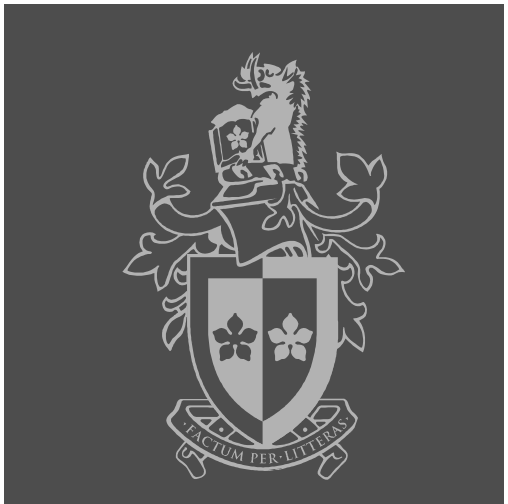
SWINBURNE

CENTRE FOR ADVANCED INTERNET ARCHITECTURES

TNE20002/TNE70003

Topic 1: Introduction to Routing



Outline

1.1 Routing Concepts

- Many Networks
- Router Tasks

1.2 Path Determination

- Best Path = s Longest Match
- Router Decision Flowchart

1.3 Routing Table

- Direct connected & Remote routes
- Routing Table Entries
- Static Routes & Default Routes
- Administrative Distance

1.4 Packet Forwarding

- Packet Forwarding Decision Process
- End to End Packet Forwarding

1.5 Routing Protocols

- Routing Protocol Characteristics
- Types of Dynamic Routing Protocols

The Router

Routers

are the

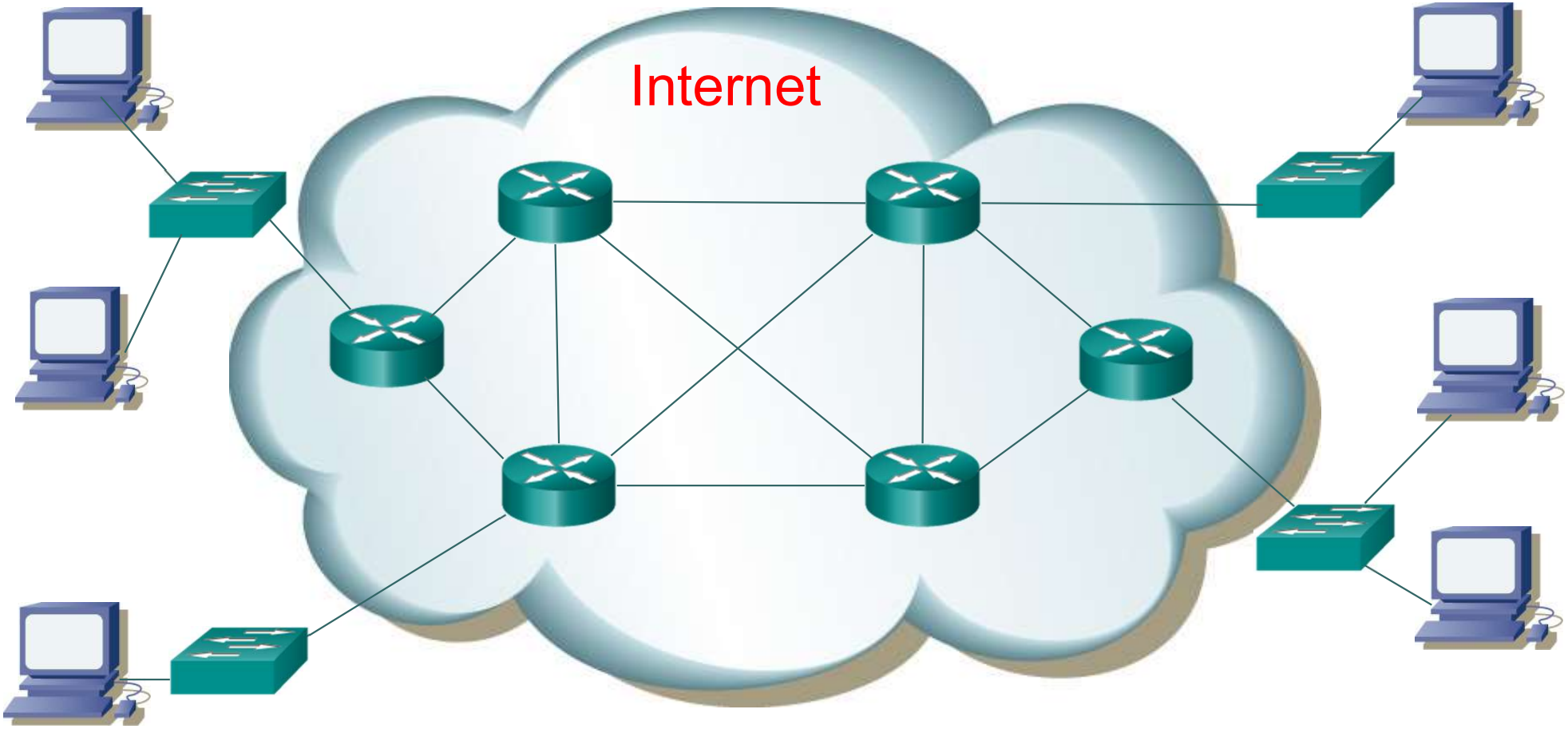
core

of

The Internet

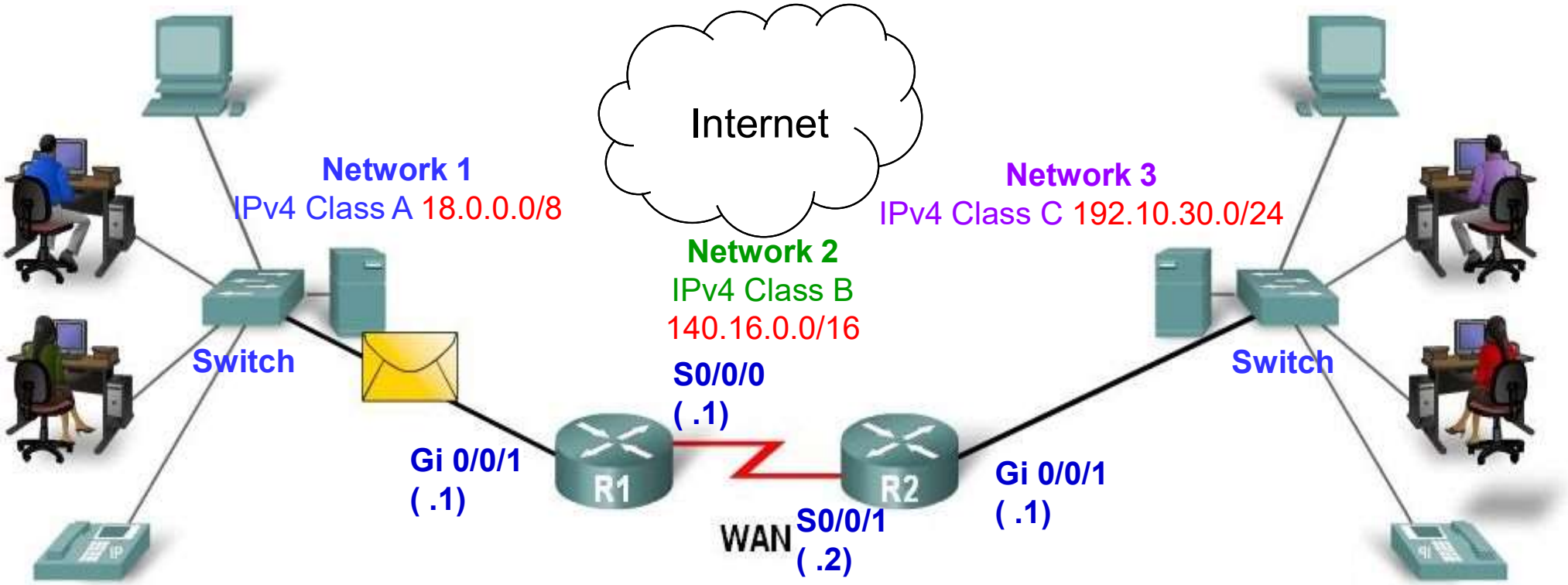
Routing

- The Internet is too large to have all hosts together as one network, it is subdivided to many networks.
- Routers are the Core of the Internet



Routers connect Networks

- The Internet is subdivided into many separate networks.
- Each router interface Gi 0/0/1, S0/0/0, etc is a **Gateway** to another a network



A Router Interface is a GATEWAY – Entry/Exit into/out of a network

The Router

Primary Task

- The router, routes IP packets between networks

Path Determination

- When a router receives an IP packet via one interface
- Router determines the Best Path to forward the IP packet
- based on information in the ‘Routing Table’

Operate at Layer 3 - Network Layer

- Responsible for routing packets to the next hop
- towards the intended destination.

The Router

The router, drops IP packets to reduce congestion

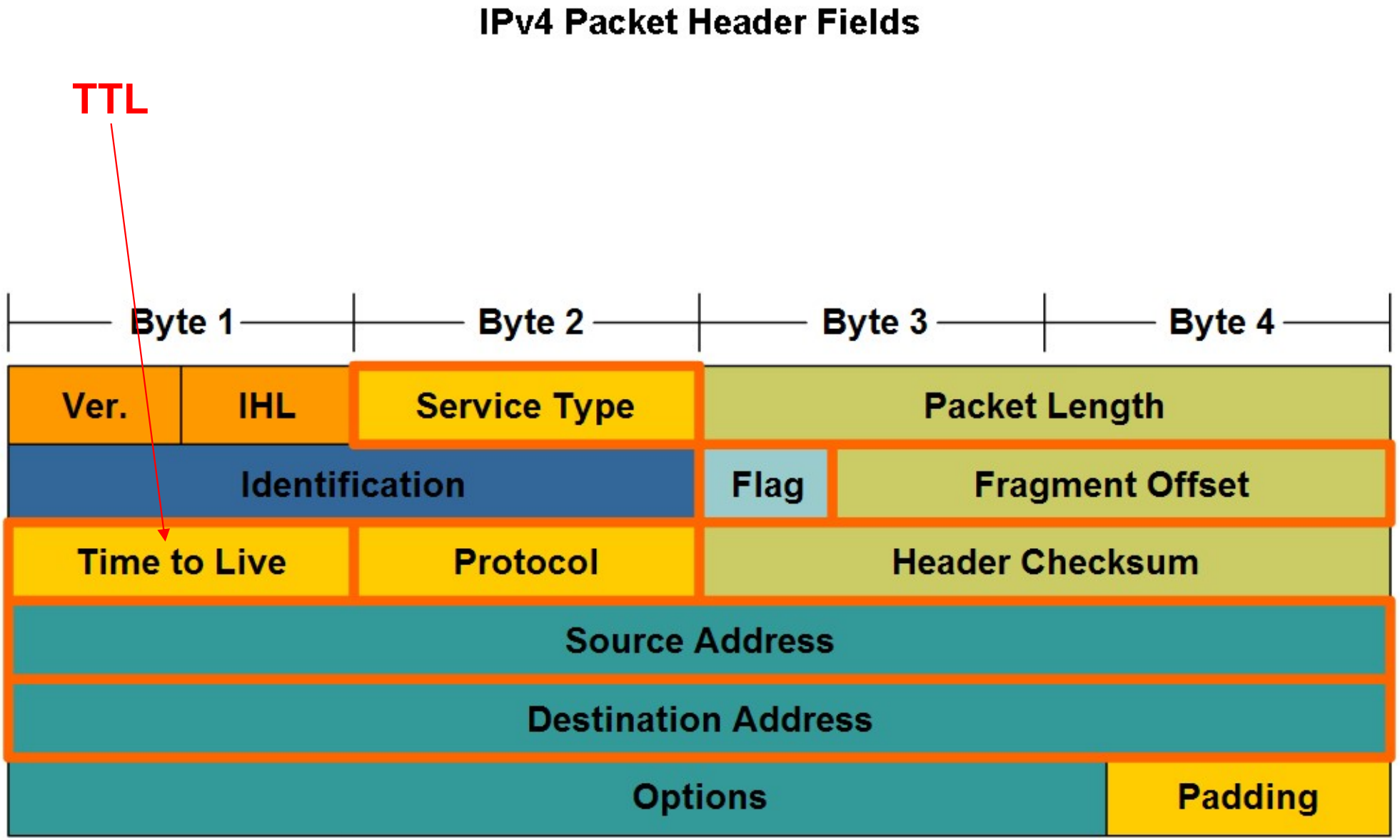
- Setting Time to Live (TTL) to 128 hops, means if the packet cannot reach its destination within 128 hops, it will be dropped
- When a packet enters a router, deduct 1 from TTL
- IF TTL = 0 the packet will be dropped

Secondary Tasks

Routers continue operating after disruptions

- Power Failure
- Broken hardware device
- Damaged cable or connection
- Manage re-routing packets after disruption.
- Manage basic access controls of Packets
- Provide QoS

IP Header TTL



1.2 Path Determination

- Best Path = s Longest Match
- Router Decision Flow Chart

Path Determination Best Path using Longest Match

Based on the **Information** in the **Routing Table**, the Router

1. Selects Best Path based on Longest Match

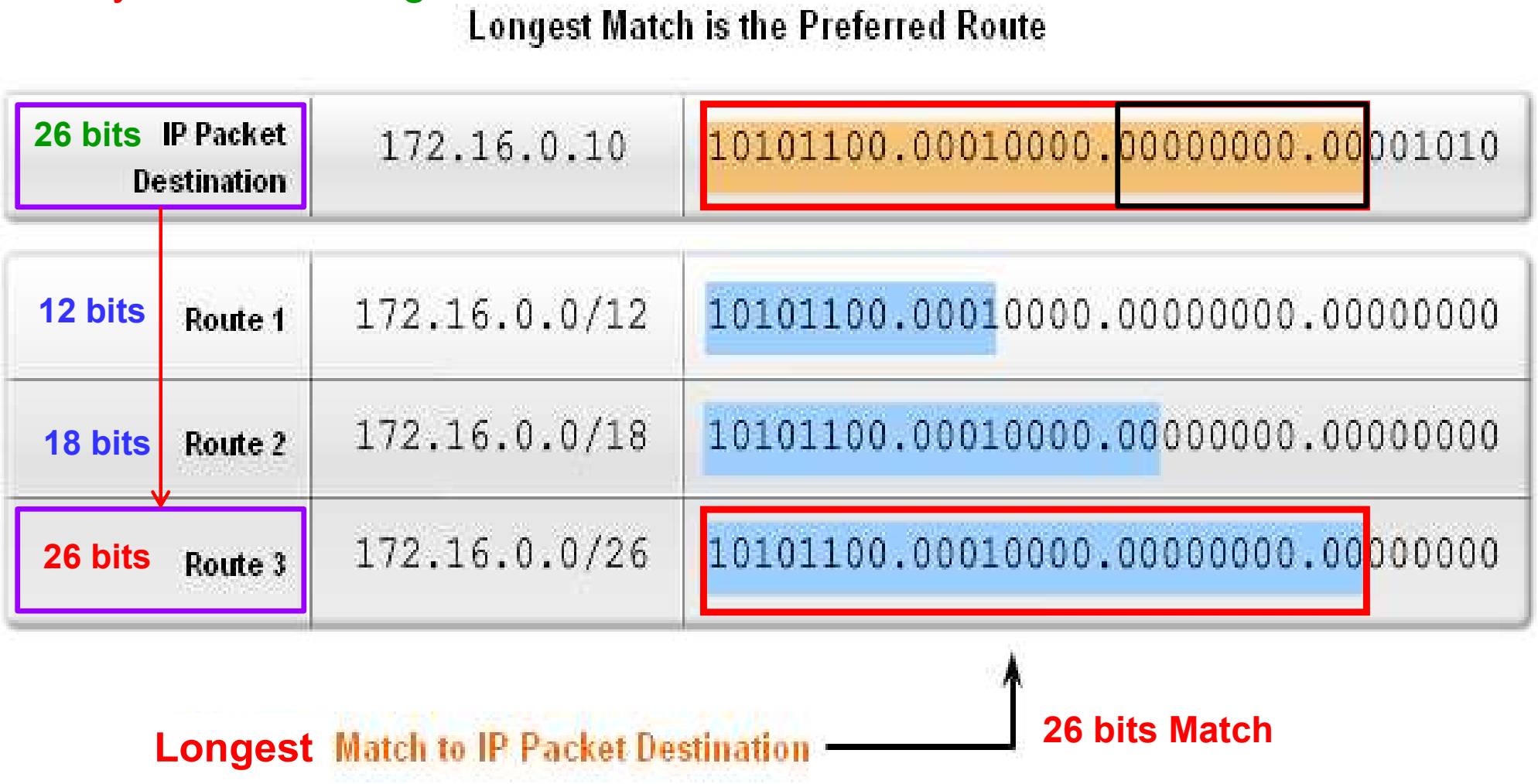
   - It determines the Longest Match,
     between the destination network address in the incoming
     packet and a network address entry in the routing table

2. Makes a Forwarding Decision

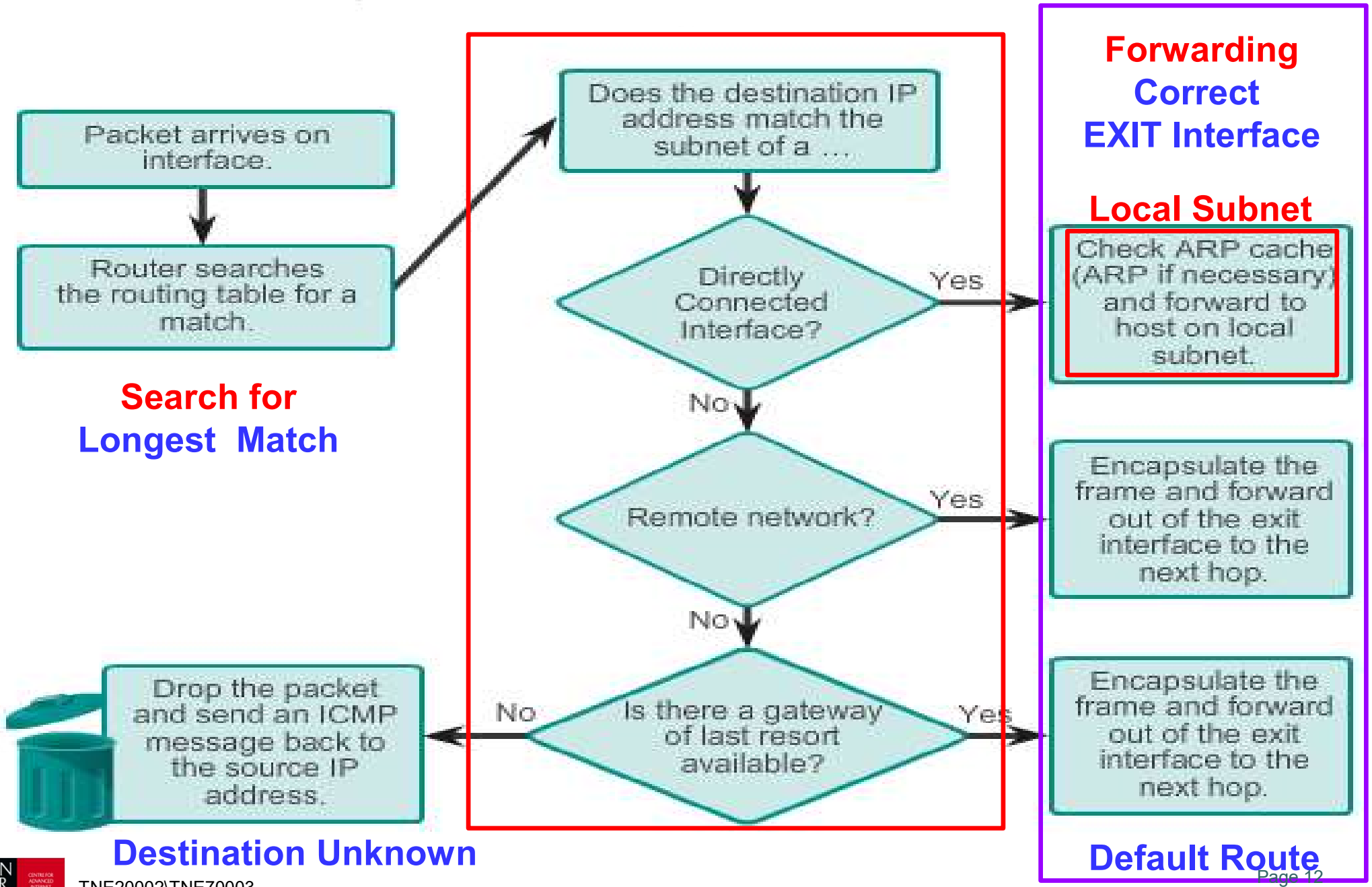
   - It determines the correct exit interface then forwards the
     packet to that exit interface, towards the destination network.

The Router - Best Path Decision

- The **Longest Match** is the one that has **most** number of bits(left to right) matching between the destination IP network address and a routing entry in the Routing Table.



Routing Decisions – Flow Chart



1.3 Routing Table

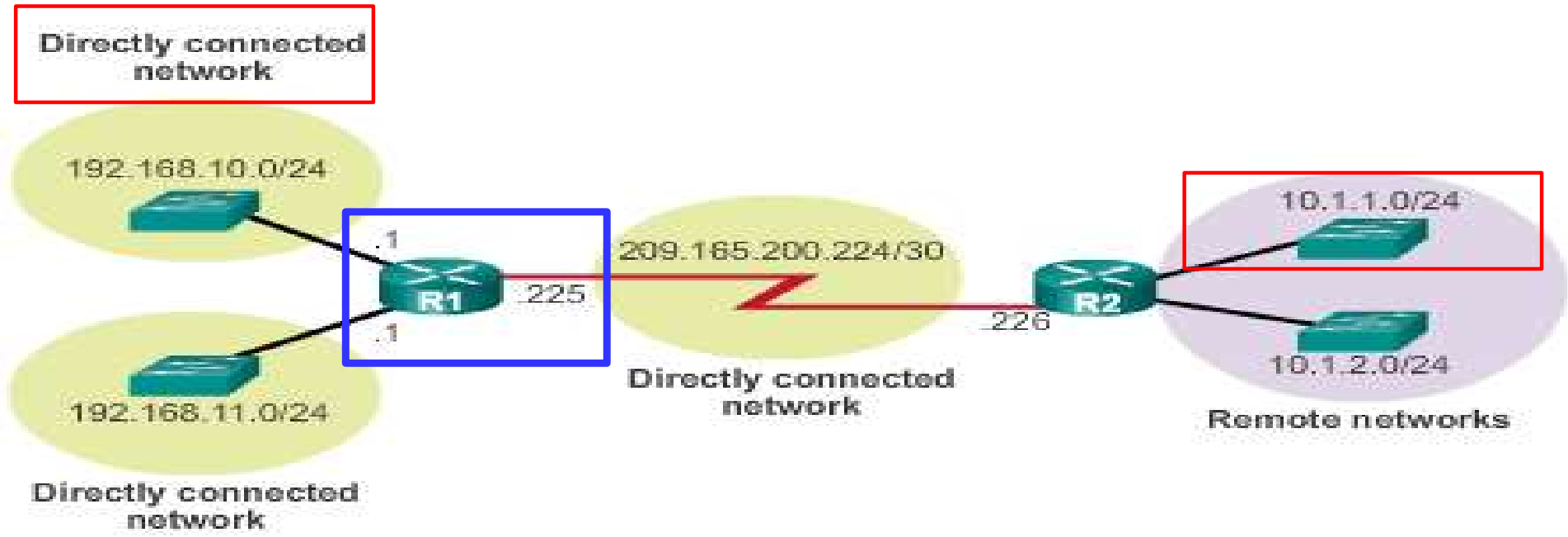
- Direct connected & Remote routes
- Routing Table Entries
- Static Routes & Default Routes
- Administrative Distance

The Routing Table

Routing Table is a list of possible routes

Routing table for R1 is a file stored in RAM contains information about:

- Directly connected networks
- Static Routes to Remote Networks (manually configured)
- Remote Networks (learnt via Dynamic routing protocol)
- Default Routes



Routing Table Entries – show ip route

- **Link local route interfaces -** Added to the routing table when an interface is configured. Shows IP address of the Interface.

- **Connected interfaces -** Added to the routing table when an interface is configured and active.

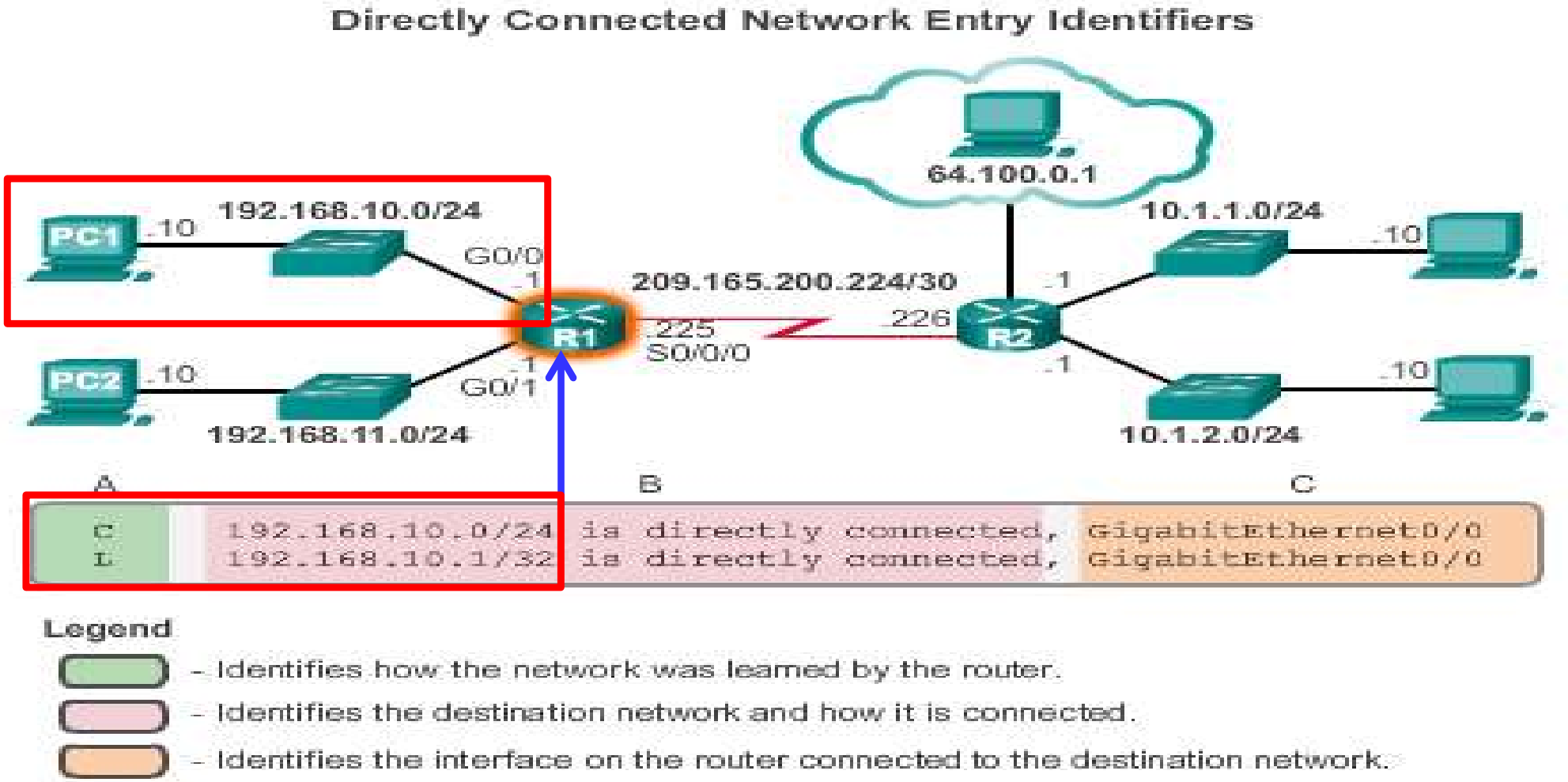
- **Static routes -** Added when a route is manually configured and the exit interface is active.

- **Dynamic routes -** Added when RIP, EIGRP or OSPF are implemented and networks are identified.

Directly Connected Routes – R1

An active, configured, directly connected interface creates two routing table entries:

- Link Local (L) and Connected (C)



Routing Table Entries - Static Routes

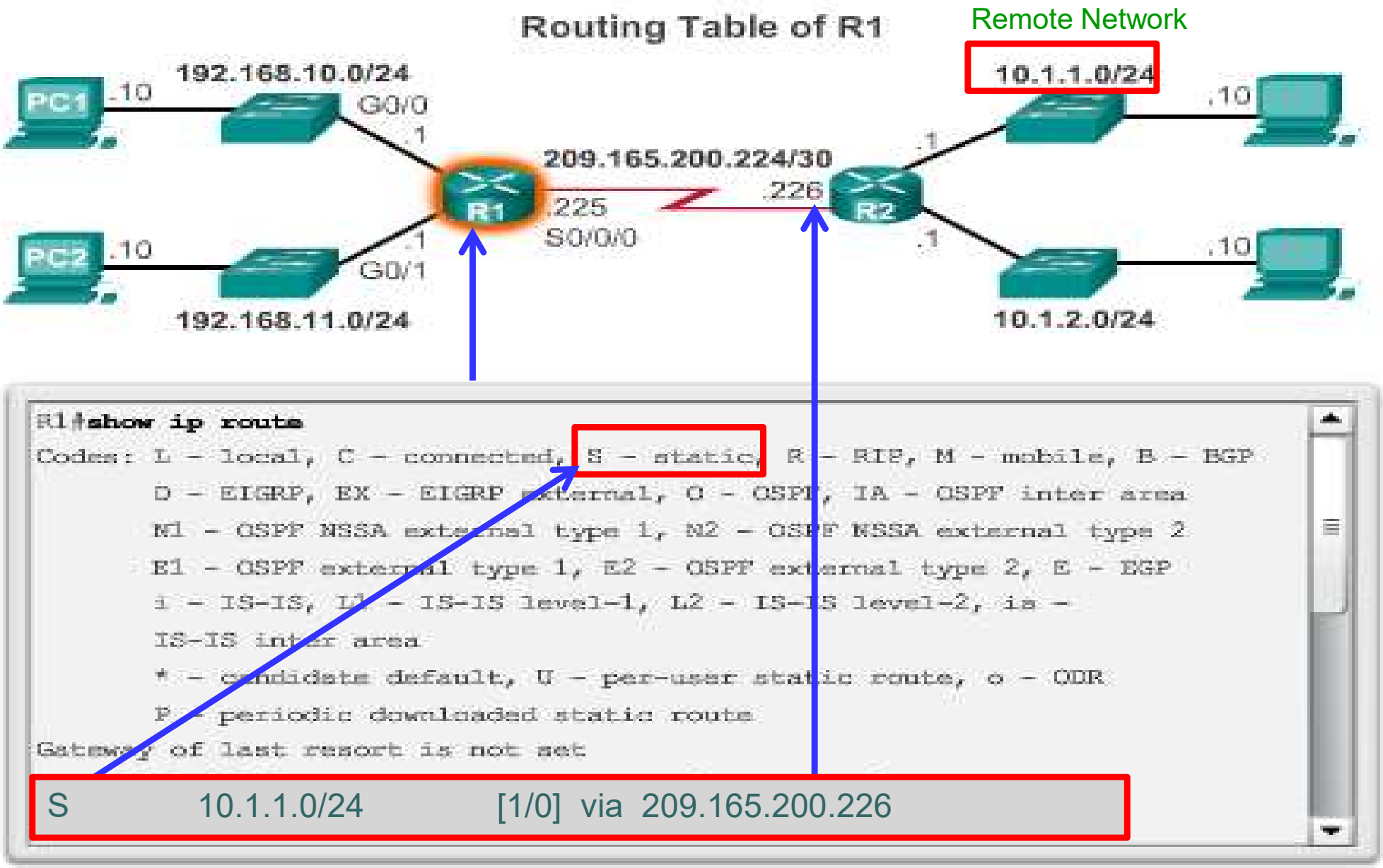
Static routes are manually configured and define an explicit path between two networking devices.

- There are two main types of static routes in the routing table:
  - Static route to a specific network
  - Default static route

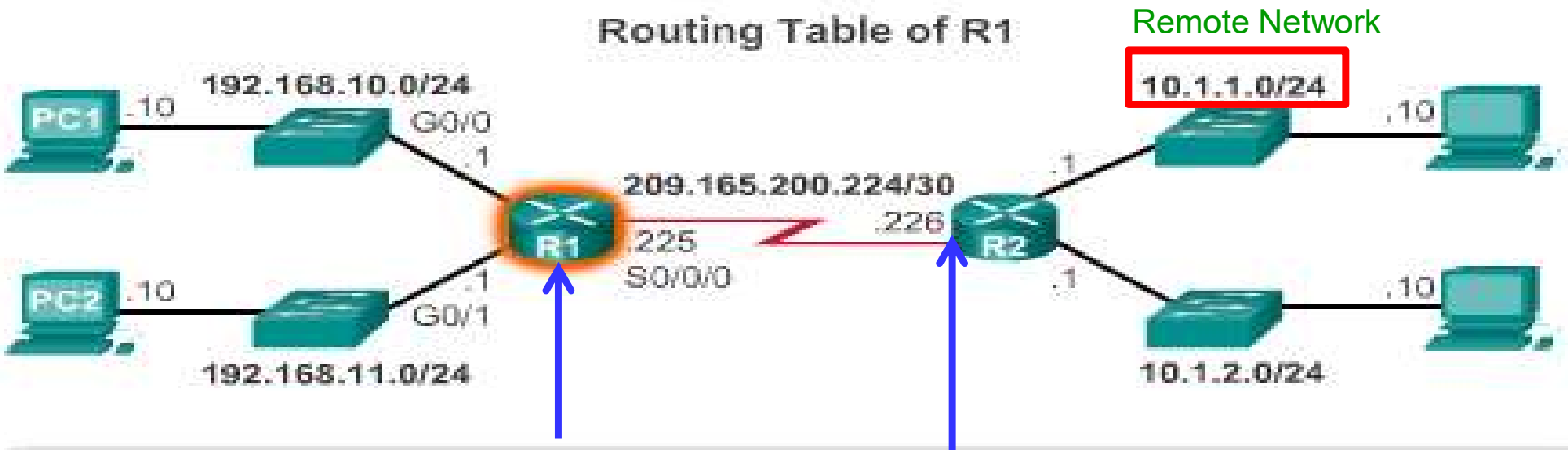
- IPv4 static routes are configured using the following command:
  - **ip route** network-address subnet-mask { *next-hop-ip* | *exit-intf* }
- A static route appears in the routing table with the code 'S'.

- A "default static route" is similar to a default gateway on a PC or host.
- The "default route" specifies exit point to use when the routing table does not have a path for the destination network. Use the command:
  - **ip route** 0.0.0.0 0.0.0.0 { exit-intf | next-hop-ip }
  - Candidate "default route" appears in routing table with the code 'S * '.

Routing Table Entries –



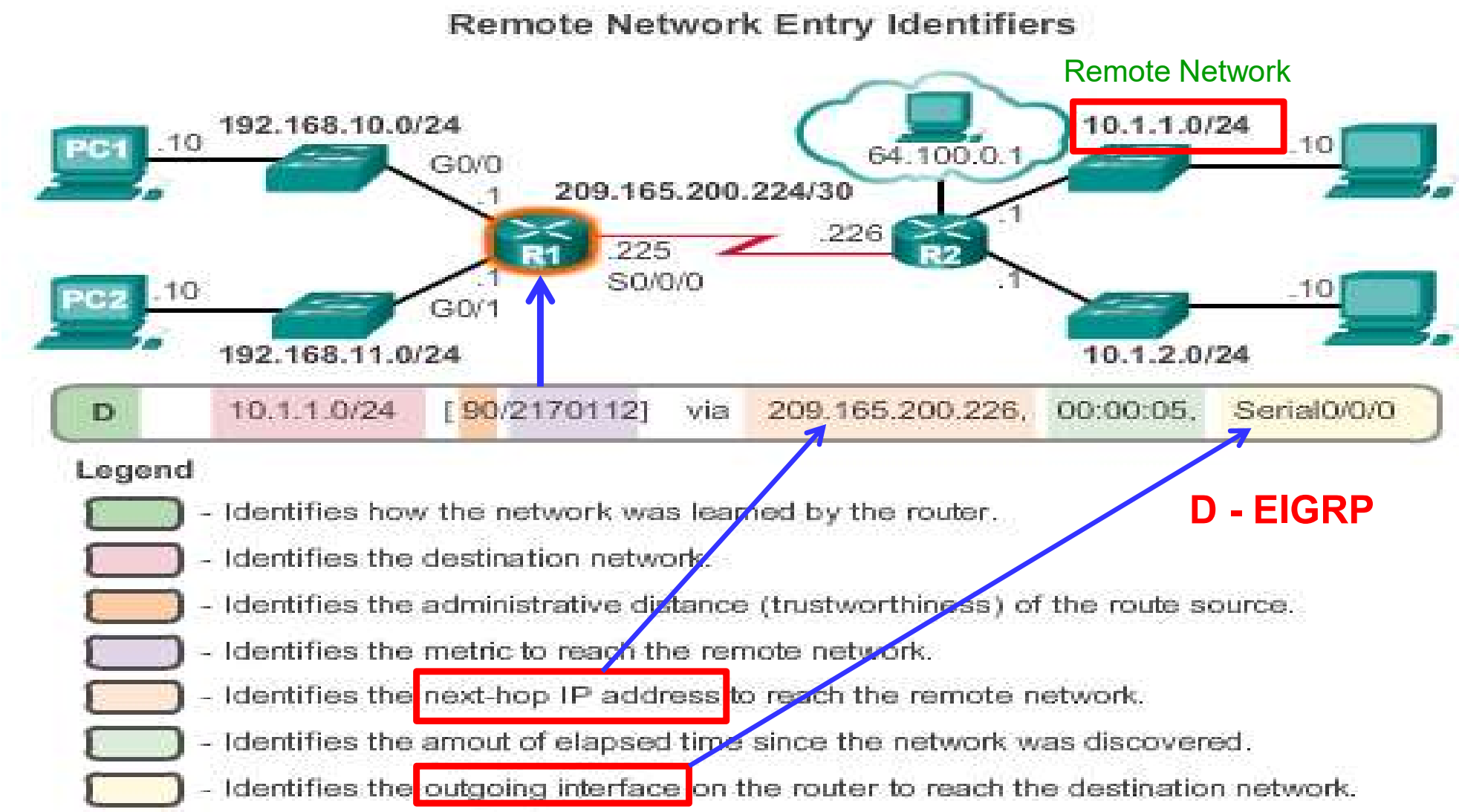
Routing Table Entries –




```
R1#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia -
       IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.1.0/24 [90/2170112] via 209.165.200.226, 00:00:05,
```

Routing Table Entries – R1: Remote Network

Interpreting the **entries** in the routing table.



Routing Table entries

- Administrative Distance
- A route entry for a specific network address (prefix and prefix length) can only appear once in the routing table.
- It is possible that the routing table learns about the same network address from more than one routing source.
- Cisco IOS uses administrative distance (AD) to determine the route to install into the IP routing table.
- The AD represents the "trustworthiness" of the route.
  The lower the AD, the more trustworthy the route source

Route Source	Administrative Distance
Directly connected	0
Static route	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

1.4 Packet Forwarding

- Packet Forwarding Decision Process
- End to End Packet Forwarding

Packet Forwarding Decision Process

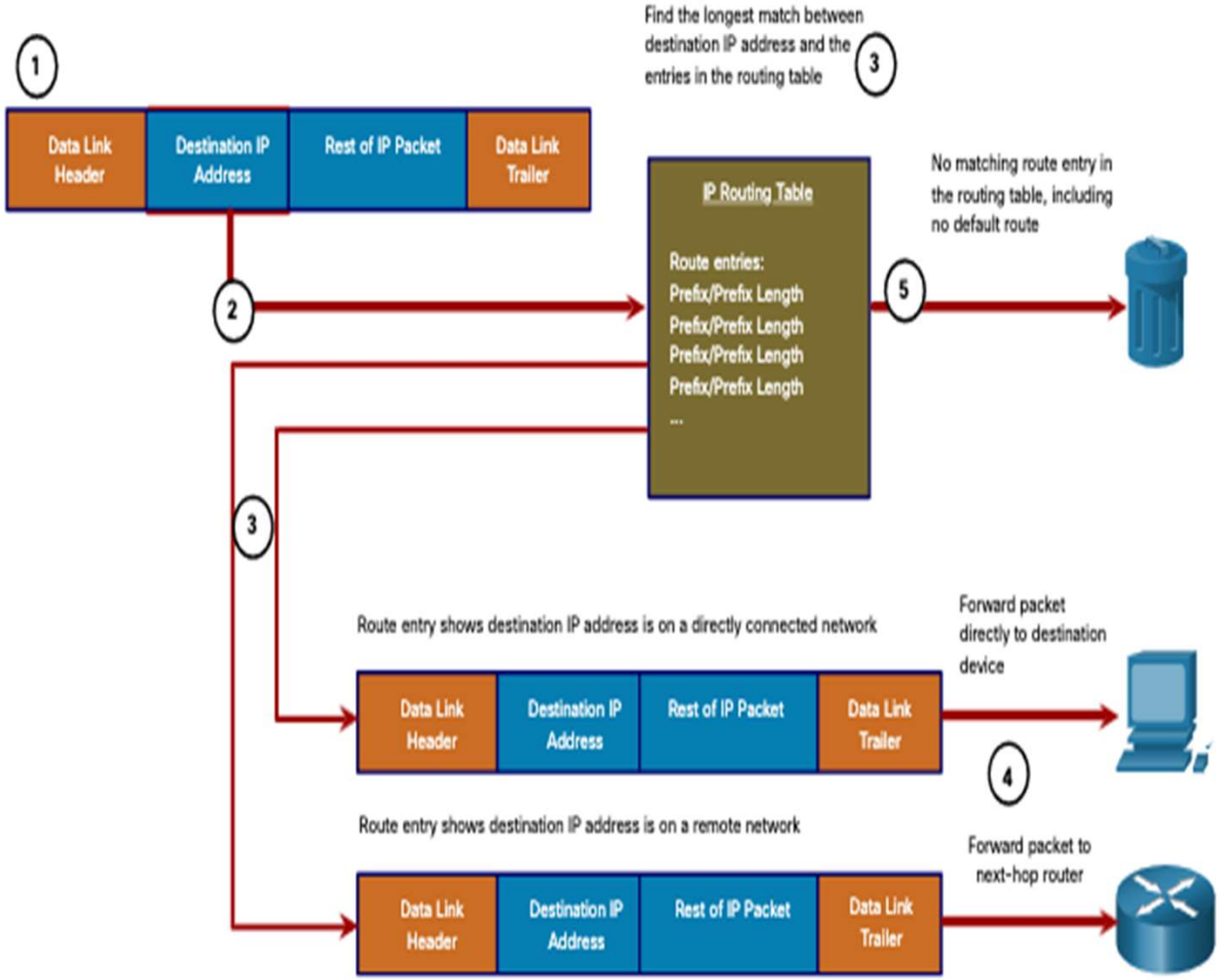
1. The data link frame with an encapsulated IP packet arrives on the ingress interface.

2. The router examines the destination IP address in the packet header and consults its IP routing table.

3. The router finds the longest matching prefix in the routing table.

4. The router encapsulates the packet in a data link frame and forwards it out the egress interface. The destination could be a device connected to the network
(Typically an Ethernet LAN)
or
The destination could be a next-hop router.

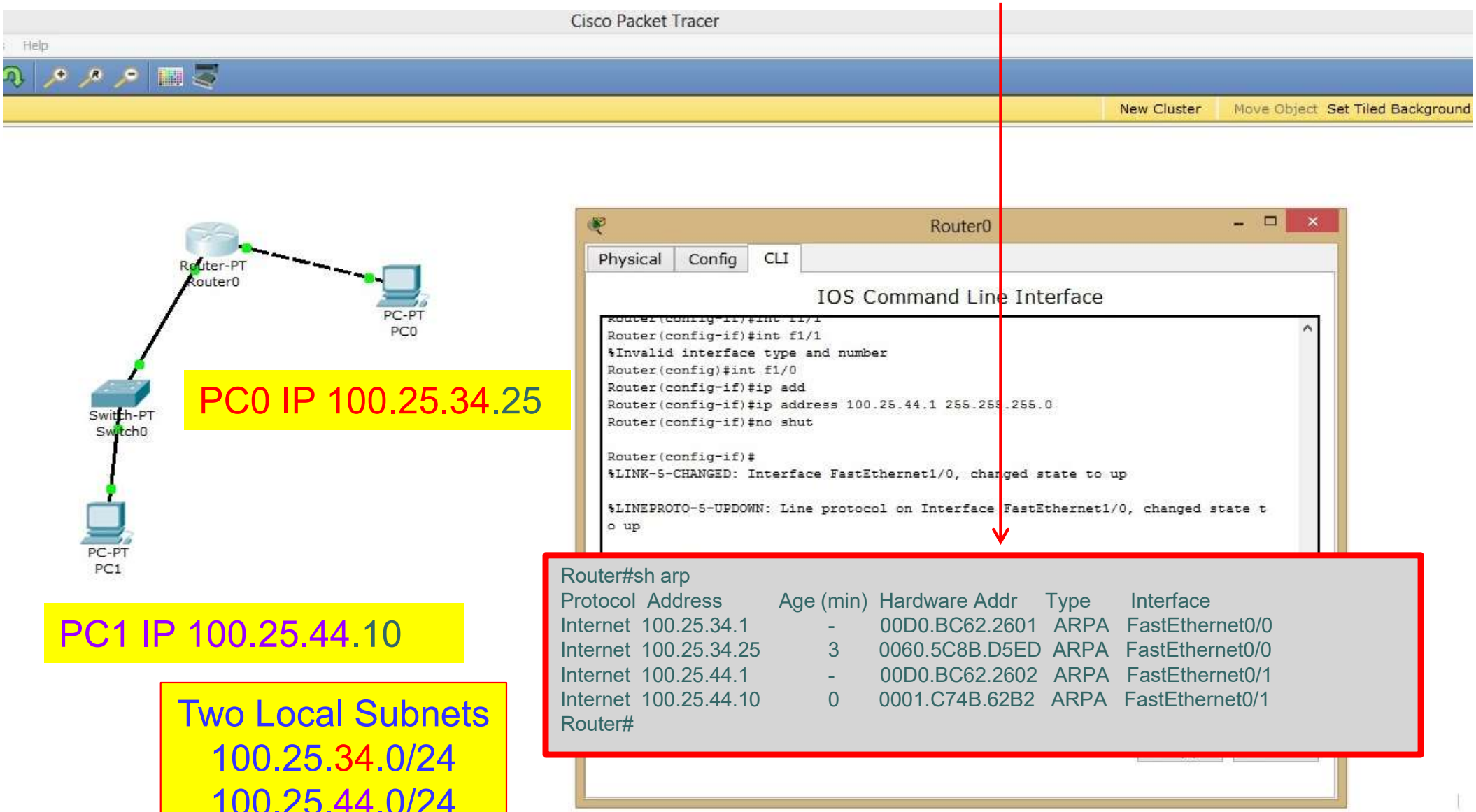
5. However, if there is no matching route entry the packet is dropped.



Router ARP Table – Local Subnets

Forwarding a packet through FastEthernet Interfaces

- Display **ARP Table** on Router - **show arp** (Mapping IP to Mac)



PC ARP Table

- Display **ARP Table** on **PC 0** in Command Window -
- **arp -a**

```
C:\>arp -a
Internet Address      Physical Address      Type
100.25.34.1           00d0.bc62.2601        dynamic
```

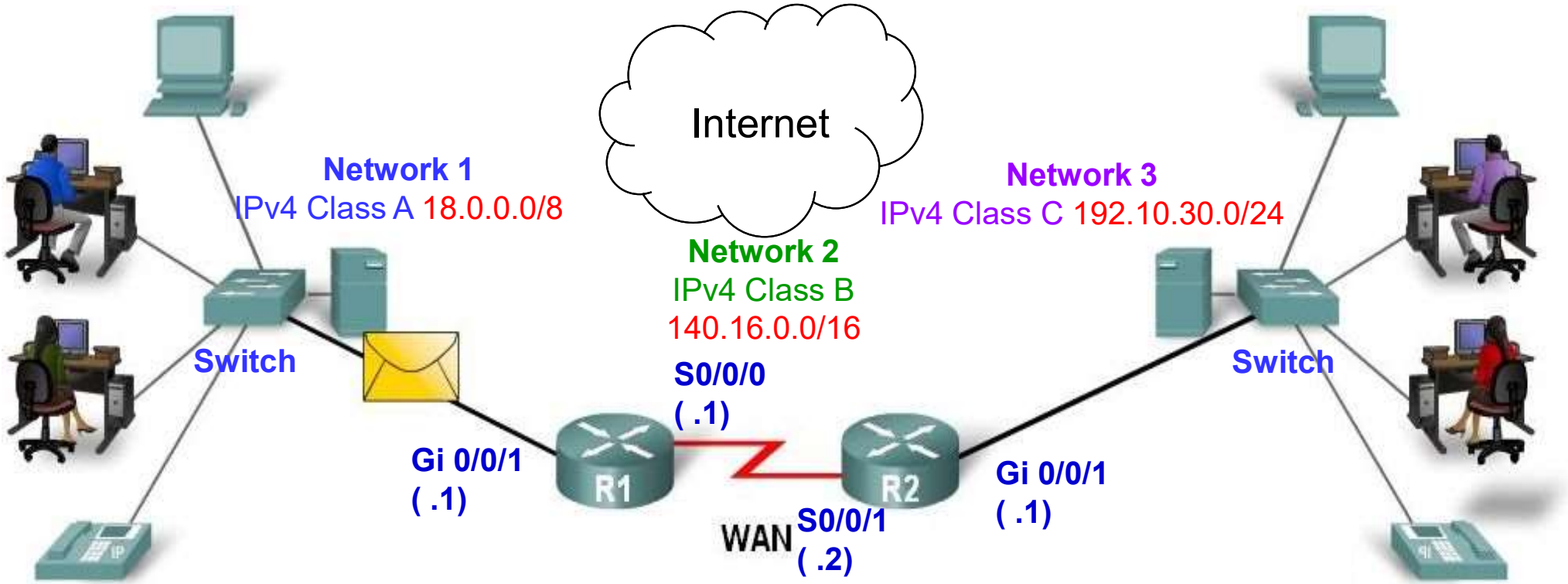
- Display **IP address** on **PC 0** in Command Window -
- **ipconfig /all**

```
C:\>ipconfig /all

FastEthernet0 Connection:(default port)
   Connection-specific DNS Suffix..:
   Physical Address.....: 0060.5C8B.D5ED
   Link-local IPv6 Address.....: FE80::260:5CFF:FE8B:D5ED
   IPv6 Address.....: ::
   IPv4 Address.....: 100.25.34.25
   Subnet Mask.....: 255.255.255.0
   Default Gateway.....: ::
                                100.25.34.1
```

End to End Packet Forwarding

Packet Forwarding function encapsulates the packet in appropriate data link frame type based on outgoing interface e.g. Gig 0/0/1 ethernet frame or Serial 0/0/0 Point to Point (PPP) protocol.



Data Link Frame – depends on Exit interface

1.5 Routing Protocols

- Routing Protocol Characteristics
- Types of Dynamic Routing Protocols

Routing Protocols

Route Table Directly connected networks

- Static Routes to Remote Networks (manually configured)
- Remote Networks (learnt via Dynamic routing protocol)

- A Routing Protocol is a set of processes, algorithms,& messages used to exchange routing information, and populate the routing table with the choice of best paths to remote networks.

The purpose of dynamic routing protocols includes:

- Discover remote networks
- Maintain up-to-date routing information in tables
- Determine least cost paths to destination networks
- Find a new least cost path if the current path is no longer available

- Routing Protocols determine the Best Path (Route) to each network
- Route is offered to the Routing Table. Route only added to Routing Table if there is no alternative 'route source' with lower 'Administrative distance'

Path Determination - Least Cost Path

Path Determination

Determining the best path to a destination network involves evaluation of multiple paths and selecting the optimum or shortest path to reach that network.

Route Table Entries

The best path to a network is the path with the lowest metric.

A metric is a quantitive value assigned to routes

Each dynamic routing protocol has their own rules and metrics to build and update routing tables.

Load Balancing

Routers can distribute packets across same cost paths

Routing Protocol Metrics

- Hop Count: counts the number of routers a (IP) packet must traverse
- Bandwidth: Influences path selection by preferring the path with the highest data capacity.
- Load: Considers the traffic utilization of a link
- Signal Delay: Considers the time a packet takes to traverse a path
- Reliability: Assesses the probability of a link failure or errors

Routing Protocol Metrics

•Dynamic routing protocols typically use their own rules and metrics to build and update routing tables.

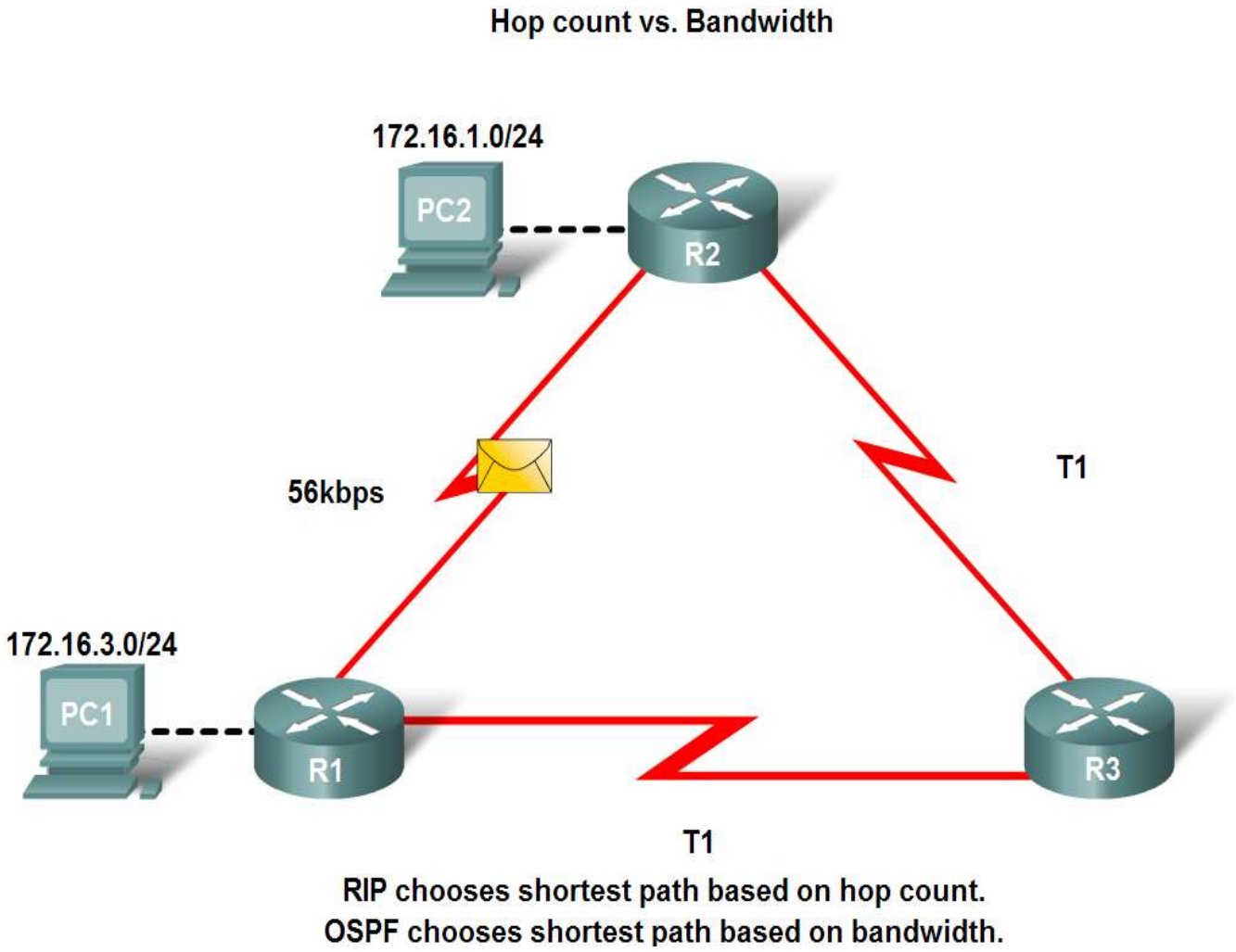
Dynamic Routing Protocol	Metric
•Routing Information Protocol (RIP)	•Metric is “hop count” •Each router along a path adds a hop to the hop count •A maximum of 15 hops
•Open Shortest Path First (OSPF)	•Metric is “cost” based on the cumulative bandwidth. •Faster links are assigned lower costs compared to slower links.
•Enhanced Interior Routing Protocol (EIGRP)	•Metric based on the slowest bandwidth and delay values •Metric calculation could include reliability and load..

Routing Protocol Metrics

Comparing Metrics

RIP
Metric=Hop Count

OSPF
Metric=Cumulative Bandwidth



Types of Dynamic Routing Protocols

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector		Link-State		Path Vector
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	MBGP

Distance Vector protocols

The distance vector routing approach determines the direction (vector) & distance (such as link cost or number of hops) to any link in the network. The only information that a router knows about a remote network is the distance or metric to reach this network and which path or interface to use to get there. Distance vector routing protocols do not have an actual map of the network topology.

Link-State protocols

The link-state approach uses the Shortest Path First (SPF) algorithm to create an abstract of the exact topology of the entire network or at least within its area. A link-state routing protocol is like having a complete map of the network topology. The map is used to determine best path to a destination.

Path Vector protocols

Path information is used to determine the best paths and to prevent routing loops. Similar to distance vector protocols, path vector protocols do not have an abstract of the network topology. Path vector protocols indicate direction and distance, but also include additional information about the specific path of the destination.

Review

1.1 Routing Concepts

- Many Networks
- Router Tasks

1.2 Path Determination

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1.3 Routing Table

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