Internet Engineering

241-461

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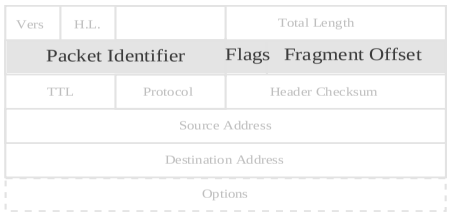
Maximum Packet Size

- If IP packet is too big
  - Broken into fragments
    - Each fragment is a new IP packet
    - Sent to destination
      - Reassembled only at destination



- Packet Identifier
  - Identifies original IP packet
    - together with addresses & protocol
    - allows all fragments to be collected
      - so they can be reassembled

Contents

- Why Fragmentation?
- Why Reassembly?
- When to Fragment
- When to Reassemble
- How to Fragment
- How to Reassemble
- Why not fragment
- How to avoid fragmentation (PMTUD)

Why Fragmentation

- Packets can be big
  - 65535 bytes
    - including header - IPv4
- Links usually have MTU
  - Maximum Transmission Unit
  - Limit on maximum packet size
    - Ethernet 1500 (+ ethernet headers)
- Packet might be bigger than MTU
  - What to do?

Why Fragmentation (2)

- Large truck - Low bridge
  - Use a different route
  - Can packets do that?
- Packet routing
  - path to destination address only
  - Nothing about packet sizes
  - Perhaps no route will handle big packets
- So NO cannot alter route
  - for different packet sizes
  - (Really could, but too much work already)
- What other choices?

Why Fragmentation (3)

- Large Truck - Shaky bridge
  - Truck too heavy
  - No other route to destination
- Take load from big truck
  - use several smaller trucks
  - each weigh much less
    - able to cross the bridge
- Same idea for packets
  - Take load from packet
  - Divide load
  - Place in several smaller packets (fragments)
    - Now packets get through link
    - Even with small MTU

Fragmentation!

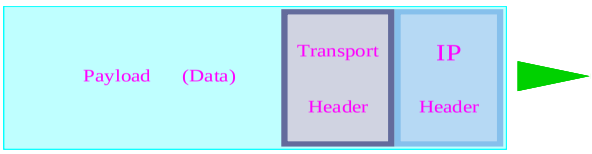
Contents

Why Reassembly

- Reassembly
  - Putting the fragments together again
  - Get original packet back
- Why?
- Don’t do this with truck & load
  - Once on small truck
  - Take load to destination
  - Deliver to recipient
- What is different about packets?

Why Reassembly (2)

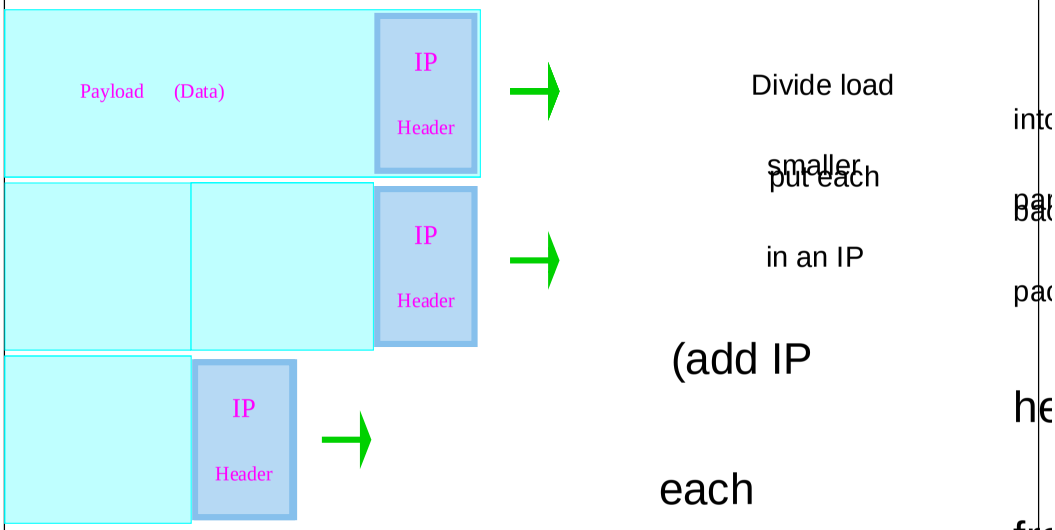
- Consider an IP packet



- Packet arrives at small MTU link
  - Must be fragmented

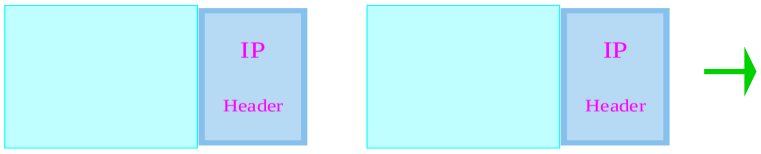
Why Reassembly (3)

- To fragment we take off the load



Why Reassembly (4)

- Fragments arrive at destination



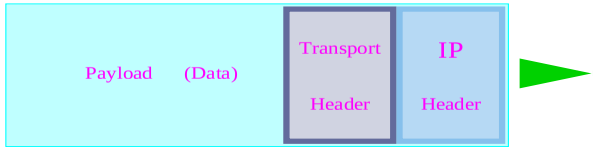
  - Ready to be delivered

- Transport header controls delivery

  - First fragment delivered OK
    (not really)
  - Second fragment??
    - No transport header - how to deliver??

Why Reassembly (5)

- Must get all payload back
  - into one packet
  - including transport header
    - and all transport data



  - Now packet can be delivered

Reassembly

Contents

- Why Fragmentation?
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- When to Fragment
- When to Reassemble
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- How to Reassemble
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When to Fragment

- When do we fragment ?
- The easy question!
  - Only when required
    - Fragmenting adds overhead
    - Extra headers
  - When packet is too big
    - For the link it is to use
      - Forwarding table tells us this
      - From routing path calculations
    - Compare MTU of link with packet size
- Always fragment?
  - No - sender can prohibit
    - (more later)

Contents

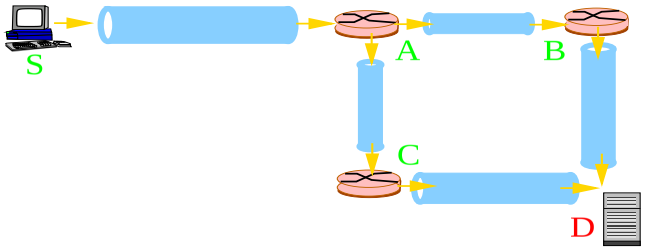
- Why Fragmentation?
- Why Reassembly?
- When to Fragment
- When to Reassemble
- How to Fragment
- How to Reassemble
- Why not fragment
- How to avoid fragmentation (PMTUD)

When to Reassemble

- When do we reassemble packet?
- The interesting question!
  - As soon as possible ?
  - After "bad" link is passed ?
- No.
  - Why??
- Might be more small MTU links
  - Would need to fragment again ??
- Yes. But...
  - Not a very good reason
  - Not the important reason

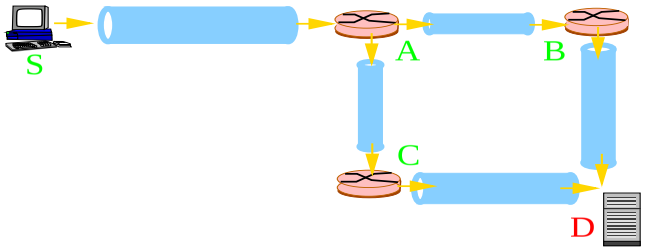
When to Reassemble (2)

- Imagine this network:



  - Thickness of PIPES
    - indicates MTU of link
- Paths from S to D
  - S - A - B - D
  - S - A - C - D
    - Equal cost
      - Can use either
      - Can use both

When to Reassemble (2)



- Large packet sent by S
  - Size less than MTU(S-A)
    - (MTU of link from S to A)
  - Size greater than MTU(A-B) and MTU(A-C)
  - Packet must be fragmented at A
- Assume one fragment sent to B
  - Other fragment sent to C
  - What happens if B wants to reassemble? C?

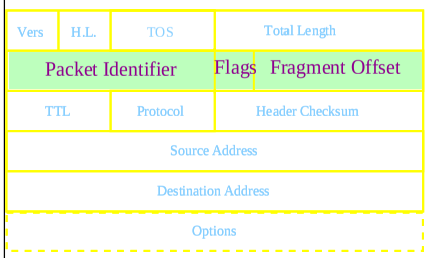
When to Reassemble (3)

- Only safe place to reassemble
  - At destination host
  - Packet was addressed to it
    - All fragments addressed to it
    - All arrive at Destination eventually
      - Or are lost forever
- Destination host
  - can reassemble
    - all fragments arrive
  - must reassemble
    - Packet cannot be delivered
    - until entire packet is back together
- No router on path can reassemble
  - no guarantee all fragments arrive there
  - must wait for last fragment to reassemble
    - if sent elsewhere (not to this router)
    - wait for very long time

Contents

How to Fragment

- Have seen basic procedure already
  - Separate IP header from payload
  - Divide payload into pieces
  - Attach header to each piece
    - Done!
- Now to look at some details



IP header

(seen before)

Fragmentation Fields

Exist only for fragmentation

How to Fragment (2)

- Fragmentation Fields
  - In IP header
- Packet Identifier
  - A 16 bit integer
  - The same in all fragments
    - of the same packet
  - Different in different packets
  - Allows fragments to be connected
    - to the correct packet
  - Fragments of different packets
    - do not get confused
- Packet Identifier
  - Used with Source IP address
    - If addresses different
    - Packet-IDs cannot be compared
  - Also Destination address & Protocol

How to Fragment (3)

- Fragmentation Fields
  - In IP header
- Fragment Offset
  - A 13 bit number
  - Indicates where in original packet
    - The first data byte in fragment belongs
  - Always a multiple of 8
    - Low 3 zero bits not stored
    - 13 bits in packet
    - + 3 extra zero bits
    - => 16 bit byte offset value
      - adequate for any start location in packet

How to Fragment (4)

- Fragmentation Fields
  - In IP header
- Flags
  - 3 one bit fields
    - R D M
- R Reserved flag - not used
- D Don't Fragment
- M More fragments after this
- D
  - instruction to routers
    - Do not fragment this packet
    - If too big, discard it
      - Send an ICMP error message
    - Will see use for this later

How to Fragment (5)

- M
  - More fragments after this
  - M==0 (bit not set)
    - This is the last fragment
  - M==1 (bit set)
    - This is not the last fragment
- M & Fragment Offset
  - indicate status of this packet (fragment)
  - Fragment Offset == 0
    - This is the first fragment of packet
      - First data byte in fragment
      - is first data byte of original packet
  - M == 0
    - This is the last fragment of packet
  - Fragment Offset == 0 && M == 0
    - This is a complete packet
    - It is not fragmented