• Given that IP addresses are required, come up with a suitable way of structuring them.
  • What are the pros and cons of your solution?
  • Analogy: Think about a post-office.
    − What information needs to be maintained by each post-office in order to route a letter from here to anywhere?
IP Addressing

- Addresses need to be globally unique, so they are hierarchical

- Another reason for hierarchy: *aggregation*
  - reduces size of routing tables
  - at the expense of longer routes
Network layer

• Need:
  • Hide type of subnet
  • Ethernet, Token Ring, FDDI ...
  • Hide topology of subnets

• Provides:
  • Uniform addressing
  • Packet delivery
IP characteristics

- IP can run on
  - Ethernet (CSMA/CD)
  - FDDI (token ring)
  - telephone trunks (SONET or PDH)
  - wireless links (CSMA/CA)
  - satellite links (ALOHA)
  - other technologies like X.25, ISDN

- underlying technology can be upgraded without affecting TCP/IP
Network layer functions

- Internetworking
  - uniform addressing scheme

- Routing
  - choice of appropriate paths from source to destination

- Congestion Control
  - avoid overload on links/routers
Addressing

• Address: byte-string that identifies a node; usually unique
  • physical address: device level
    – Ethernet HWaddr 00:1c:c0:ae:a7:65
  • network address: network level
    – inet addr:10.129.5.151
  • logical address: application level
    – www addr: www.cse.iitb.ac.in
Address Resolution Protocol (ARP)
RFC 1010

- Address resolution provides mapping between IP addresses and datalink layer addresses
- point-to-point links don’t use ARP, have to be configured manually

![Diagram showing the relationship between 32-bit IP address and 48-bit Ethernet address using ARP and RARP protocols]

- 32-bit IP address
- ARP
- 48-bit Ethernet address
- RARP
ARP request/reply; cache

- ARP requests are broadcasts
  - “Who owns IP address x.x.x.x.?”.

- ARP reply is unicast

- ARP cache is created and updated dynamically
  - `arp –a` displays entries in cache
  - Every machine broadcasts its mapping when it boots
IP addressing

- Internet Protocol (IP)
  - connectionless packet delivery and “best-effort” quality of service

- Every host interface has its own IP address

- Routers have multiple interfaces, each with its own IP address
IP addressing example

```
10.1.1.2
10.1.1.3
10.1.1.4
```

```
11011111 00000001 00000101 00000010
223 1 5 2
```
IP forwarding

At a host:
- Destination on my net?
  - If yes, use ARP and deliver directly.
  - If not, give to default gateway.

At a gateway:
- Am I the destination IP?
  - If yes, deliver packet to higher layer.
  - If not, which interface to forward on?
    - consult Routing Tables to decide.
Think-Pair-Share: Address space

- Why 32 bit address space?

- How many bits should be allocated for network number and host number?

- How does a router know which bits to consider for network number and which ones for host number?
IPv4 addresses

• Logical address at network layer

• 32 bit address space
  • Network number, Host number
  • boundary identified by a subnet mask
  • can aggregate addresses within subnets

• Machines on the same "network" have same network number
Address classes

- Class A addresses - 8 bits network number
- Class B addresses - 16 bits network number
- Class C addresses - 24 bits network number

Distinguished by leading bits of address
- leading 0 => class A (first byte < 128)
- leading 10 => class B (first byte in the range 128-191)
- leading 110 => class C (first byte in range 192-223)
# IPv4 addresses

## Class

<table>
<thead>
<tr>
<th>Class</th>
<th>Network</th>
<th>Host</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>0</td>
<td>1.0.0.0 to 127.255.255.255</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>0</td>
<td>128.0.0.0 to 191.255.255.255</td>
</tr>
<tr>
<td>C</td>
<td>110</td>
<td>0</td>
<td>192.0.0.0 to 239.255.255.255</td>
</tr>
<tr>
<td>D</td>
<td>1110</td>
<td></td>
<td>240.0.0.0 to 247.255.255.255</td>
</tr>
</tbody>
</table>

32 bits
IPv4 address issues

- Inefficient: wasted addresses
- Inflexible: fixed interpretation
- Not scalable:
  - Number of networks is growing
  - Not enough network numbers
Group Activity – IP addressing

• IPv4 addressing is inefficient due to wasted addresses in class A and class B networks.
• It is also not scalable to growing number of networks.

• Design a solution to fix the above IP address inefficiency problems.
  • What are the pros and cons of your solution?
IP addressing schemes

• Sub-netting: Subnet Masks
  • Create sub networks within an address space.

• CIDR: Classless InterDomain Routing
  • Variable interpretations for the network number.

• DHCP: Dynamic Host Configuration Protocol
  • Assign addresses dynamically from a pool.

• NAT: Network Address Translation
  • Private IP addresses within intranet; Translate to a public IP address at gateway before internet access. So reuse is possible.

• Ipv6: 128 bit address space
Subnet mask

<table>
<thead>
<tr>
<th>Network Number</th>
<th>Host Number</th>
</tr>
</thead>
</table>

Class B address

```
11111111111111111111111111111111  00000000
```

Subnet Mask (255.255.255.0)

<table>
<thead>
<tr>
<th>Network Number</th>
<th>Subnet ID</th>
<th>Host ID</th>
</tr>
</thead>
</table>

Subnetted Address
Subnet addressing

- Internal routers & hosts use subnet mask to identify “subnet ID” and route packets between “subnets” within the “network”

- Subnet mask can end on any bit

- Mask must have contiguous 1s followed by contiguous zeros. Routers do not support other types of masks.
Classless Inter Domain Routing (CIDR)

- Medium sized networks choose class B addresses, leading to wasted space
  - allow ways to represent a set of class C addresses as a block, so that class C space can be used
  - use a CIDR mask
CIDR

201.10.0.0 / 21 = 201.10.0.0 - 201.10.0.255
  201.10.1.0 - 201.10.1.255
  201.10.2.0 - 201.10.2.255
  201.10.3.0 - 201.10.3.255
  201.10.4.0 - 201.10.4.255
  201.10.5.0 - 201.10.5.255
  201.10.6.0 - 201.10.6.255
  201.10.7.0 - 201.10.7.255

EIGHT CLASS C NETWORKS = 256 x 8 = 2048 ADDRESSES

256 ADDRESSES = 1 CLASS C NETWORK
Closure

• Self-study:
  • Read about CIDR (Classless Interdomain Routing).

• Tutorial question:
  • Given an IP address 144.16.116.2 and subnet mask 255.255.255.192. Identify the Net:Subnet and the Host parts of the IP address.