IPv4 Addresses and Address Resolution Protocol

1) Your computer with the IP address 134.226.36.18 wants to transmit an http-request to a server at Google with the IP address 173.194.37.104. For http-requests, your machine uses a proxy with the IP address 134.226.32.54 (see figure on next page). Your computer is connected through an IEEE 802.11 access point to the sub-network 134.226.36.0. The two sub-networks 134.226.36.0 and 134.226.32.0 are separate Ethernet broadcast domains, both of them are connected through a router in the School of Computer Science and Statistics with at least two interfaces for 134.226.32.254 and 134.226.36.254. The computers in the sub-networks use these addresses as the addresses for the default gateway.

   Describe the journey of the http-request and the exchanges of information at the Network and Link Layer i.e. using IPv4 and Ethernet from your computer to the server at Google. The description should include the information that is necessary for the computers and routers to process the IPv4 packets and Ethernet frames. You can assume that the routers have a full view of the internal network of TCD and do not have to update their routing information.

   - The sender discovers that the destination is not in its local network
   - and that it needs to communicate with the default gateway
   - An ARP request from 134.226.36.18 for the hardware address of the default gateway
   - An ARP response from default router to 134.226.36.18
   - Transfer of the IPv4 packet in an 802.11/Ethernet frame addressed to the default router with the IP address of the proxy server as destination address
   - AARP request for hardware address of proxy server
   - ARP reply from proxy server
   - Transfer of HTTP request to proxy server
   - Transfer of HTTP request by proxy server to default gateway addressed to IP address of Google server
   - Transfer of HTTP by default gateway to next router and so on until the IP packet is delivered to the router at the network of the Google server
   - ARP request for hardware address of Google server
   - ARP response from Google server
   - Delivery of HTTP request to Google server

2) An Internet Service Provider (ISP) has bought the right to use the IP addresses in the range from 213.49.0.0 to 214.57.255.255. It uses Classless Inter-Domain Routing (CIDR) to route traffic to these addresses. It receives a number of requests from companies. First company A buys a block of 14,000 addresses, then company B requests 6,000, followed by company C with 850 addresses and company D requests 350 addresses. The ISP processes these requests in the order it receives

them. What is the address range allocated for each client? Give the first and last address of the range, the number of significant bits and the subnet mask.

If CIDR wasn't used, what classes of network addresses would be allocated to each client? How many addresses would be allocated in total? What would be the fraction of addresses actually used by each client? Compare this to the use of CIDR.

First company A buys a block of 14,000 addresses,
then company B requests 6,000,
followed by company C with 850 addresses
and company D requests 350 addresses.

Client A: 213.49.0.0/18 (213.49.0.0-213.49.63.255)
Client B: 213.49.64.0/19 (213.49.64.0-213.49.95.255)
Client C: 213.49.96.0/22 (213.49.96.0-213.49.99.255)
Client D: 213.49.100.0/23 (213.49.100.0-213.49.101.255)

Client A:
14000 – next 2x: 16384 - 214
213.49.0.0
213.49.63.255
213.49.0.0/18

Client B:
6000 – next 2x: 8192 - 213
213.49.64.0
213.49.95.255
213.49.64.0/19

Client C:
850 – next 2x: 1024 - 210
213.49.96.0
213.49.99.255
213.49.96.0/22

Client D:
350 – next 2x: 512 - 29
213.49.100.0
213.49.101.255
213.49.100.0/23

Without CIDR, each client would require a class B address range, because every request is larger than a class C network with 254 addresses.

without CIDR:
Client A: 14000/65536 = 0.213 ~ 21% usage
Client B: 6000/65536 = 0.077 ~ 9% usage
Client C: 850/65536 = 0.013 ~ 1% usage
Client D: 350/65536 = 0.005 ~ 0.5% usage

with CIDR:
Client A: 14000/16384 = 0.854 ~ 85% usage
Client B: 6000/8192 = 0.61 ~ 73% usage
Client C: 850/1024 = 0.83 ~ 83% usage
Client D: 350/512 = 0.68 ~ 68% usage

3) Assume you have a dial-up connection and want to send a UDP datagram of 5000 bytes to a server on the Internet. The connection between the two nodes that includes a PPP link with an MTU of 512 bytes, two Ethernet links with an MTU of 1500 bytes and an FDDI ring with an MTU of 4096 bytes. Draw a diagram of the connections, describe the fragmentation of the datagram as it is transferred to its destination and show the effect of the loss of a fragment. Contrast the behaviour of the 512-MTU-bytes dial-up link with 1500-MTU-bytes ADSL connection.

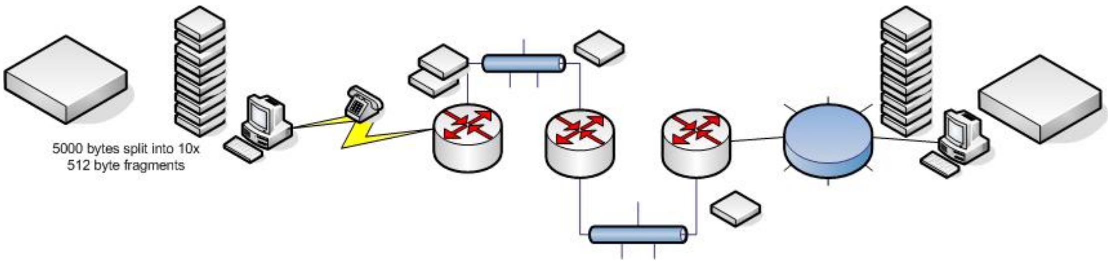
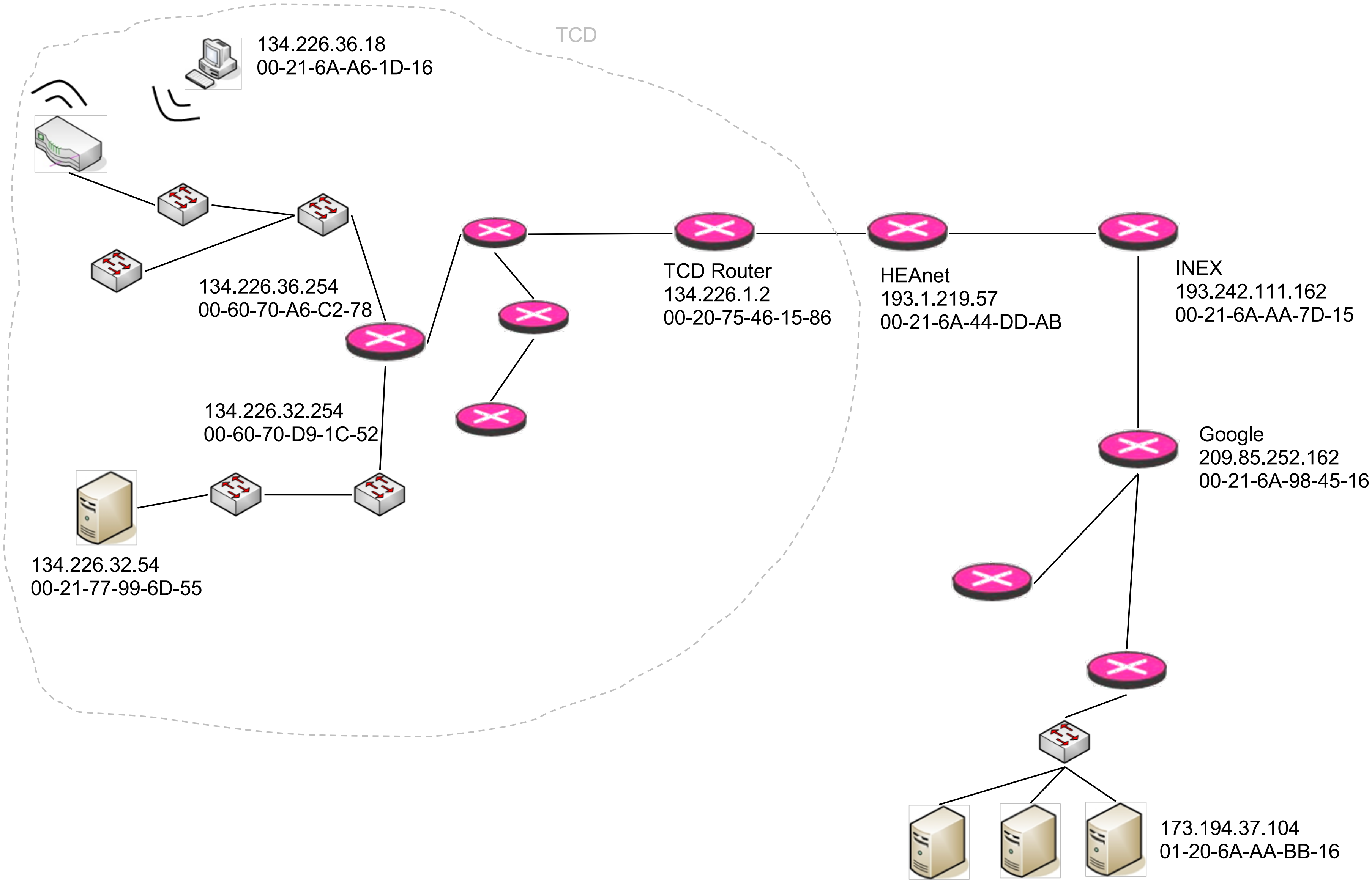
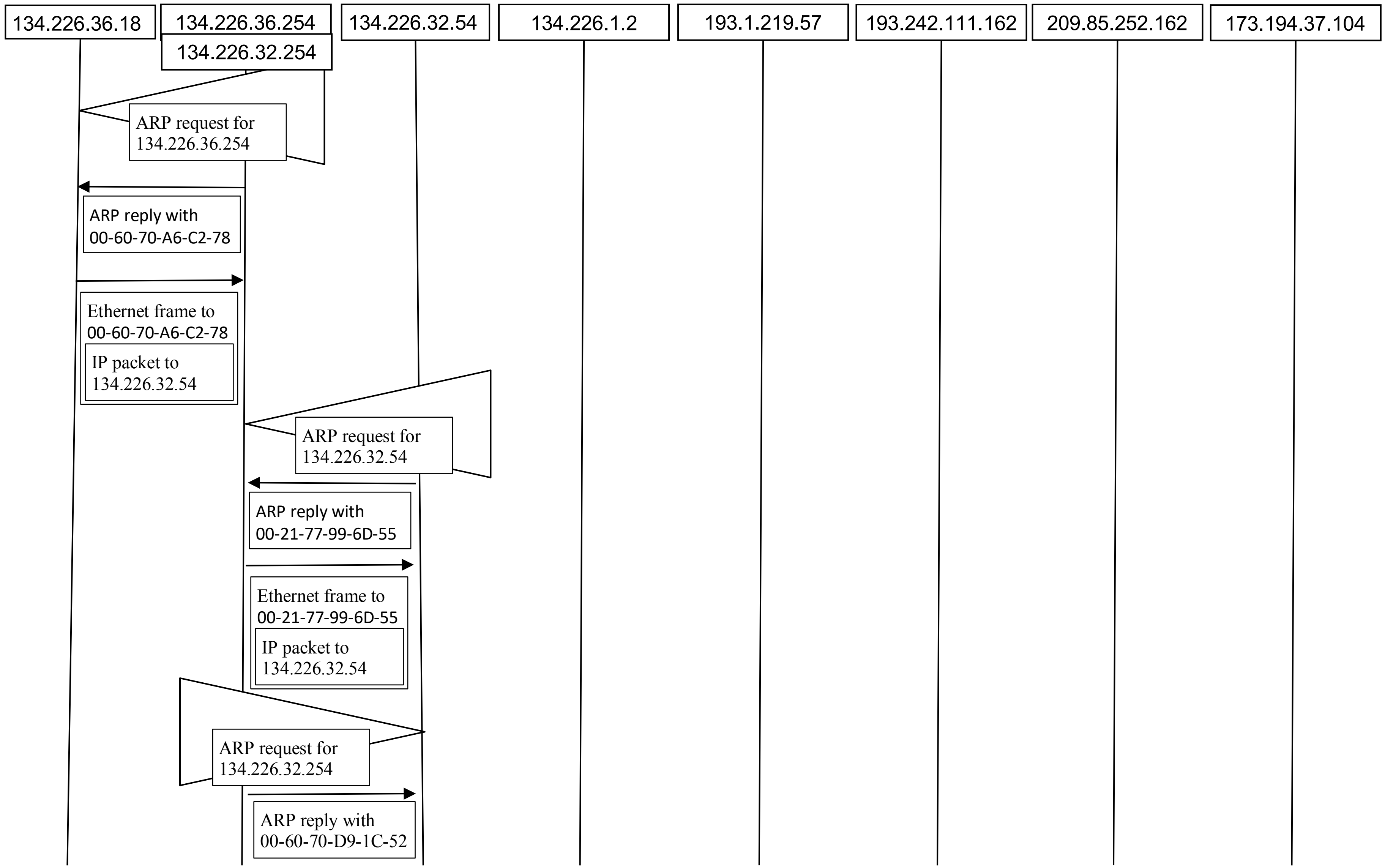


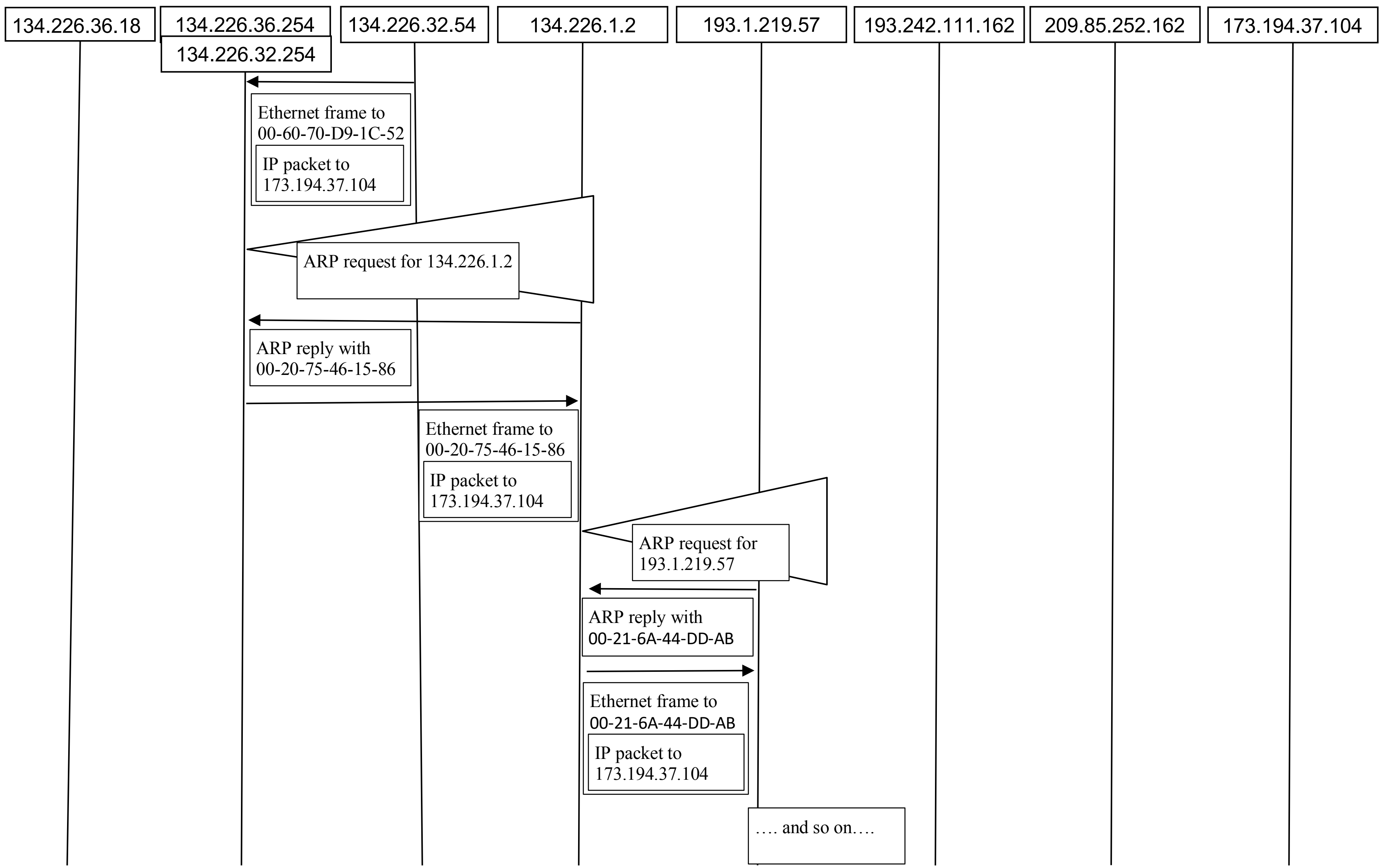
Figure 1 Fragmentation of a packet of 5000 bytes into 10 512-byte fragments

4) Assume that a local network with addresses in the range of 192.168.1.0-255 uses Network Address Translation (NAT) to communicate with nodes on the Internet through the address 208.125.22.15. Describe the processes that are used by NAT for this communication and discuss the limitation of NAT.

5) The depletion of IPv4 addresses was a topic for discussions in the early 1990s. Discuss the causes for the depletion of these addresses and the effect that the use of CIDR and NAT had on address depletion.


TCD
134.226.36.18
00-21-6A-A6-1D-16
134.226.36.254
00-60-70-A6-C2-78
134.226.32.254
00-60-70-D9-1C-52
134.226.32.54
00-21-77-99-6D-55
TCD Router
134.226.1.2
00-20-75-46-15-86
HEAnet
193.1.219.57
00-21-6A-44-DD-AB
INEX
193.242.111.162
00-21-6A-AA-7D-15
Google
209.85.252.162
00-21-6A-98-45-16
173.194.37.104
01-20-6A-AA-BB-16


134.226.36.18
134.226.36.254
134.226.32.254
134.226.32.54
134.226.1.2
193.1.219.57
193.242.111.162
209.85.252.162
173.194.37.104
ARP request for 134.226.36.254
ARP reply with 00-60-70-A6-C2-78
Ethernet frame to 00-60-70-A6-C2-78
IP packet to 134.226.32.54
ARP request for 134.226.32.54
ARP reply with 00-21-77-99-6D-55
Ethernet frame to 00-21-77-99-6D-55
IP packet to 134.226.32.54
ARP request for 134.226.32.254
ARP reply with 00-60-70-D9-1C-52


134.226.36.18
134.226.36.254
134.226.32.254
134.226.32.54
134.226.1.2
193.1.219.57
193.242.111.162
209.85.252.162
173.194.37.104
Ethernet frame to
00-60-70-D9-1C-52
IP packet to
173.194.37.104
ARP request for 134.226.1.2
ARP reply with
00-20-75-46-15-86
Ethernet frame to
00-20-75-46-15-86
IP packet to
173.194.37.104
ARP request for
193.1.219.57
ARP reply with
00-21-6A-44-DD-AB
Ethernet frame to
00-21-6A-44-DD-AB
IP packet to
173.194.37.104
…. and so on….