Network Layer Fields

These are the header fields in an IP packet header. All field lengths are fixed except for IP options and the padding fields.
The ARP Process

1. Send Data to a device
   - Is the MAC address in my ARP cache?
     - Yes: Get an ARP reply
     - No: Send an ARP request
   - Send Data
ARP Table Functions

**FIGURES**

<table>
<thead>
<tr>
<th>IP Address</th>
<th>MAC Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>FE:ED:31:A3:47:14</td>
<td>176.10.16.2</td>
</tr>
<tr>
<td>FE:ED:31:AF:49:67</td>
<td>176.10.16.4</td>
</tr>
<tr>
<td>176.10.16.7</td>
<td>FE:ED:31:A2:22:05</td>
</tr>
<tr>
<td>176.10.16.5</td>
<td>FE:ED:31:A2:22:77</td>
</tr>
</tbody>
</table>
**ping Command**

Microsoft Windows 2000 [Version 5.00.2195]
<C> Copyright 1985-2000 Microsoft Corp.

C:\> ping 198.133.219.25

Pinging 198.133.219.25 with 32 bytes of data:

Reply from 198.133.219.25: bytes=32 time=16ms TTL=247
Reply from 198.133.219.25: bytes=32 time=16ms TTL=247
Reply from 198.133.219.25: bytes=32 time=16ms TTL=247
Reply from 198.133.219.25: bytes=32 time=16ms TTL=247

Ping statistics for 198.133.219.25:
  Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
  Minimum = 16ms, Maximum = 16ms, Average = 16ms
C:\>
Echo Reply

FIGURES

1
2
3

Is B reachable?

Yes, I am here.

A

ICMP echo request

ICMP echo reply

B

Traffic generated by the ping command
### ICMP Message Types

<table>
<thead>
<tr>
<th>ICMP Message Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Echo Reply</td>
</tr>
<tr>
<td>3</td>
<td>Destination Unreachable</td>
</tr>
<tr>
<td>4</td>
<td>Source Quench</td>
</tr>
<tr>
<td>5</td>
<td>Redirect/ Change Request</td>
</tr>
<tr>
<td>8</td>
<td>Echo Request</td>
</tr>
<tr>
<td>9</td>
<td>Router Advertisement</td>
</tr>
<tr>
<td>10</td>
<td>Router Selection</td>
</tr>
<tr>
<td>11</td>
<td>Time Exceeded</td>
</tr>
<tr>
<td>12</td>
<td>Parameter Problem</td>
</tr>
<tr>
<td>13</td>
<td>Timestamp Request</td>
</tr>
<tr>
<td>14</td>
<td>Timestamp Reply</td>
</tr>
<tr>
<td>15</td>
<td>Information Request</td>
</tr>
<tr>
<td>16</td>
<td>Information Reply</td>
</tr>
<tr>
<td>17</td>
<td>Address Mask Request</td>
</tr>
<tr>
<td>18</td>
<td>Address Mask Reply</td>
</tr>
</tbody>
</table>
Destination Unreachable Message

A

Send data to Z.

I do not know how to get to Z. Send ICMP.

Data network

To Z

Destination unreachable
### UDP Segment Format

<table>
<thead>
<tr>
<th>Bit 0</th>
<th>Bit 15 Bit 16</th>
<th>Bit 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port (16)</td>
<td>Destination Port (16)</td>
<td></td>
</tr>
<tr>
<td>Length (16)</td>
<td>Checksum (16)</td>
<td></td>
</tr>
<tr>
<td>Data (if any)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8 Bytes

No sequence or acknowledgment fields
The field format of a TCP segment contains a TCP header followed by data. Segments are used to establish connections as well as to carry data and acknowledgments.
TCP Three-Way Handshake/Open Connection

1. Send SYN(seq=100, ctl=SYN)
2. SYN Received
   Send SYN, ACK(seq=300, ack=101, ctl=syn,ack)
3. SYN Received
   Established(seq=101, ack=301, ctl=ack)
TCP Basic Window

Window size = 1

Sender

send 1
receive ACK 2
send 2
receive ACK 3
send 3
receive ACK 4

Receiver

receive 1
send ACK 2
receive 2
send ACK 3
receive 3
send ACK 4
TCP Sliding Window

FIGURES

1

2

Sender
send 1
send 2
send 3
receive ACK 4
send 4
send 5
send 6
receive ACK 7
Window size = 3

Receiver
receive 1
receive 2
receive 3
send ACK 4
receive 4
receive 5
receive 6
send ACK 7
TCP Sliding Window

Sender Host
send 1
send 2
send 3
send 3
send 4
send 5
send 5
send 6

Receiving Host
receive 1
receive 2
receive 3
receive 4
receive 5
receive 5
receive 6
receive 5

ACK 3 window size 2
ACK 5 window size 2
ACK 7 window size 2