Lecture 5

The Way Networks Work (continued)

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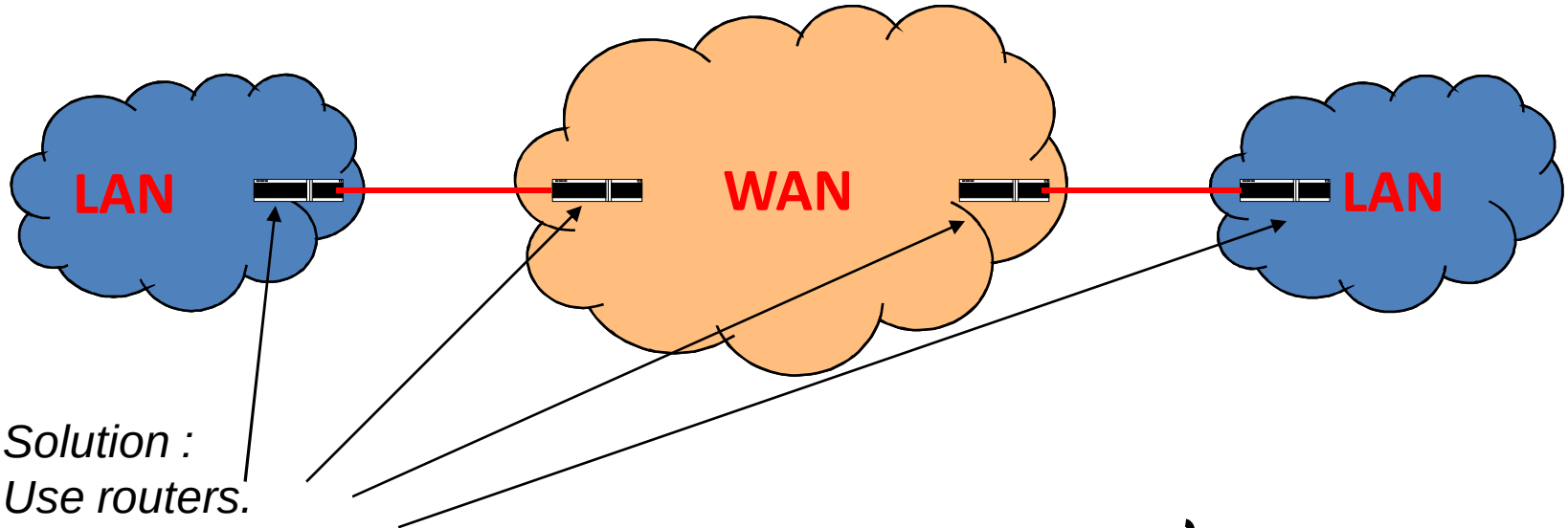
Routers

Why use a Router ?

❑ Ethernet switches can separate collision domains of shared Ethernets. This allows extension of geographic coverage.
However, for very large distances (10,'s,100's and 1000's of kilometers), one needs to interconnect Ethernets via non-Ethernet NW's (e.g. using leased lines, PSTNs, Asynchronous Transfer Mode (ATM) NWs, ... , etc).

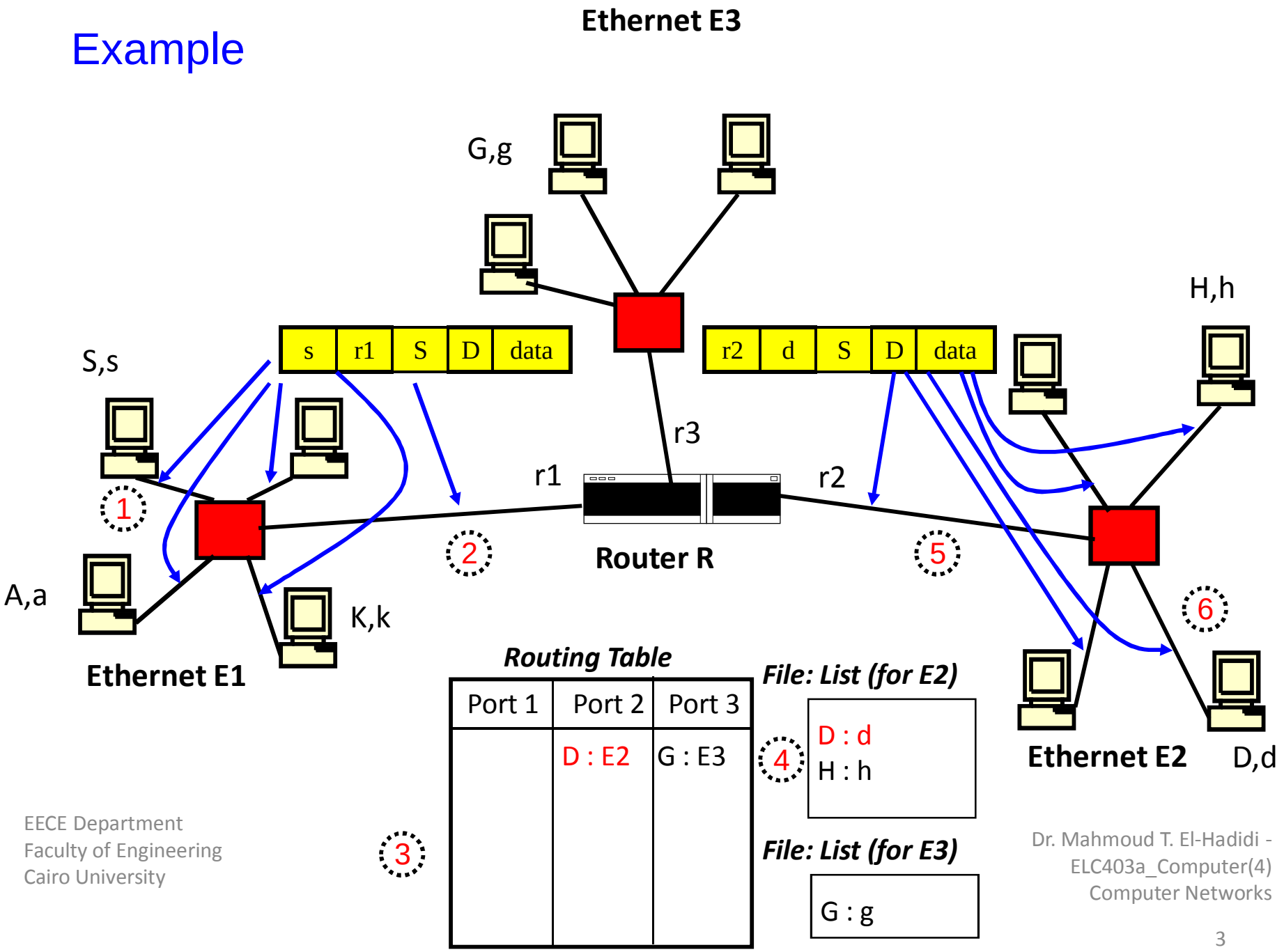


Solution :
Use routers.

❑ Routers decide *whether* to forward an incoming pkt
where to forward an incoming pkt

} Based on NW address of pkt

Example


Ethernet E3
G,g
H,h
S,s
s
r1
S
D
data
r2
d
S
D
data
r3
r1
r2
1
2
Router R
5
A,a
K,k
6
Ethernet E1
Ethernet E2
D,d
Routing Table
Port 1
Port 2
Port 3
D : E2
G : E3
3
File: List (for E2)
4
D : d
H : h
File: List (for E3)
G : g

Remarks

R1 – Procedure for generating entries of routing table is carried out using special procedures called “Routing Protocols”. These are classified into “Distance Vector” protocols and “Link State” protocols.

R2 - The router spends more time in processing the received pkt compared to a switch, since it has to inspect the payload of the pkt (the network addresses). Therefore, the router is considered a Layer 3 device (because it processes data belonging to Layer 3), and its throughput is less than that of a switch.

Remarks (continued)

R3 - In some cases the network of the destination is not directly connected to the current router. This would appear in the "Routing Table" by a field specifying the ID of the next router along the route.

R4 – The ports of a router act in a way similar to that of Ethernet NIC. Thus, each router port has an Ethernet address (as well as a network address), and this contrasts with switches, whose ports have no Ethernet addresses, nor Network addresses.

R5 – A switch decides based on Ethernet addresses. It repeats a pkt without any changes.

A router decides based on network addresses. It changes Ethernet address of a pkt.

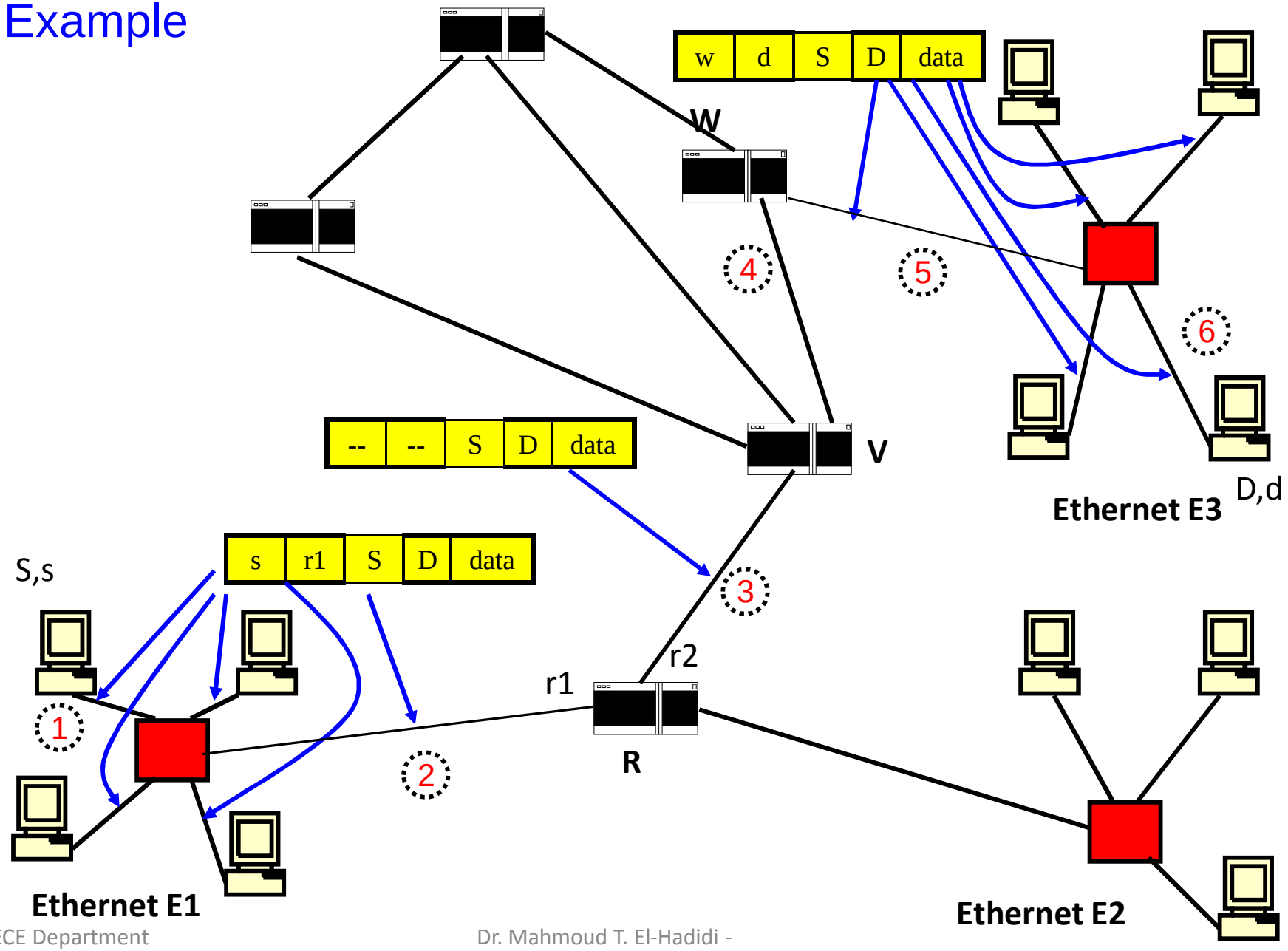
Internet

Q1 : How pkts are routed bet. source and destination in an Internet ?
(Source and Destination may be continents' apart !!!)

Q2 : How to make such routing scalable ?

Q3 : How to guarantee delivery and regulate delivery of pkts bet. Source and Destination ?

Example


w d S D data
W
4
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-- -- S D data
V
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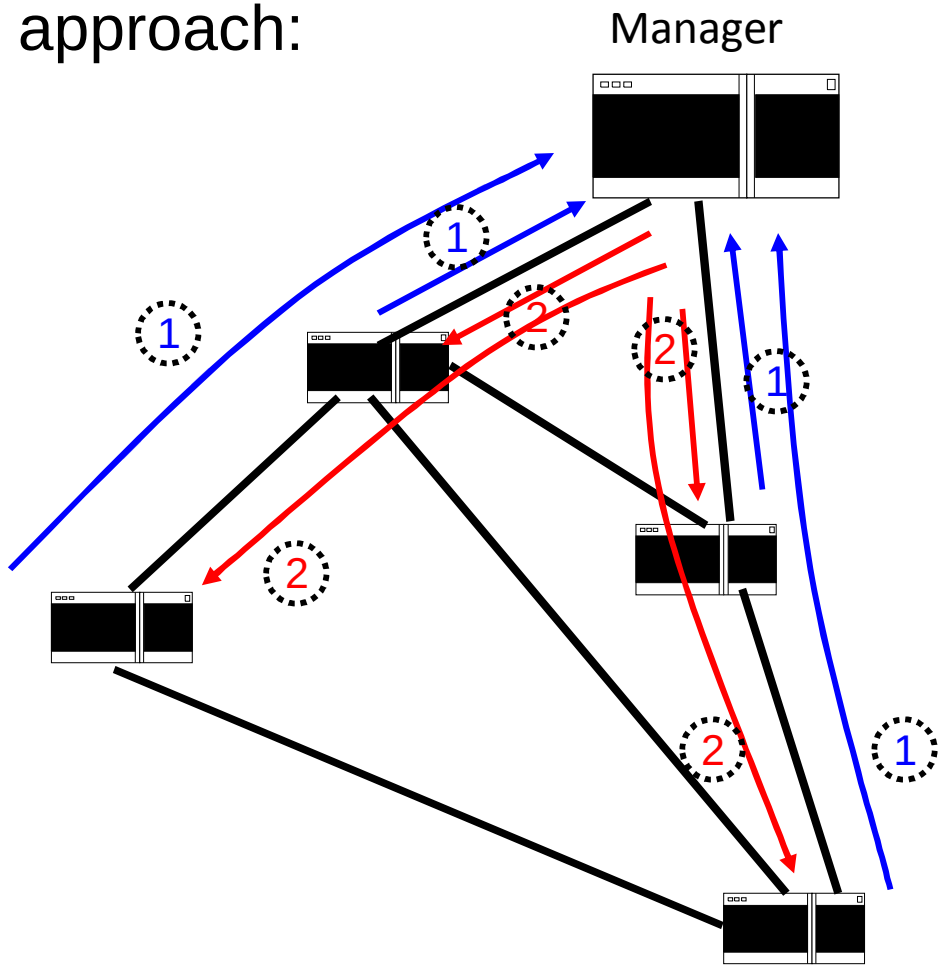
Ethernet E3
s r1 S D data
S,s
3
r2
r1
1
2
R
Ethernet E1
Ethernet E2

Building routing table (Answer to Q1)

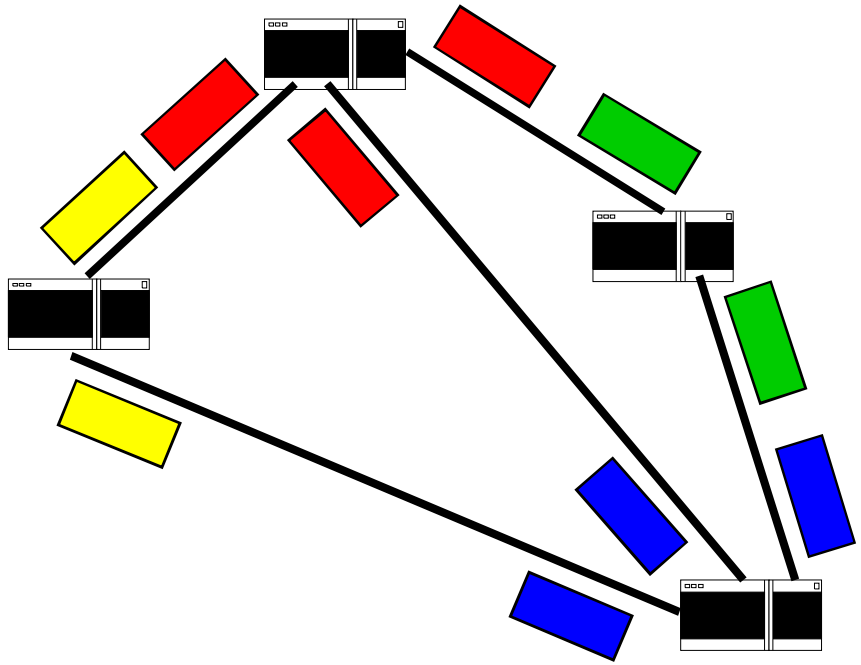
Centralized approach:



- From received information from each router, Manager constructs Global Map.
- Manager sends resulting Global Map to each router to use.

Building routing table (continued)

Distributed approach:



- Each router sends exploratory pkts on all its links (flooding).
- As exploratory pkts travel through routers, a router deduces from NW address of source – on an incoming pkt. – the link for that source router.

Building routing table (continued)

To improve distributed approach, one usually associatse with each entry in routing table, additional parameters :

Port x					
Destination address	**Bandwidth of link**	**Max. size of pkt**	**Expected link delay**	**Link reliability**	**Link security**
D	2 Mbps	1500 bytes	150 msec	0.075	medium

Using above additional parameters, each router can compute for itself the shortest path to a desired destination (called Open Shortest Path First – OSPF).

Making routing scalable (Answer to Q2)

Origin of problem

Routing Table

Port 1	Port 2	Port 3
A : E1 K : E1 S : E1	D : E2 H : E2	G : E3

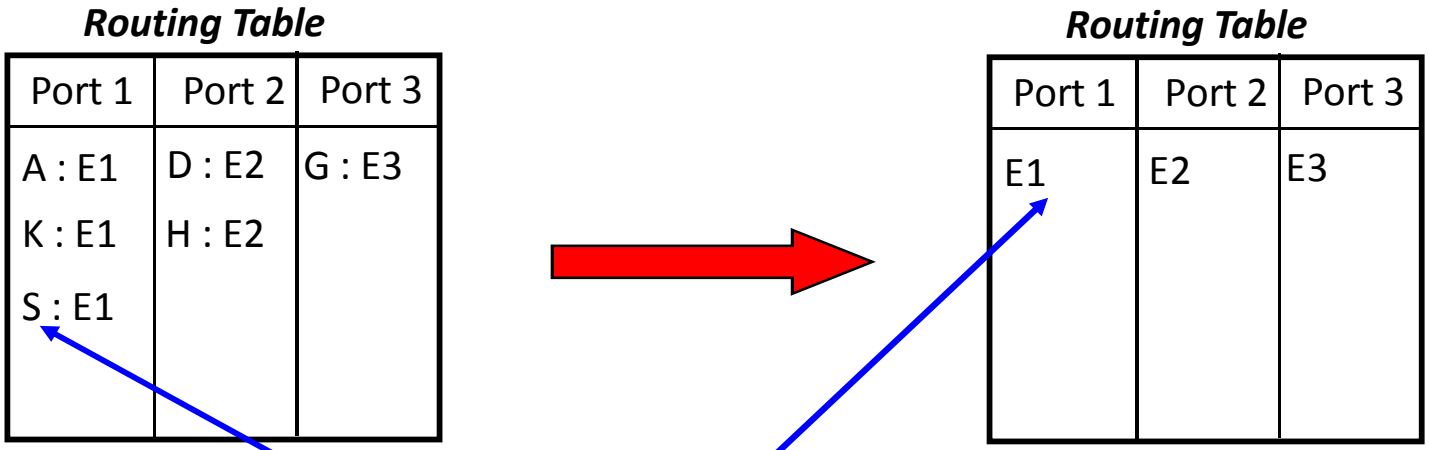
In an Internet, # of entries of routing table grows exponentially, with # of connected networks.

To overcome this problem, certain ideas are used to facilitate scalability.

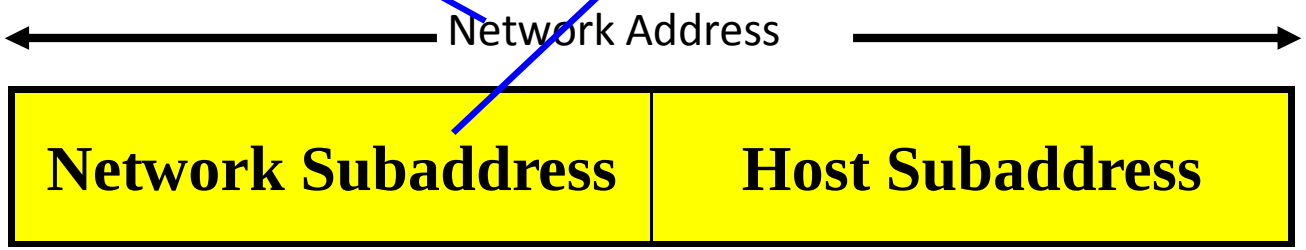
Making routing scalable (Answer to Q2 – Continued))

1st Idea

Store addresses of entire networks (subnetworks) in the routing table, instead of individual network address for each device.



Achieved by defining a network address for a device as two parts

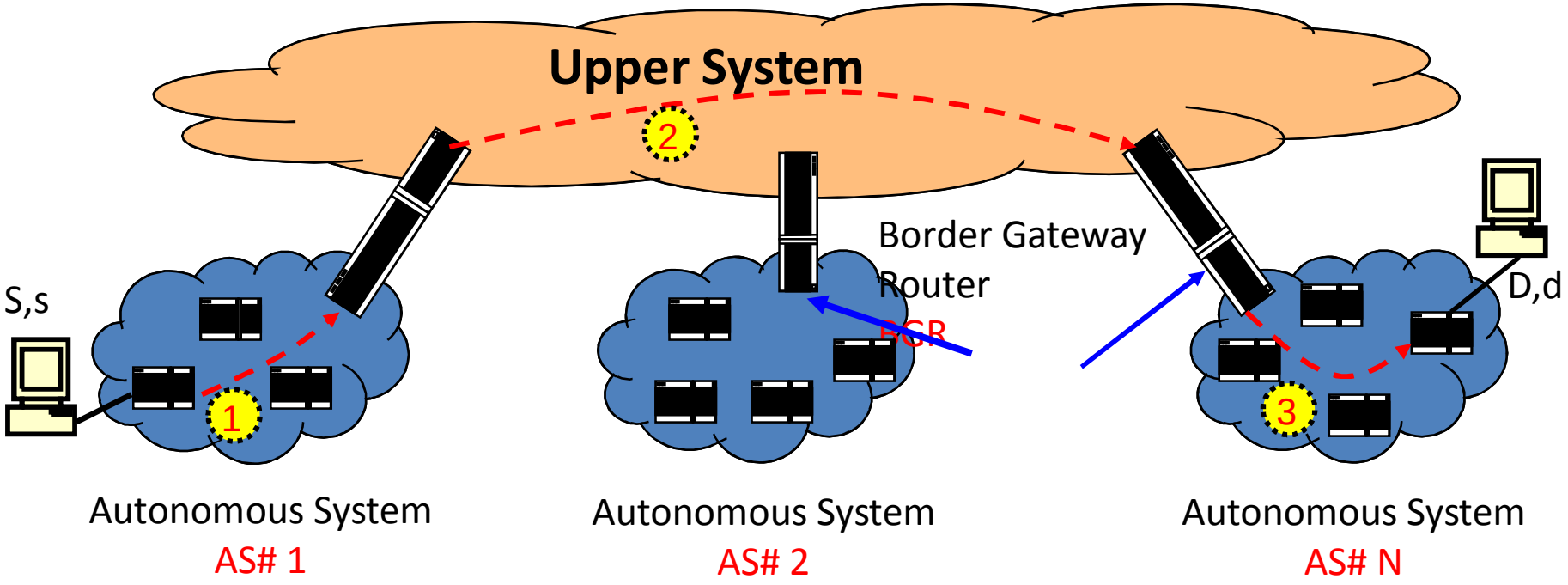


$\therefore$ <u># of entries</u> in routing table $\alpha\ell$ <u># of networks</u> (not # of devices)

Making routing scalable (Answer to Q2 – Continued)

2nd Idea

Use hierarchical approach



(Inside each AS, routers are governed by the same "Authority".)

In going from S to D, apply same idea used for road travel between two small towns in two remote provinces (the "Highway" idea).

Remarks :

R1 – By using hierarchical approach, each local router in an AS no longer needs to store information for all subnetworks in all AS's, in his routing table.
It only needs to store :

- routing information for reaching all other routers in own AS
- routing information for reaching BGR in own AS

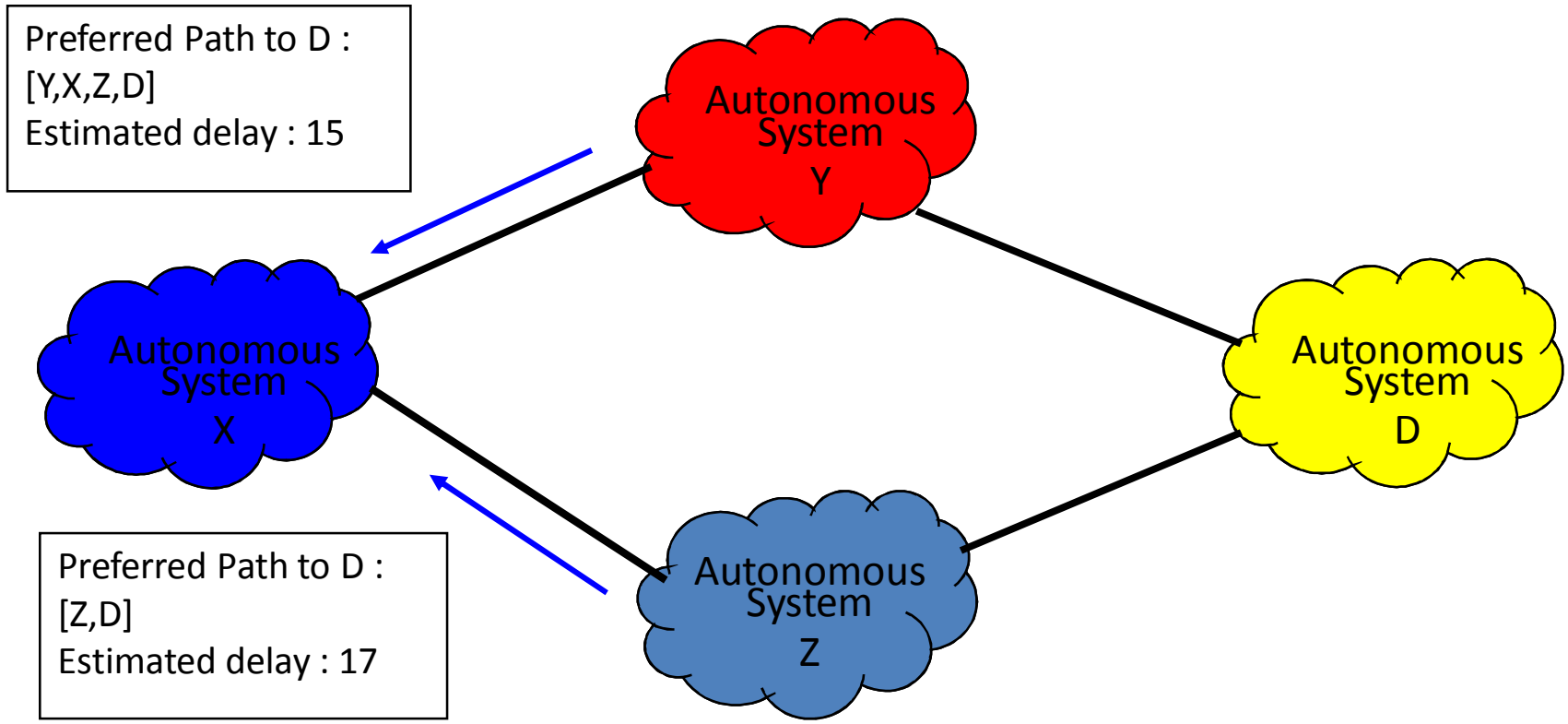
(Such information is typically generated by AS protocols such as OSPF.)
Meanwhile, each BGR needs to store :

- routing information stored by a typical local router
- routing information generated by Border Gateway Protocol (BGP)

Remarks (continued):

R2 – BGP is more sophisticated than local routing protocols. E.g., in BGP it is required to avoid looping. This is done by having each AS advertise its preferred path for it in going to other AS's.
(Such advertisement is given by listing those other AS's lying along path from source AS to Destination AS).

Example



If X uses the preferred path of Y to go to AS "D" :

Resulting path : X, Y, X , Z , D & Delay (Y, X , Z , D) = 15

If X uses the preferred path of Z to go to AS "D" :

Resulting path : X, Z , D & Delay (Z , D) = 17

X will select the path along Z, since a loop exists when using path along Y