

Internet Engineering

241-461

Robert Elz

kre@munnari.OZ.AU

kre@coe.psu.ac.th

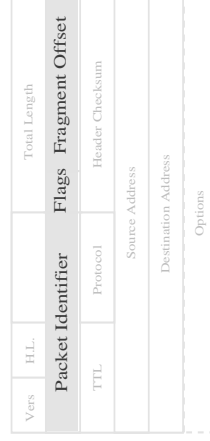
<http://fivedots.coe.psu.ac.th/~kre>

Dealing with Link Layer

- ◇ Link Layer
 - Has its own addressing
 - Has packet size limits
 - ▷ maximum packet size (usually)
 - ▷ minimum packet size (sometimes)
- ◇ IP must cope with this
 - Minimum packet size
 - ▷ Easy
 - if IP packet is too small
spoofed frame, which is too small
 - receiver knows original length
from IP header packet length field
 - repeated for each link crossed
separately and independently

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

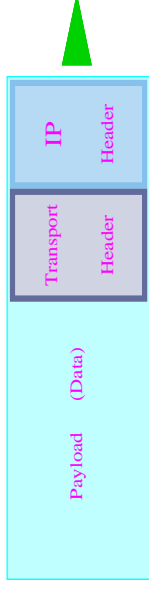
- ◇ Why Fragmentation?
- ◇ Why Reassembly?
- ◇ When to Fragment
- ◇ When to Reassemble
- ◇ How to Fragment
- ◇ How to Reassemble
- ◇ Why not fragment
- ◇ How to avoid fragmentation (PMTUD)

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)

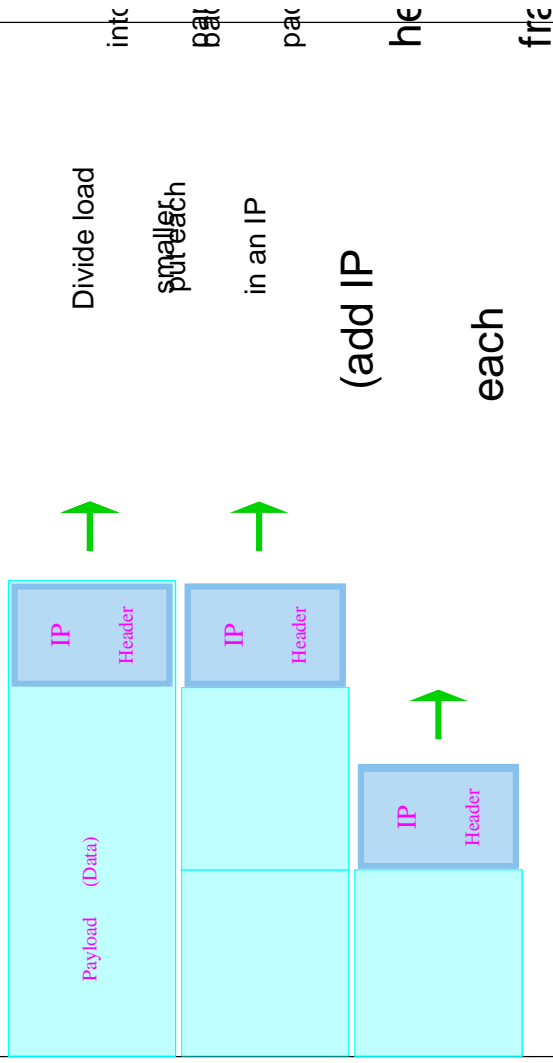
- ◊ Consider an IP packet



- ◊ Packet arrives at small MTU link
 - Must be fragmented

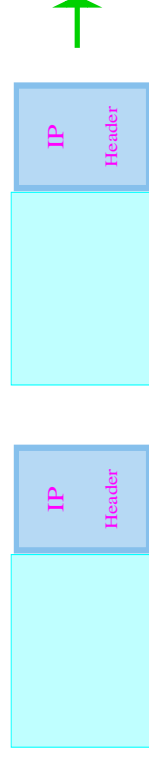
Why Reassembly (3)

- ◊ To fragment we take off the load



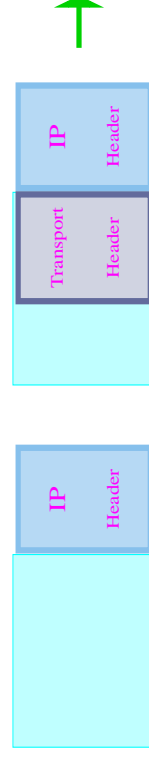
Why Reassembly (4)

- ◊ Fragments arrive at destination



- Ready to be delivered

- ◊ Transport header controls delivery



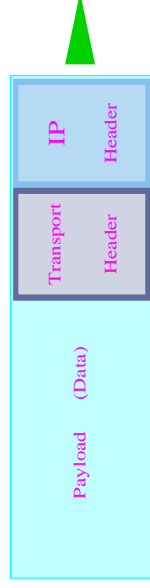
- First fragment delivered OK

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

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

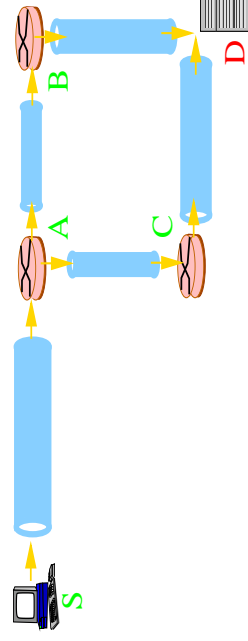
- ◊ Why Fragmentation?
- ◊ Why Reassembly?
- ◊ When to Fragment
- ◊ When to Reassemble
- ◊ How to Fragment
- ◊ How to Reassemble
- ◊ Why not fragment
- ◊ How to avoid fragmentation (PMTUD)

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

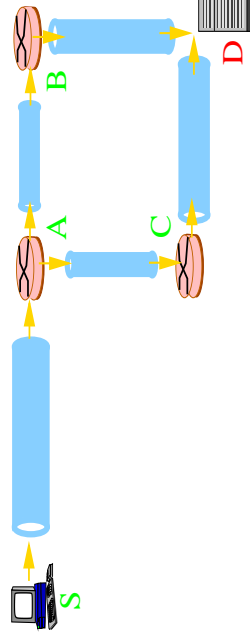
- ◊ Paths from S to D

- 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