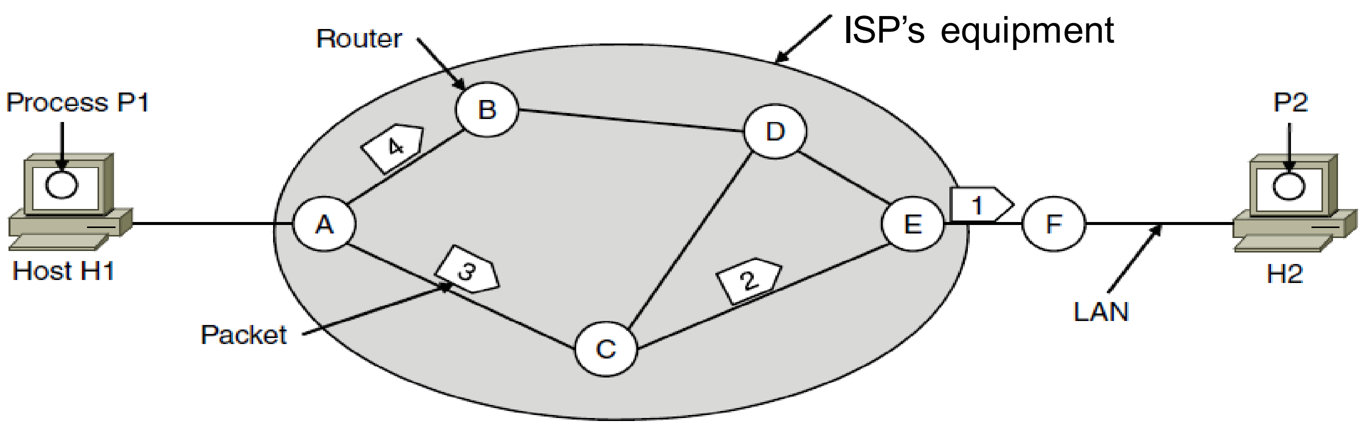
Week 6 – Network Layer Contd

Internet Technologies
COMP90007

Routing within a datagram subnet

- **<u>Post office model</u>**: packets are routed individually based on destination addresses in them
- Packets can take different paths
- E.g, P1 sends a long message to P2



A's table (initially)

A	⊠
B	B
C	C
D	B
E	C
F	C

Dest. Line

A's table (later)

A	⊠
B	B
C	C
D	B
E	B
F	B

C's Table

A	A
B	A
C	⊠
D	E
E	E
F	E

E's Table

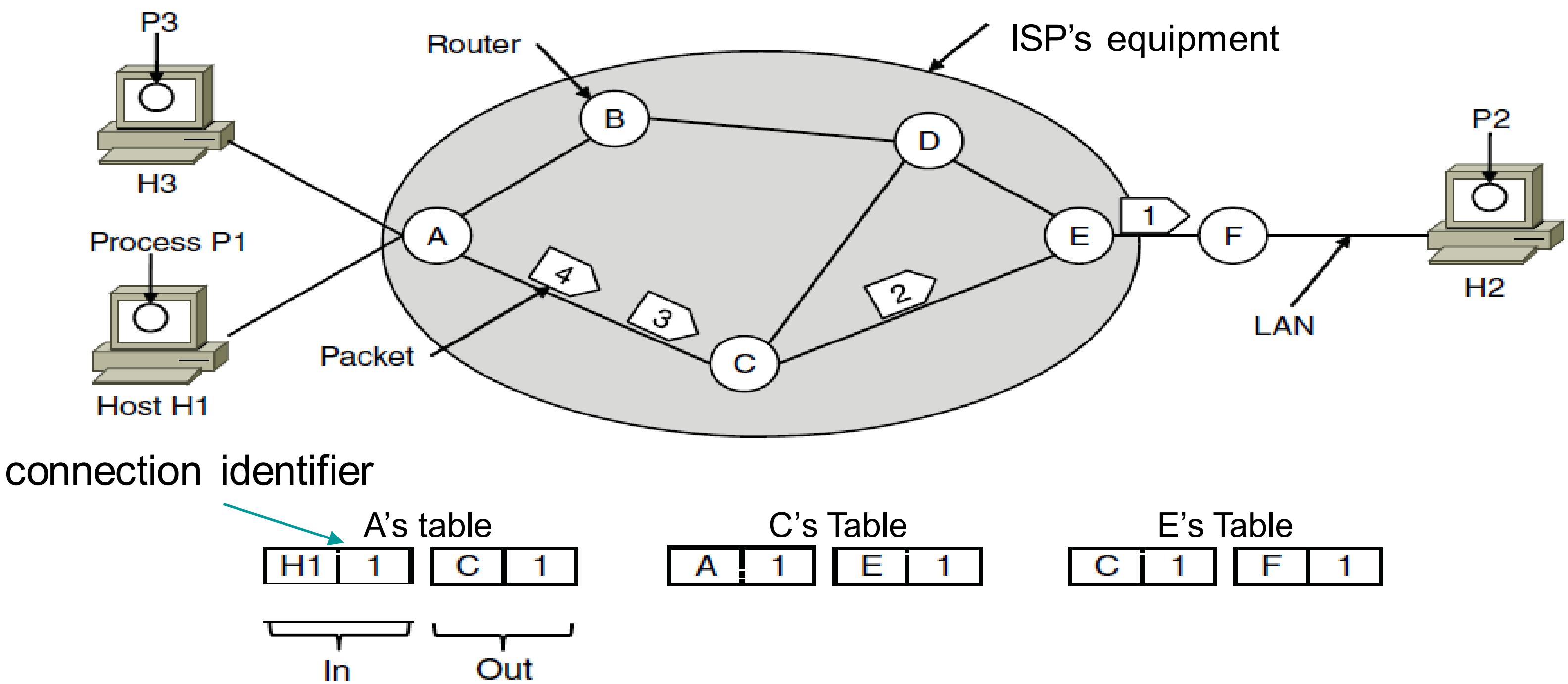
A	C
B	D
C	C
D	D
E	⊠
F	F

Routing table can change over time

Routing algorithm – manages the routing table

Routing within virtual-circuit subnet

- Model is **<u>like telephone network</u>**
  - Packets are routed through virtual circuits (created earlier) based on tag number (not full address but unique at a given link) in them
  - Packets take the same path (to avoid having to choose a new route for every packet sent)
  - E.g., Multi-protocol Label Switching Network (to provide QoS) – 20 bit label or Conn. Identifier



Differences in Virtual Circuit and Datagram Subnets

Issue	Datagram network	Virtual-circuit network
Circuit setup	Not needed	Required
Addressing	Each packet contains the full source and destination address	Each packet contains a short VC number
State information	Routers do not hold state information about connections	Each VC requires router table space per connection
Routing	Each packet is routed independently	Route chosen when VC is set up; all packets follow it
Effect of router failures	None, except for packets lost during the crash	All VCs that passed through the failed router are terminated
Quality of service	Difficult	Easy if enough resources can be allocated in advance for each VC
Congestion control	Difficult	Easy if enough resources can be allocated in advance for each VC

Compromises: VC vs Datagram Subnets

- Compromises:
  - Memory vs bandwidth
    - VC's require space in router memory but save potential overhead in full addressing of each packet and computation of path
  - Setup time vs address parsing time
    - VC's require setup time and resources, but packet transmission is very fast
  - Amount of memory
    - datagram subnets require large tables of every possible destination routes, whereas VC requires entry per link which depends on the load
  - QoS and congestion avoidance
    - VC's can use a tighter QoS - able to reserve CPU, bandwidth and buffer in advance
  - Longevity
    - VC's can exist for a long time
  - Vulnerability
    - VC's particularly vulnerable to hardware/software crashes - all VC's aborted and no traffic until they are rebuilt; datagram uses an alternative route

Issue of Internetworking

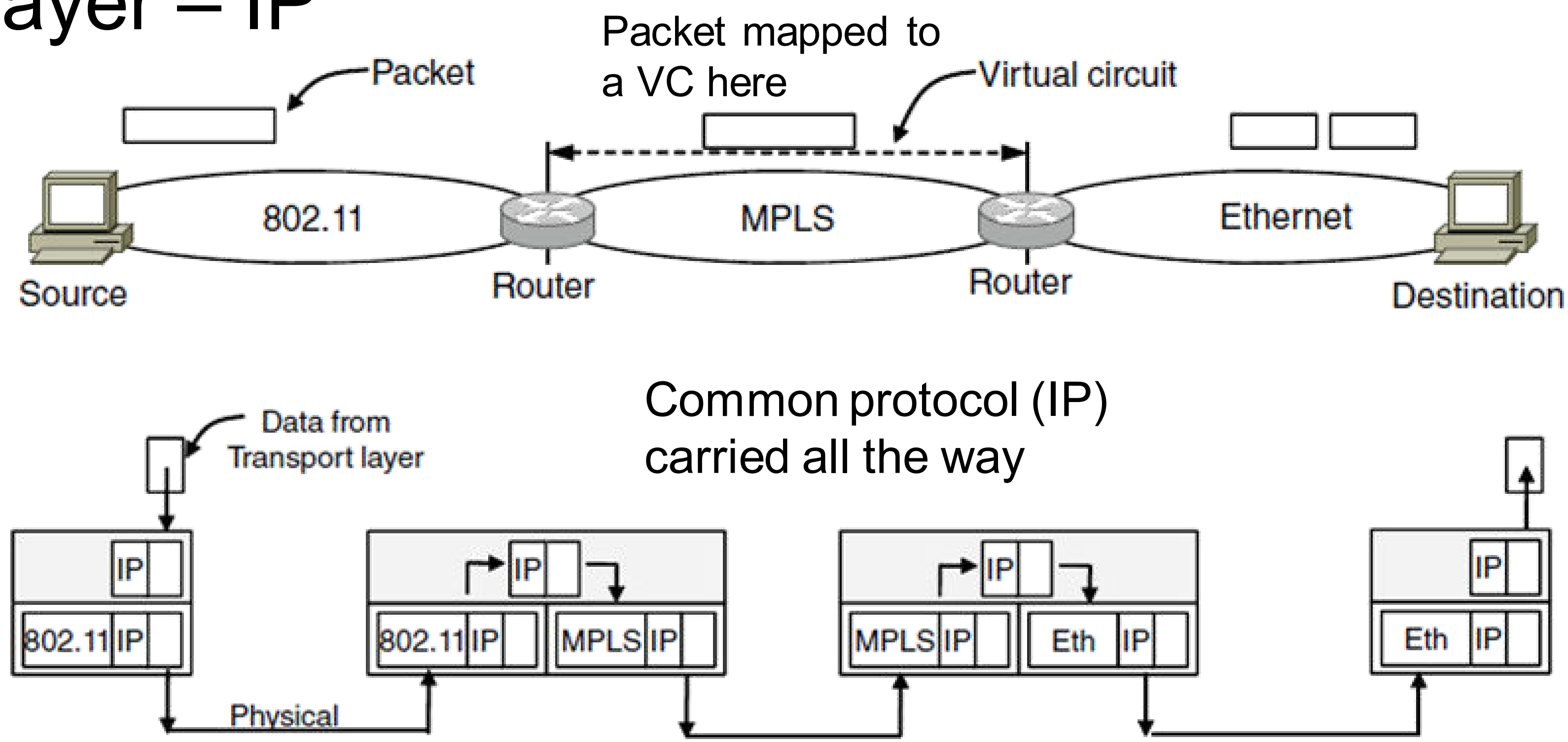
- We cannot assumed a single homogeneous network
- Internetworking joins multiple, different networks into a single larger network
- Issues when connecting networks:
  - Different network types and protocols
  - Different motivations for network choices
  - Different technologies at both hardware and software levels

Differences Dealt at the Network Layer

Item	Some Possibilities
Service offered	Connectionless versus connection oriented
Addressing	Different sizes, flat or hierarchical
Broadcasting	Present or absent (also multicast)
Packet size	Every network has its own maximum
Ordering	Ordered and unordered delivery
Quality of service	Present or absent; many different kinds
Reliability	Different levels of loss
Security	Privacy rules, encryption, etc.
Parameters	Different timeouts, flow specifications, etc.
Accounting	By connect time, packet, byte, or not at all

How Different Networks are Connected

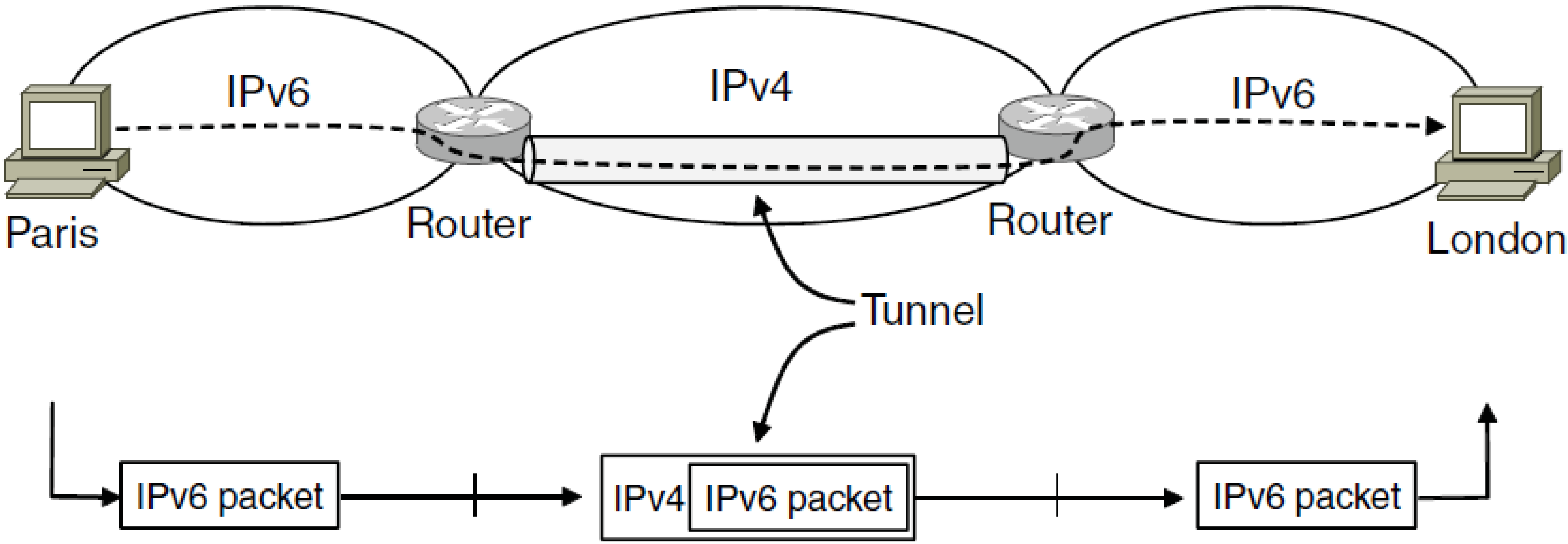
- Internetworking based on a common network layer – IP



Tunneling

- Tunneling is a special case used when the source and destination are on the same network, but there is a different network in between.
  - Source Packets are encapsulated over the packets in the connecting network

Tunneling IPv6 packets through IPv4

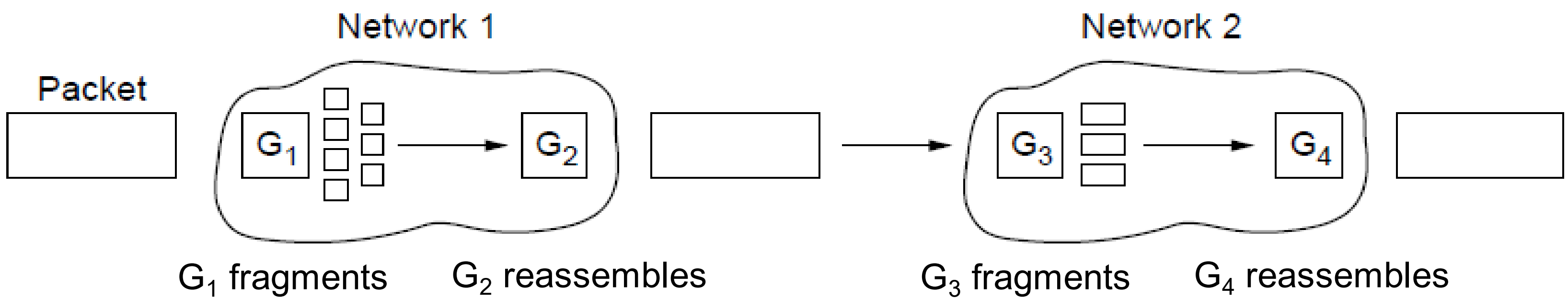


Fragmentation

- All networks have a maximum size for packets, could be motivated by:
  - Hardware
  - Operating system
  - Protocols
  - Standards compliance
  - Desire to reduce transmissions due to errors
  - Desire for efficiency in communication channel
- Fragmentation (division of packets into fragments) allows network gateways to meet size constraints

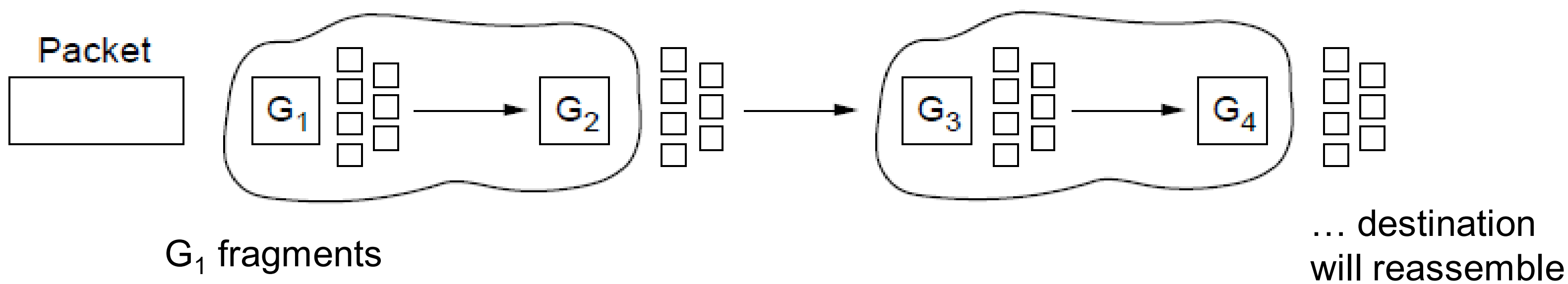
Types of Fragmentation

- Large packets need to be routed through a network whose maximum packet size is too small.
- Fragmentation and Reassembly is a solution.



Transparent – packets fragmented / reassembled in each network

- Route constrained, more work



Non-transparent – fragments are reassembled at destination

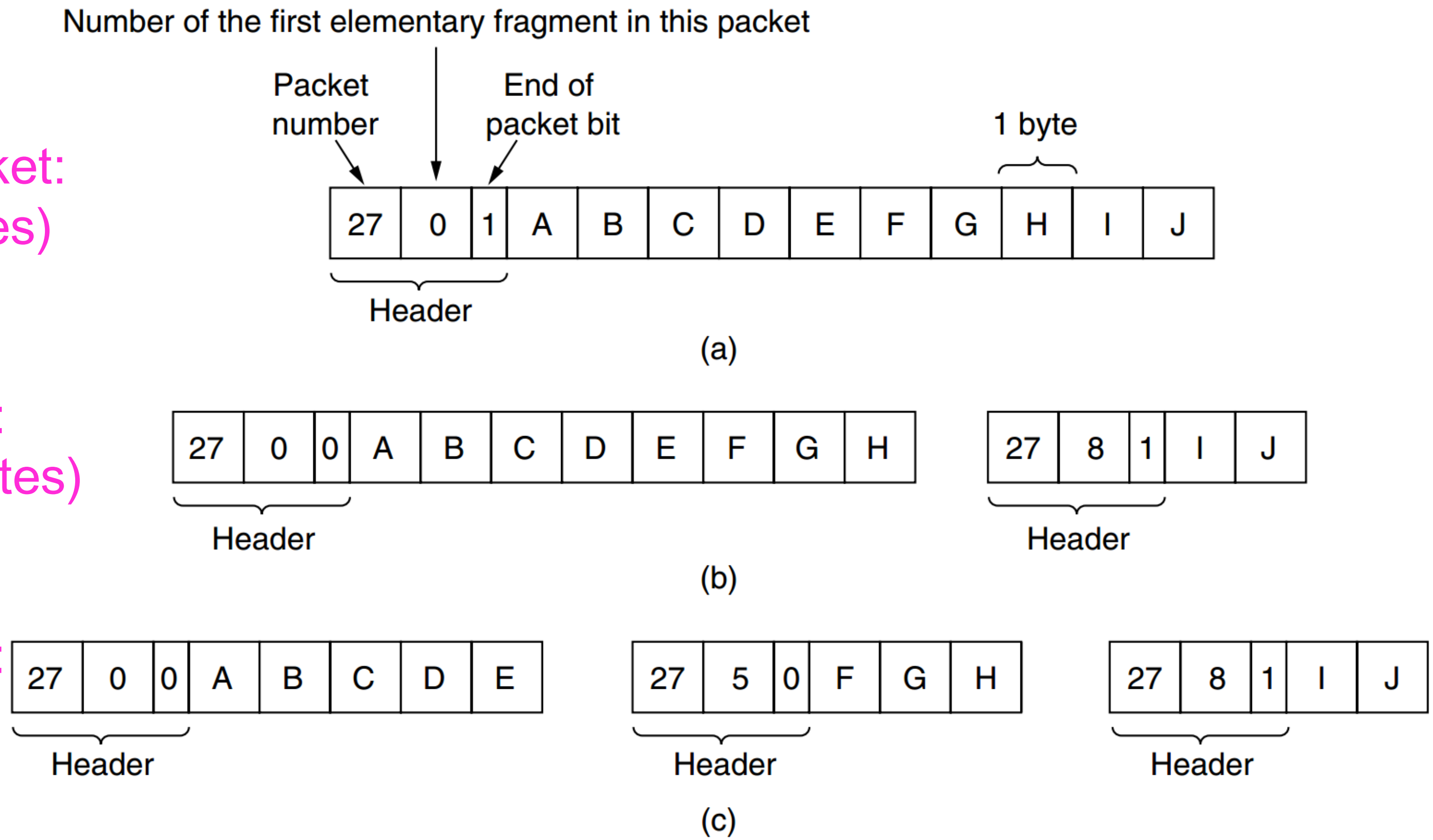
- Less work (IP works this way) – packet number, byte offset, end of packet flag

Example: IP Style Fragmentation

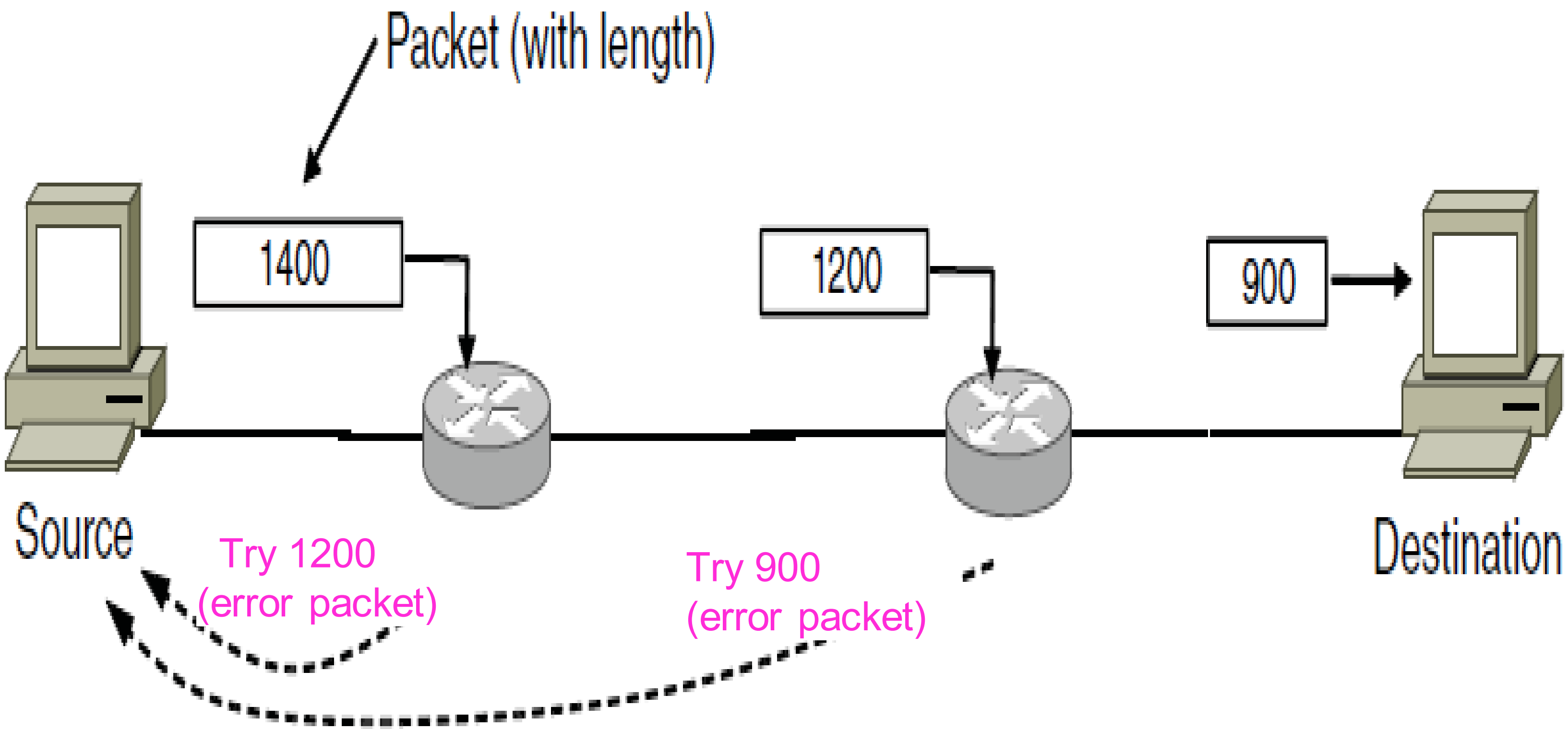
Original packet:
(10 data bytes)

Fragmented:
(to 8 data bytes)

Re-fragmented:
(to 5 bytes)



Path MTU Discovery: Alternative to Fragmentation



Advantage: The source now knows what length packet to send but if the routes and path MTU change, new error packets will be triggered and the source will adapt to the new path