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CSE 30264
Homework 6

P1. IP addresses must have one address per network interface because IP addresses are hierarchical, including identifiers for the network on which the node is connected, and the host that identifies that node specifically. For routers that connect multiple network interfaces, they must have different IP addresses identifying themselves on all of these interfaces. When delivering packets, IP first finds the network on which the destination host is found using the network component of the address, then it uses the host component of the address to deliver the packet to the correct node. This design requires that every node on a network is identified as part of that network. Thus, nodes that are on two or more networks (ie. routers) have to have identifiers for each of these networks. IP tolerates point-to-point interfaces with no or nonunique addresses because point-to-point interfaces have only one place where they can go. Thus, the packet is forwarded to the next node without requiring a globally unique (or any) address.

P2. Because the Length field of the IP header is 16 bits long, the maximum size of an IP packet is 2^16, and this is measured in bytes. The Offset field in the IP header, however, has only 13 bits for encoding the offset of a fragment. Since this does not cover the 2^16 byte maximum size if the Offset were measured in bytes, the Offset unit is 8-byte units. Thus, the Offset can be as large as (2^13 units) * (8 bytes/unit) = 2 ^16 bytes. This allows for the Offset field to cover an IP packet of maximum size.

P3. 1024 bytes + 20 bytes (header) = 1044 bytes in payload of IP packet
+ 20 bytes for each IP header

At the first interface -- MTU = 1024
- MTU - (IP header size) = 1004
- fragment 0:
  - 1000 bytes (multiple of 8)
  - Offset = 0
- fragment 1:
  - 44 bytes
  - Offset = 125 (1000/8)

At the second interface (what the destination host will receive) -- MTU = 576
- MTU - (IP header size) = 556
- **fragment 0:**
  - **552 bytes**
  - **Offset = 0**
- **fragment 1:**
  - **448 bytes**
  - **Offset = 69**
- **fragment 2:**

44 bytes
Offset = 125

P4. Ident field is 16 bits. Therefore there are 2^16 = 25536 unique Ident values.
packet size = 576 bytes * (8 bits / byte) = 4608 bits / packet
can have a maximum of 25536 packets within 60 seconds

max bandwidth = (4608 bits / packet) * (25536 packets / 60 s)
max bandwidth = 1961164 bits/s = 1.96 Mbs

If the bandwidth were to exceed this amount, then the destination host could receive two packets with the same Ident field, which indicates that the packet has been fragmented. This could cause problems with the host resolving the packets correctly. In the case that the MTU of one part of the physical network that is traversed is less than 576, then the two packets with the same Ident value would have fragments that could get interchanged with each other. For example, suppose *packetM* with field Ident = k is sent at time *t* seconds and had to be fragmented into two fragments, *packetM_f0* and *packetM_f1*. Then, *packetN* with Ident = k is sent at time *t* + *55* seconds (the bandwidth is greater than the maximum we indicated above so the Ident field wraps around every 55 seconds) and had to fragmented with *packetN_f0* and *packetN_f1*. If *packetM_f1* and *packetN_f1* have the same offset value, then the destination host could resolve the two packets as *packetM* with *packetM_f0* and *packetN_f1* and *packetN* with *packetN_f0* and *packetM_f1*, since the offset field, Ident field, and the fragment flags would be identifcal for the *packetX_f0*'s and the *packetX_f1*'s.

P5. Fragment reassembly should be done at the endpoint instead of the next router because of the overhead required to reassemble. After a packet is reassembled, it could end up on a physical interface that again requires it to be fragmented before being sent. To prevent this kind of overhead, the packets remain fragmented until they arrive at the destination host. Additionally, this simplifies the development of a router. Ipv6 abandoned fragmentation entirely for efficiency purposes. First, when one fragment is lost in Ipv4, the entire packet is discarded and needs to be resent. If a large packet was fragmented, then a large amount of data has to be resent because one of the pieces was lost. Additionally, without fragmenting, Ipv6 reduces the overhead of routers needing to break up packets and add IP headers to each of the fragments, and the overhead of destination hosts reassembling the fragments.