

I. IP Fragmentation (pg 45-52)

Week 9

- recall IP is responsible for 1) network addressing and 2) fragmentation
- the 2nd “word” of the IP header is the fragmentation related data, composed of the **ID** (16 bits), the **fragment flags** (3 bits), and the **fragment offset** (13 bits) (see IP PDU)
- physical layer typically imposes an upper limit on the size of a frame, e.g. MTU (max Ethernet frame data size?)
- IP compares the datagram size (as stored in the ? field) with the MTU
 - if $TL > MTU$ then
fragmentation should occur
- fragmentation may occur on original host, or on intermediate nodes (e.g. routers) along the way
- datagrams & fragments can be fragmented more than once
- once fragmentation occurs, reassembly does not take place until the final destination
- each datagram fragment becomes an individual packet, so gets its own:
 - header (+ 20 octets per fragment)
 - data
 - route to destination and arrival order
- only data gets fragmented, never the header
- if one fragment is lost, the entire datagram is useless and must be retransmitted
- IP datagram – IP header and all data (i.e. all fragments)
- IP packet – IP header along with some data
- on Windows from cmd prompt: **netsh interface ipv4 show interfaces**

How does fragmentation work: (see IP RFC link on syllabus)

1. IP layer queries the MTU of physical layer
 - if TL <= MTU then
 transmit datagram
 - elseif DF flag = 1 then
 drop datagram
 - else
 fragment datagram
2. number of fragments NF = $(TL - IHL) / (MTU - IHL)$ (taking the ceiling of this)
note: IHL is 5 “words” * 4 octets/word = 20 octets
3. # fragment blocks (8 octets per block) NFB = INT $((MTU - IHL \text{ octets}) / 8)$
4. copy original header to the first (eventually all) fragment headers, including the same ID, protocol, destination and source addresses
5. fill in data and update header fields:
 - append NFB * 8 data octets, unless last fragment
 - TL = NFB * 8 + IHL octets, unless last fragment
 - Fragment Offset (FO) = (fragment # -1) * NFB
 - set may frag flag = 0
 - set more frag flag = 1, unless last fragment, then set = 0
 - decrement TTL if at router
 - recalculate checksum
6. transmit fragment
7. goto # 4 for next fragment

Fragmentation Example (see pg 49)

- beginning total length: 4464 octets, fragment?
- MTU: 1500

original datagram:

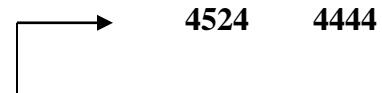
Frag #	Frag ID	DF	MF	Frag Offset	IHL	TL	data len
-	321	0	0	0	20	4464	4444

fragmented datagram (packets):

$$NF = (TL - IHL) / (MTU - IHL) = 4444/1480 = 3.0027, \text{ take next largest INT value, so 4 fragments}$$

$$NFB = ((MTU - IHL) / 8 \text{ octets/block}) = (1500 - 20) / 8 = 185$$

Frag #	Frag ID	DF	MF	Frag Offset	IHL	TL	data len
1	321	0	1	0	20	1500	1480
2	321	0	1	185	20	1500	1480
3	321	0	1	370	20	1500	1480
4	321	0	0	555	20	24	4



Note that the sum of the data lengths = sum of original data length, but the sum of the total lengths is original TL + ((NF - 1) * 20) for extra headers