Network Technologies (TCP/IP Suite)

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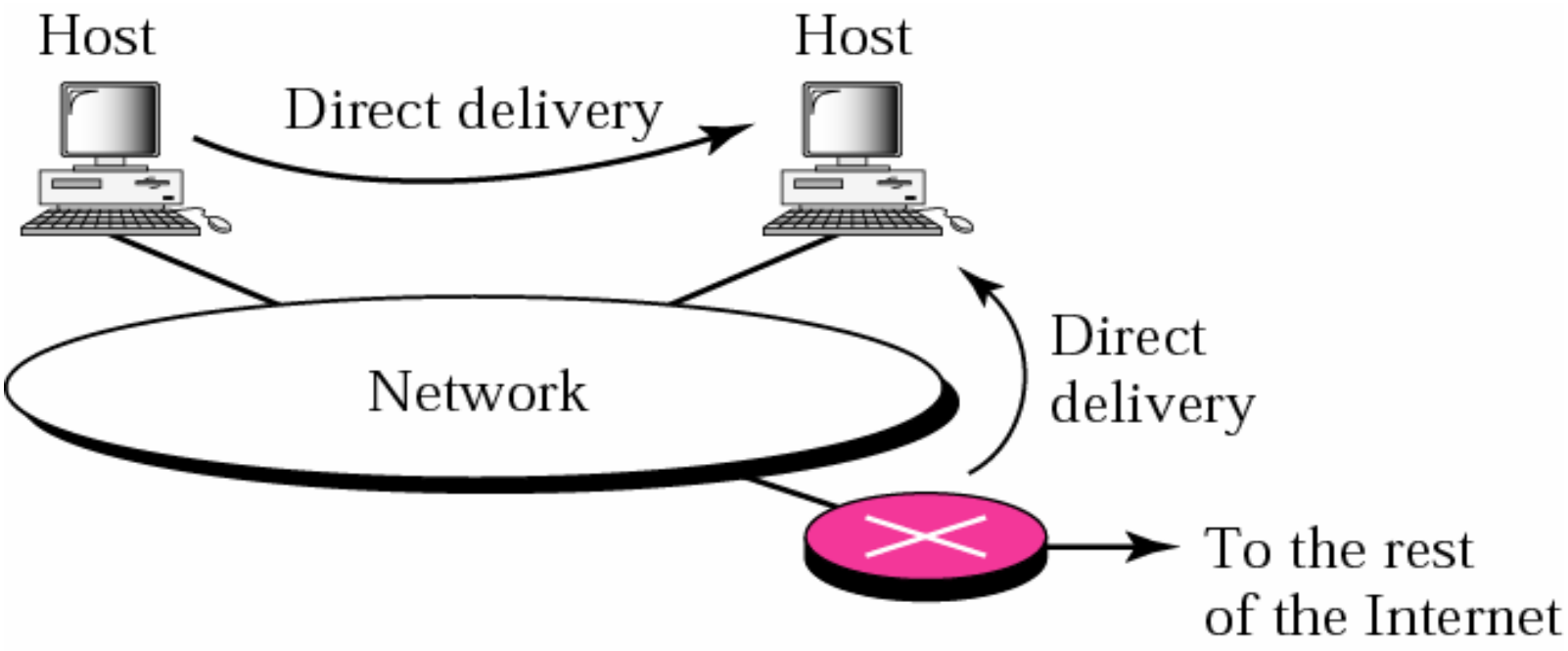
Outline

- Direct & Indirect delivery
- Forwarding & Forwarding Techniques
- Forwarding with classful addressing
  - Without subnetting
  - With subnetting
- Forwarding with classless addressing
  - Longest subnet mask
- Aggregation
- Autonomous Systems

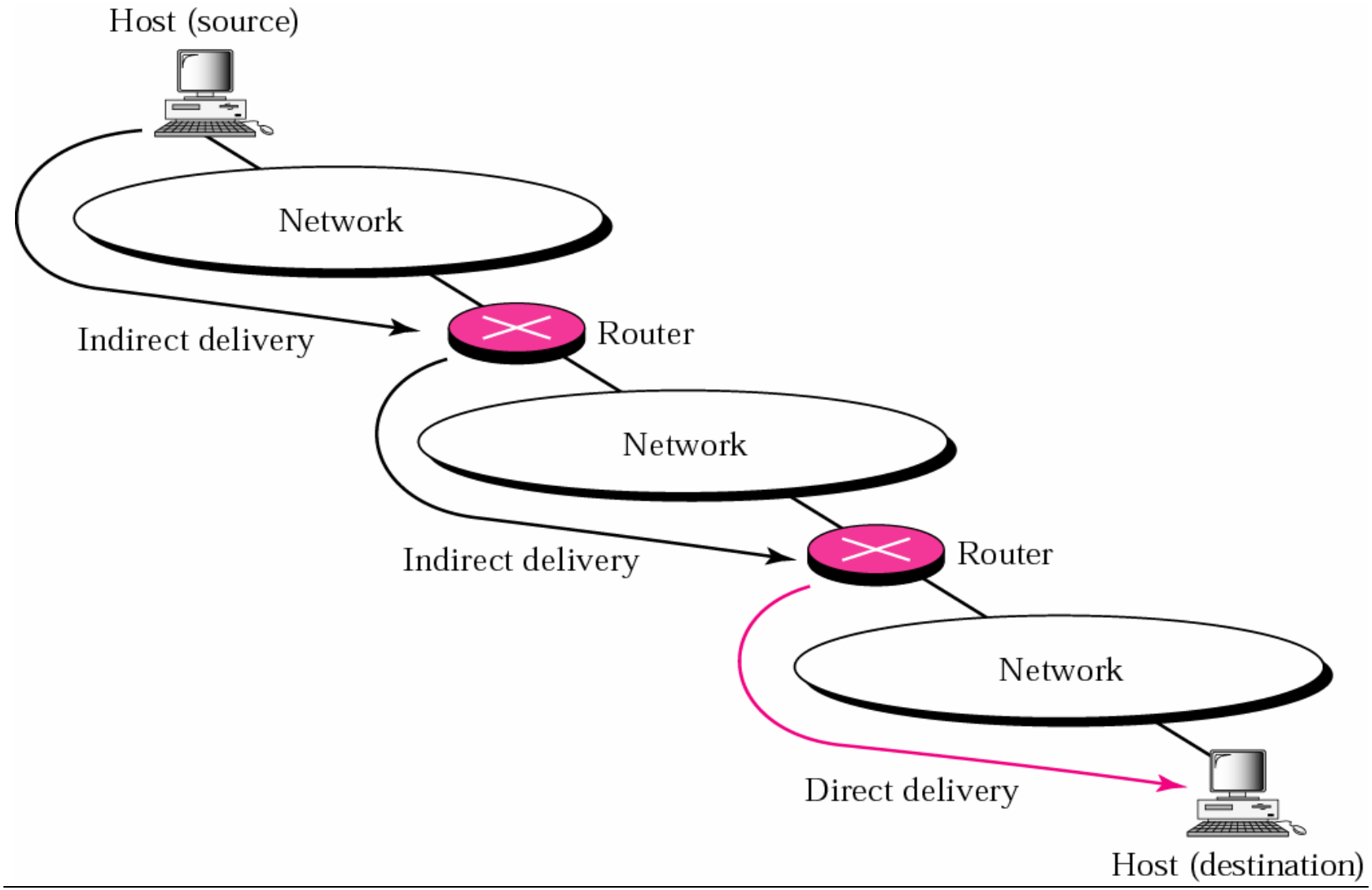
Trivia – Network Elements?

- Repeater?
- Hub?
- Bridge?
- Switch?
- Router?
  - Layer-3-Switch?

Direct delivery



Indirect delivery



Forwarding VS Routing

- Earlier we assumed that routers have knowledge of network structure
  - Virtual Circuits ~ routing is an issue for the connection request
  - Datagram Model ~ routing is an issue for every packet
- Forwarding ~ collect a packet, look at the destination, consult a table, send the packet in the right direction
  - Relatively simple
- Routing ~ The process of constructing the tables
  - Reasonably complex distributed algorithms

Forwarding Tables VS Routing Tables

- Terms used interchangeably ~ incorrect!
- Forwarding tables ~ used when packet is being sent on the right path
  - Mapping of network identity to physical address (of the next hop on the path) and outgoing interface
- Routing tables ~ Built by the routing algorithms as a precursor to building the forwarding tables
  - Mapping of network identity to the next hop on the path

Forwarding Tables VS Routing Tables

- Whether these tables are separate data structures is a consideration for implementation
  - Usually separate

Network Identity	Next Hop
10	171.69.245.10

Routing table

Network Identity	Interface	MAC Address
10	if4	8:0:2b:e4:b:1:2

Forwarding table

Forwarding

- Forwarding means to place the packet in its route to its destination
- Forwarding requires a host or a router to have a routing table
- Whenever a packet is to be forwarded, we have to lookup in the routing table to identify the route to the destination

Forwarding techniques

- Considering the number of interfaces and interconnecting devices, we need to have an efficient forwarding technique
  - We cannot maintain a list of all the hosts/interfaces
- Efficient algorithm
- A small routing table

Next-Hop Method

- The table holds only the address of the next hop
- No information about the complete route

Routing table for host A

Destination	Route
Host B	R1, R2, Host B

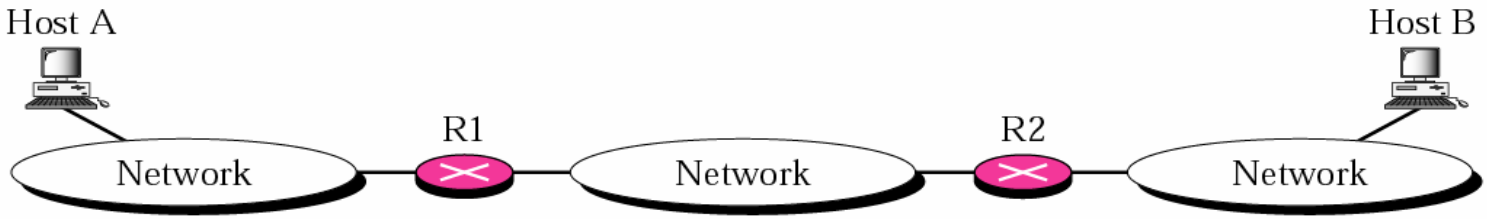
Routing table for R1

Destination	Route
Host B	R2, Host B

Routing table for R2

Destination	Route
Host B	Host B

a. Routing tables based on route



Routing table for host A

Destination	Next Hop
Host B	R1

Routing table for R1

Destination	Next Hop
Host B	R2

Routing table for R2

Destination	Next Hop
Host B	Ñ

b. Routing tables based on next hop

Network-Specific Method

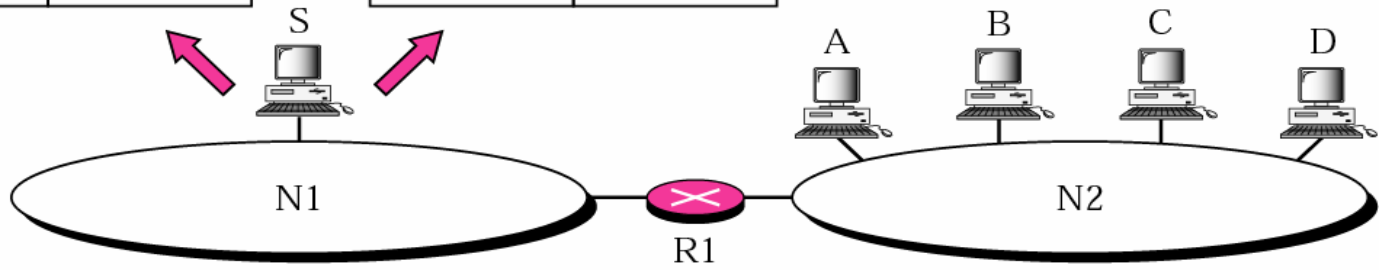
- For every destination host connected to the same network, we have only one entry that defines the address of the destination adress

Routing table for host S based on host-specific method

Destination	Next Hop
A	R1
B	R1
C	R1
D	R1

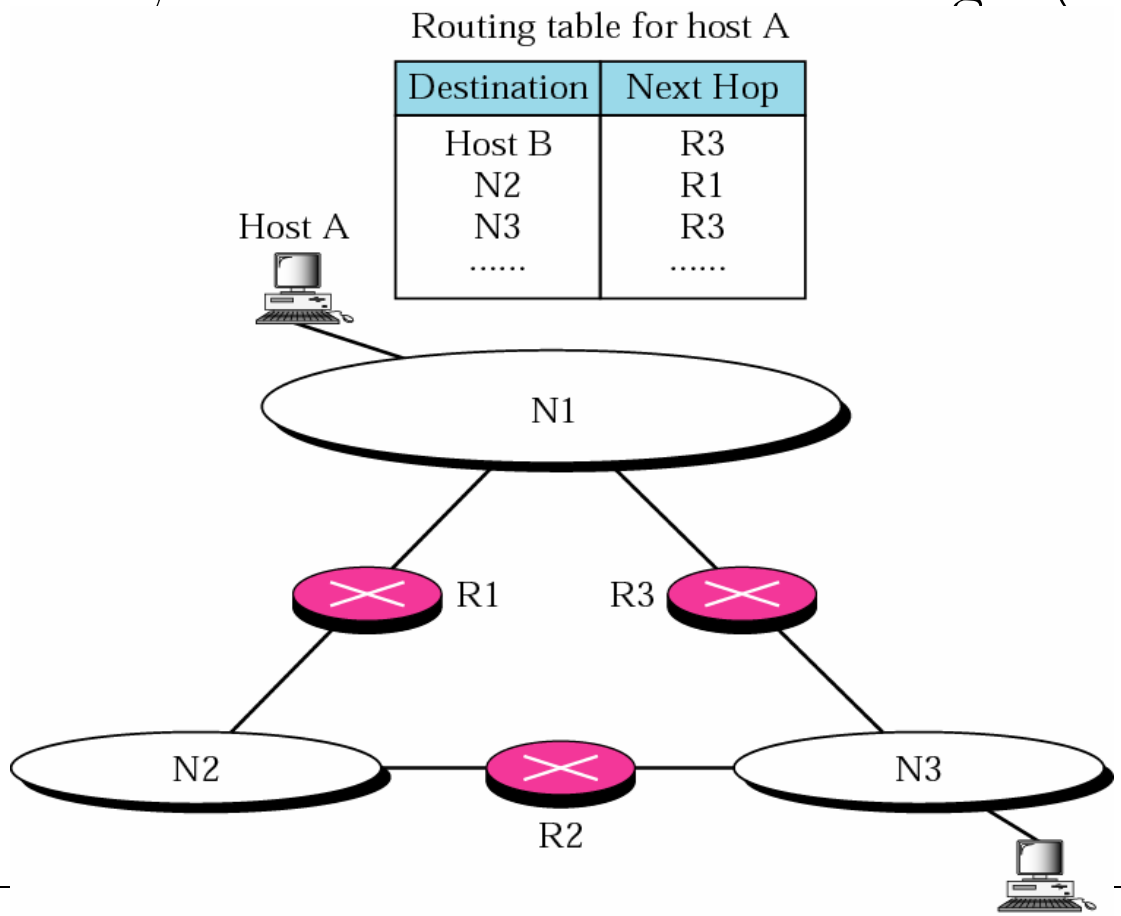
Routing table for host S based on network-specific method

Destination	Next Hop
N2	R1

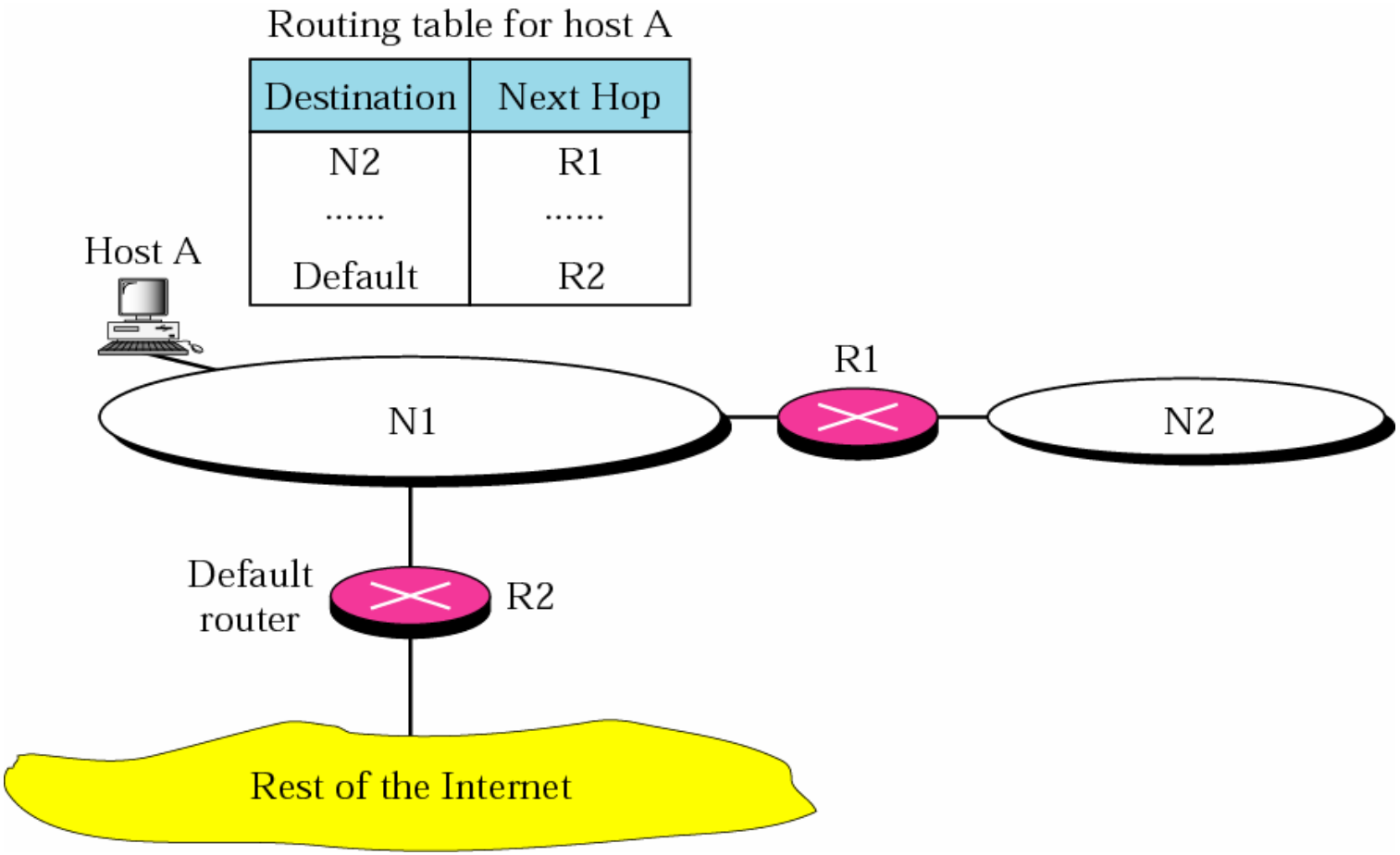


Host-Specific Method

- The destination host address is given in the routing table
- Here efficiency is sacrificed for other advantages (strict-routing)



Default Method



Forwarding with Classful Addressing

Forwarding without subnetting

- Maintain one table each for the unicast classes (A, B and C)
- If multicasting is supported, we can have a fourth table for class D

Forwarding without subnetting

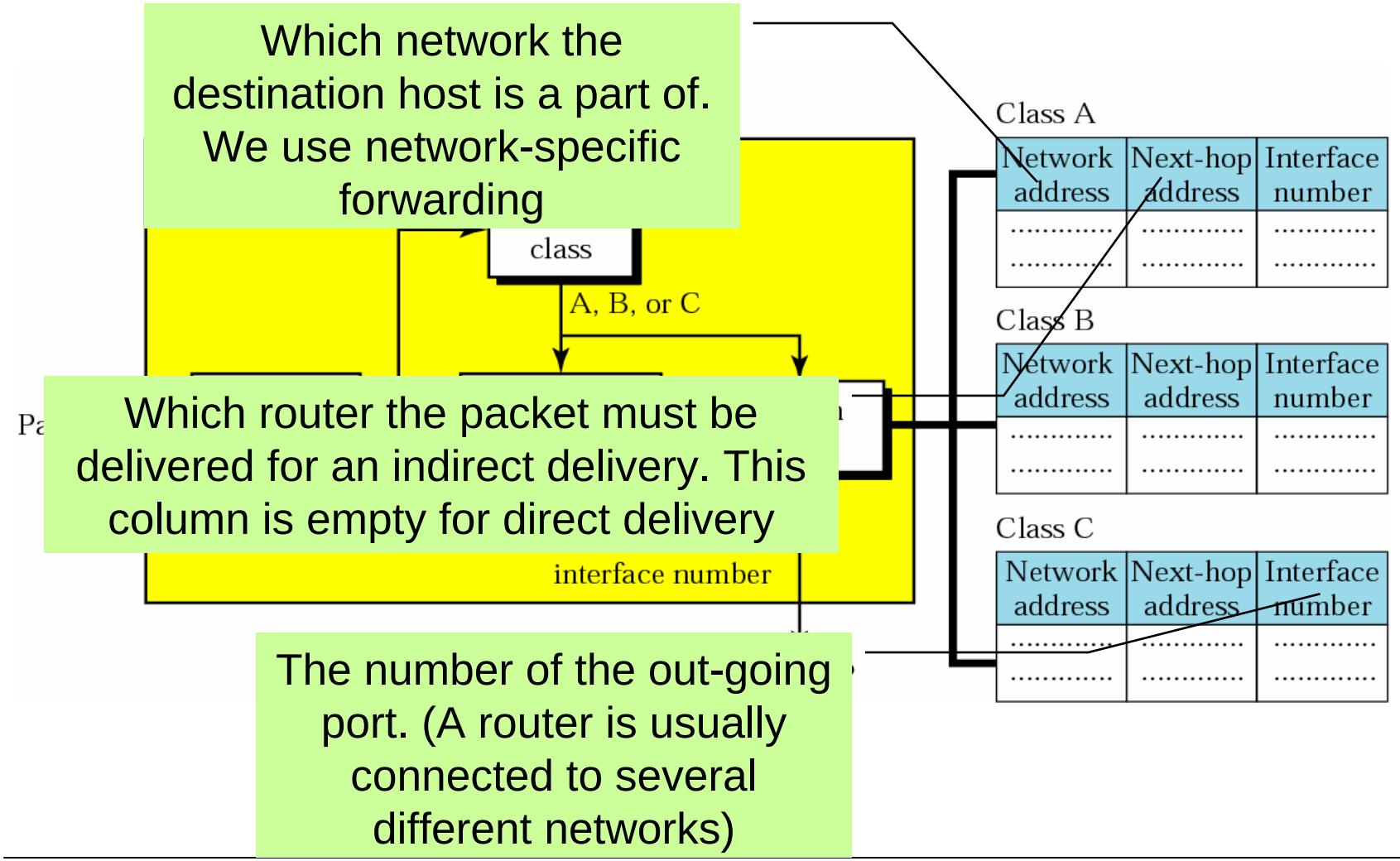
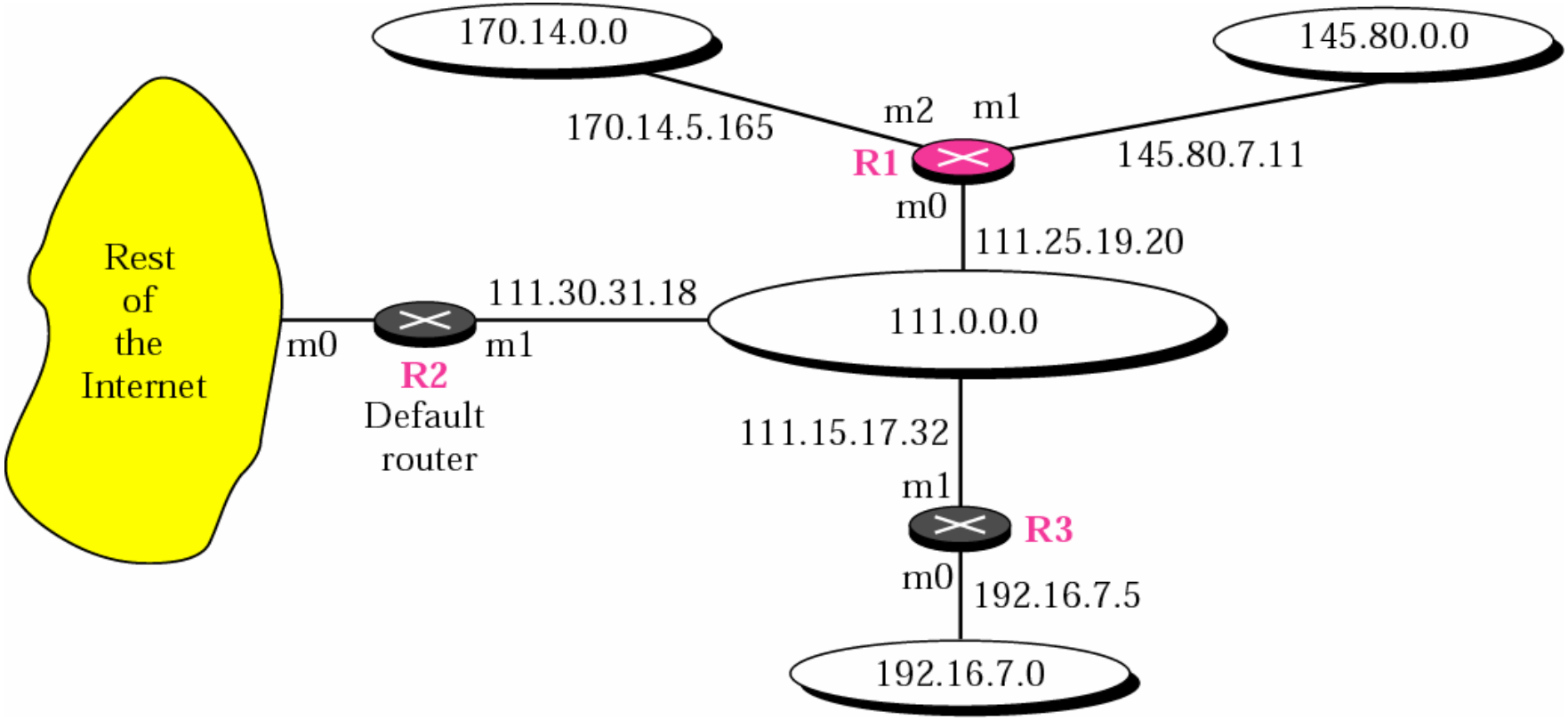


Figure shows an imaginary part of the Internet. Show the routing tables for router R1.



Class A

Network address	Next-hop address	Interface
111.0.0.0	----------	m0

Class B

Network address	Next-hop address	Interface
145.80.0.0	----------	m1
170.14.0.0	----------	m2

Class C

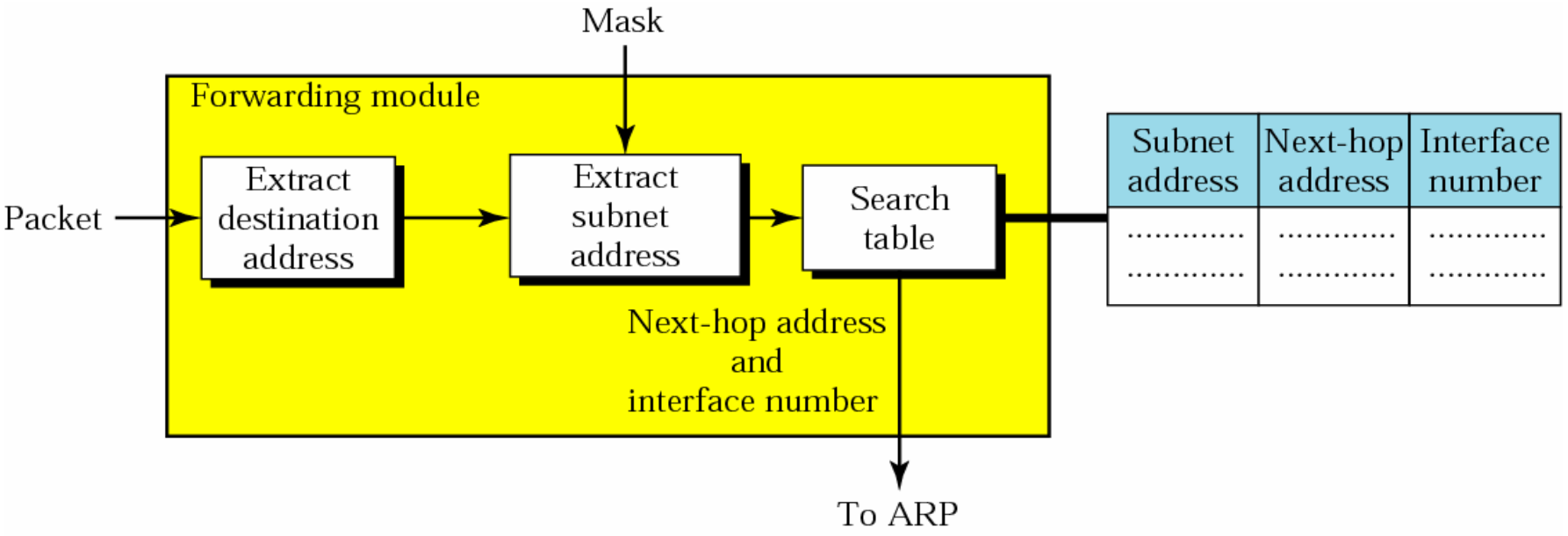
Network address	Next-hop address	Interface
192.16.7.0	111.15.17.32	m0

Default: 111.30.31.18, m0

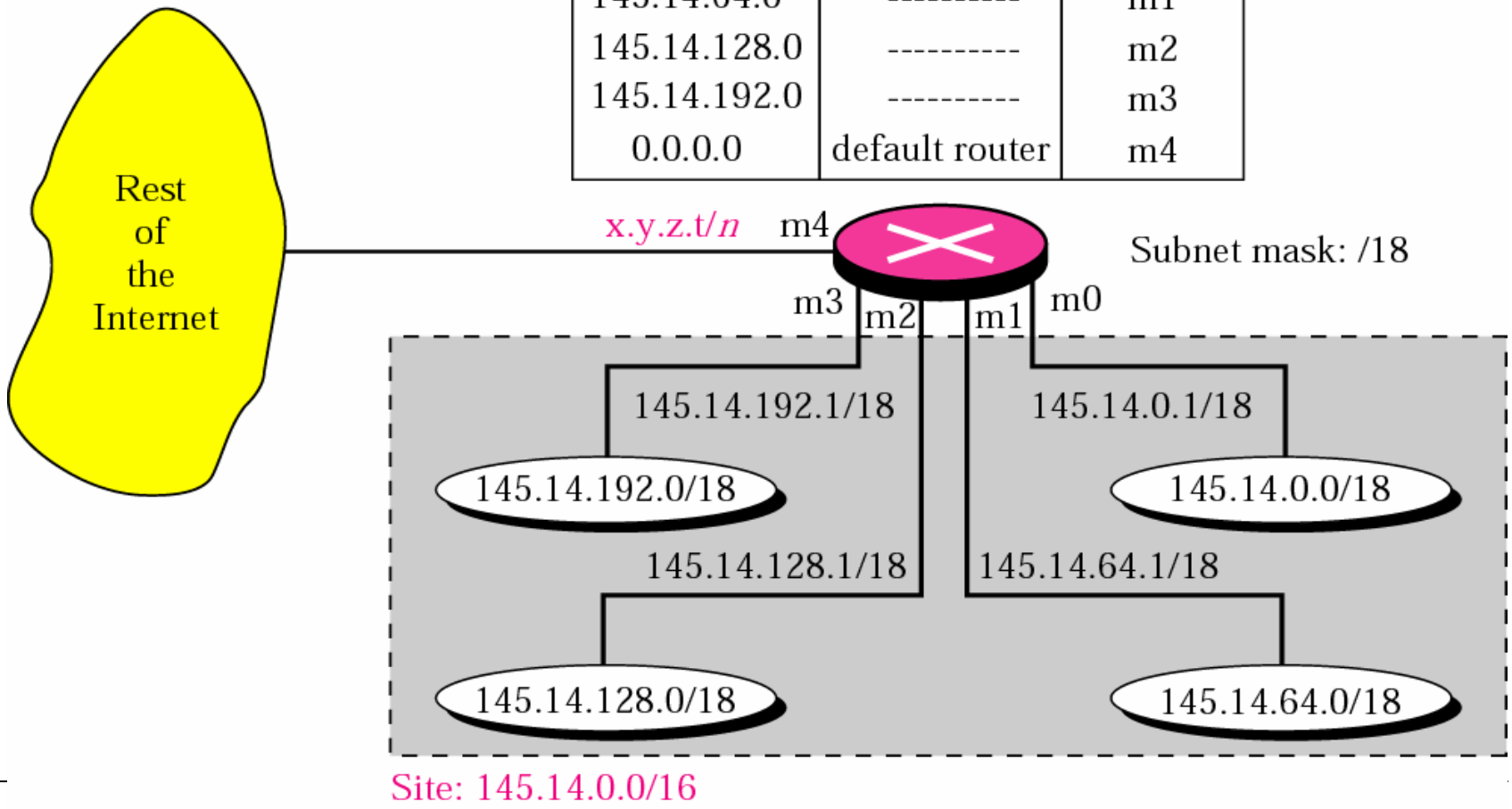
Forwarding with subnetting

- Subnetting is done inside the organization
- The routers which handle subnetting are either on the boundary or inside the boundary of the network
- If variable length subnetting is used we need several tables
- Otherwise we need only one table

Forwarding with subnetting



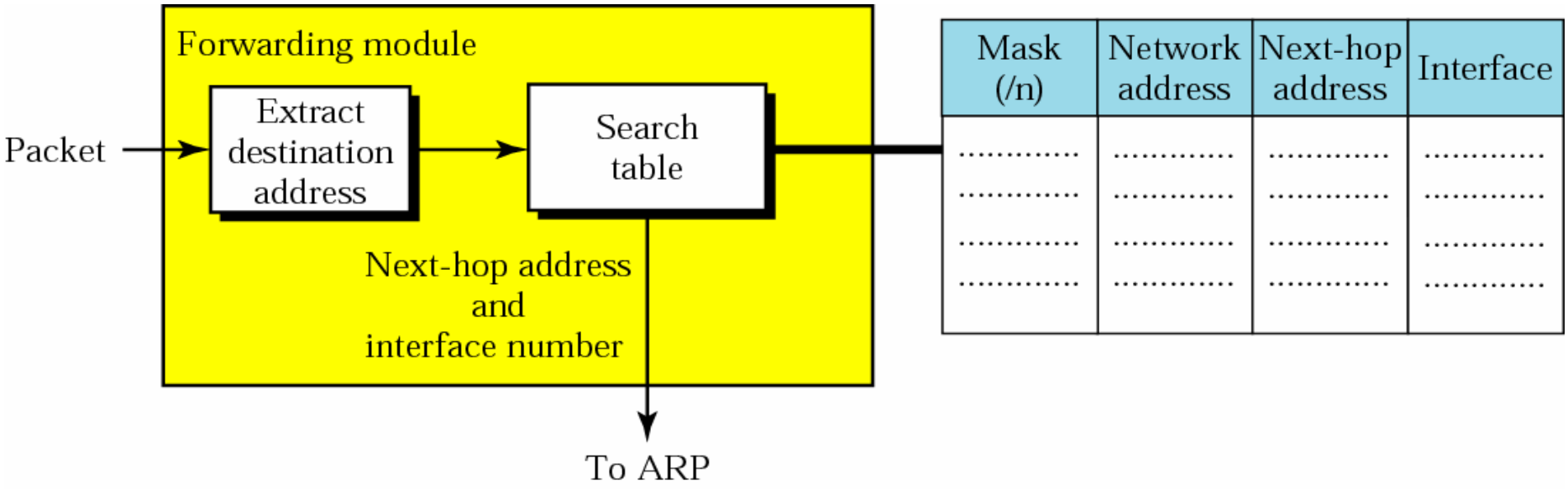
Subnet address	Next-hop address	Interface number
145.14.0.0	----------	m0
145.14.64.0	----------	m1
145.14.128.0	----------	m2
145.14.192.0	----------	m3
0.0.0.0	default router	m4



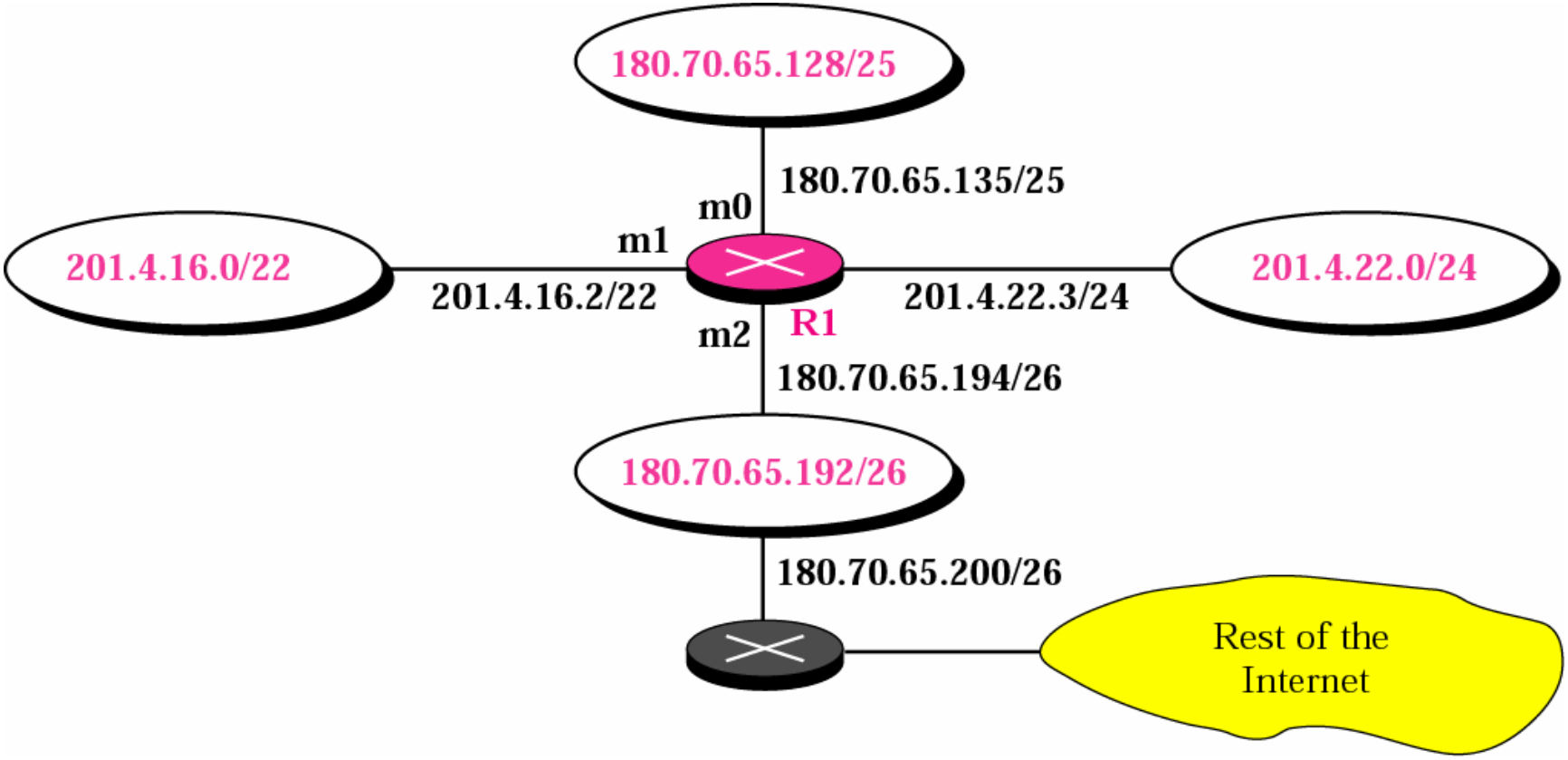
Forwarding with Classless Addressing

- Since the whole address is available for allocation, one entry for every block is required
  - As the address alone has no significance
- Information about the mask is required
- Thus we add another column for the mask

Forwarding with Classless Addressing



- ***Make a routing table for router R1 using the configuration in Figure***



Mask	*Network Address*	*Next Hop*	*Interface*
/26	180.70.65.192	-	m2
/25	180.70.65.128	-	m0
/24	201.4.22.0	-	m3
/22	201.4.16.0	....	m1
Default	Default	180.70.65.200	m2

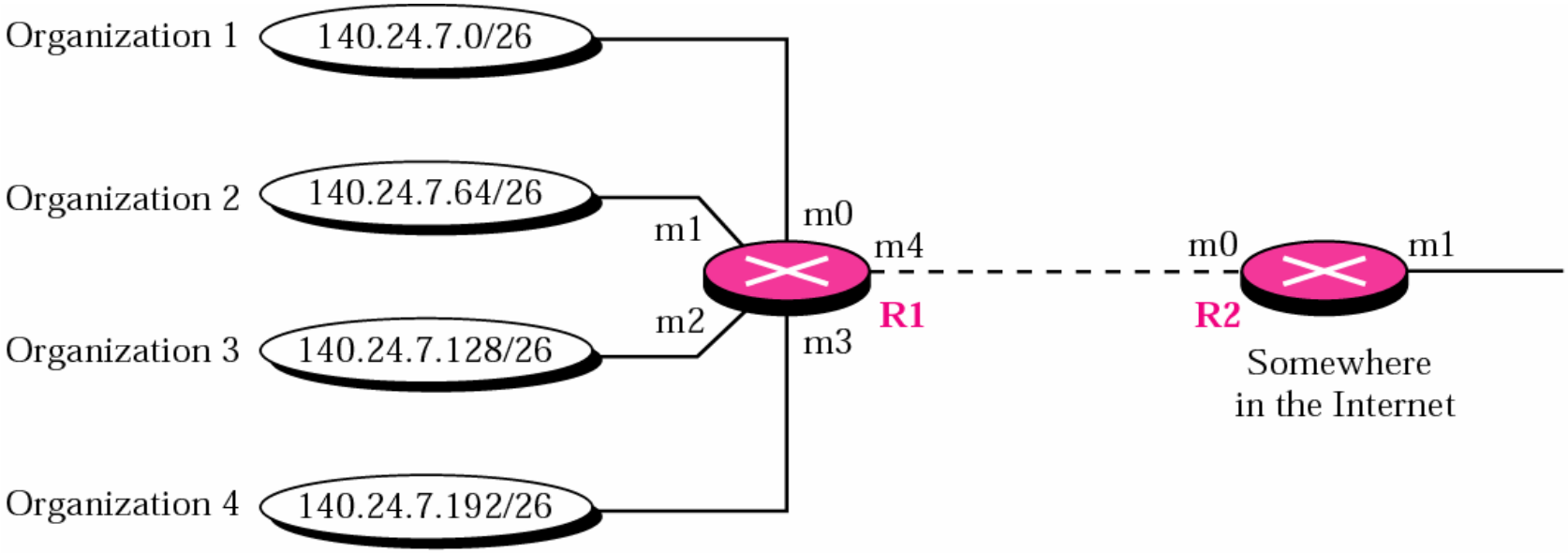
Show the forwarding process if a packet arrives at R1 in the last example with the destination address 180.70.65.140.

- The first mask (/26) is applied to the destination address. The result is 180.70.65.128, which does not match the corresponding network address.
- The second mask (/25) is applied to the destination address. The result is 180.70.65.128, which matches the corresponding network address.

Address Aggregation

- For classful addressing there is **one** entry for every site outside the organization
- The entry defines the site (even if it is subnetted)
- With classless addressing the number of entries may increase
  - A variety of blocks
  - Similar addresses with different masks

Address Aggregation



Mask	Network address	Next-hop address	Interface
/26	140.24.7.0	----------	m0
/26	140.24.7.64	----------	m1
/26	140.24.7.128	----------	m2
/26	140.24.7.192	----------	m3
/0	0.0.0.0	default router	m4

Routing table for R1

Mask	Network address	Next-hop address	Interface
/24	140.24.7.0	----------	m0
/0	0.0.0.0	default router	m1

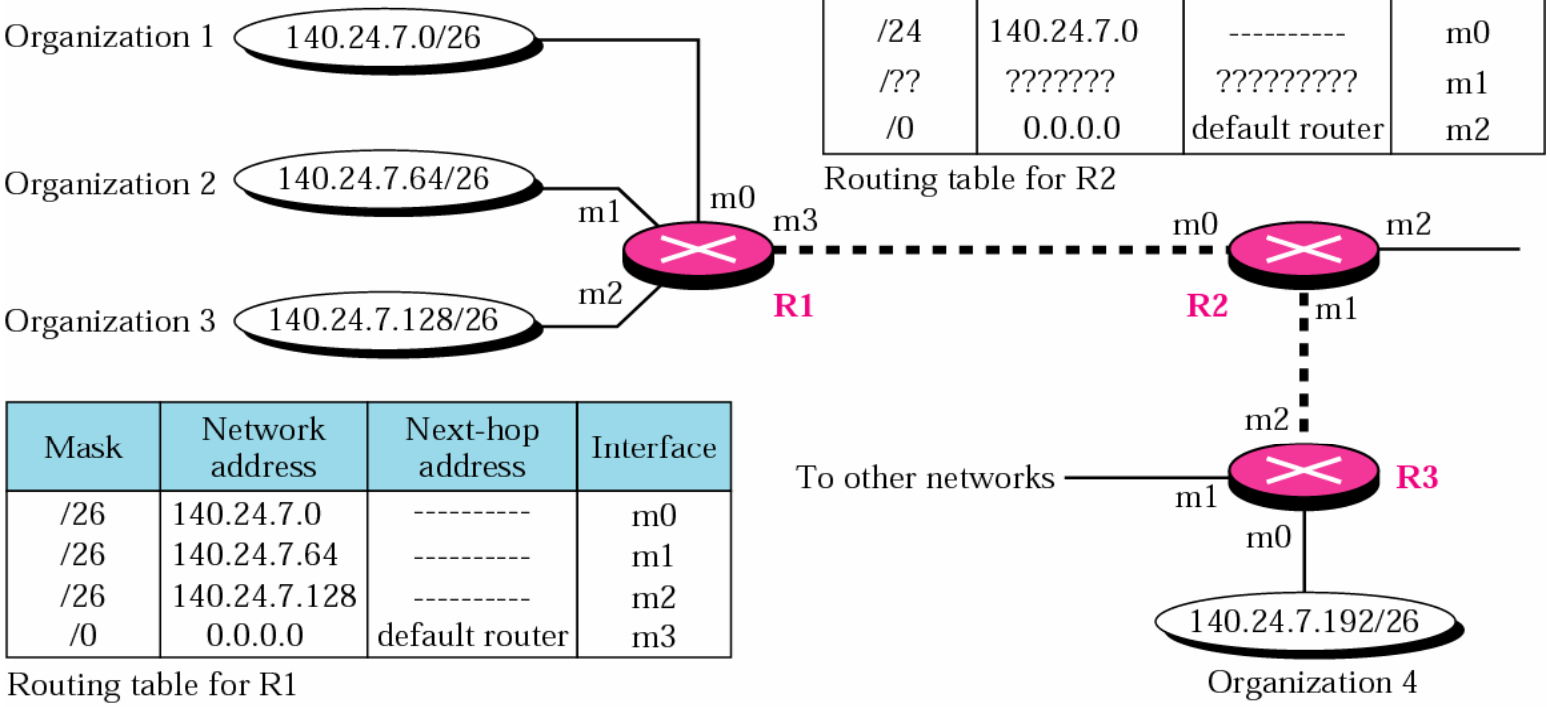
Routing table for R2

Address Aggregation

- Note that although the idea of address aggregation is similar to the idea of subnetting, **we do not have a common site here**
- The network of each organization is independent
- Also, we can have several levels of aggregation

Longest Mask Matching

- Usually address aggregation is done with sites which are close to each other –geographically
- What if an organization is not located in the same vicinity?
- Solution: longest mask matching
  - Sorted with the longest mask first



Mask	Network address	Next-hop address	Interface
/26	140.24.7.192	----------	m1
/24	140.24.7.0	----------	m0
/??	???????	?????????	m1
/0	0.0.0.0	default router	m2

Routing table for R2

Mask	Network address	Next-hop address	Interface
/26	140.24.7.0	----------	m0
/26	140.24.7.64	----------	m1
/26	140.24.7.128	----------	m2
/0	0.0.0.0	default router	m3

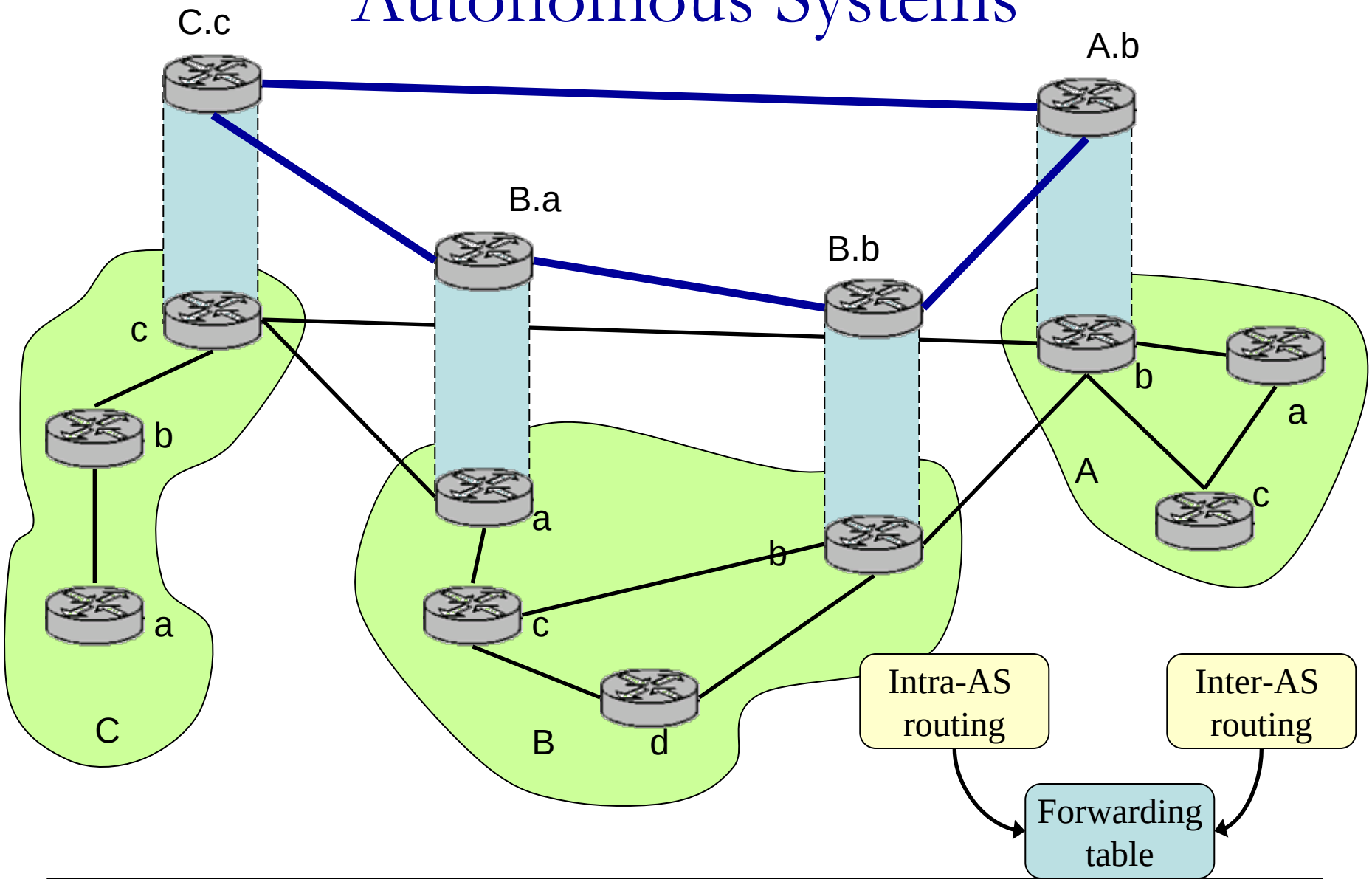
Routing table for R1

Mask	Network address	Next-hop address	Interface
/26	140.24.7.192	----------	m0
/??	???????	?????????	m1
/0	0.0.0.0	default router	m2

Routing table for R3

Autonomous Systems & Hierarchical Routing

Autonomous Systems



Questions?

That's all folks!