

TNE20002/TNE70003

Topic 1: Routing





Routers

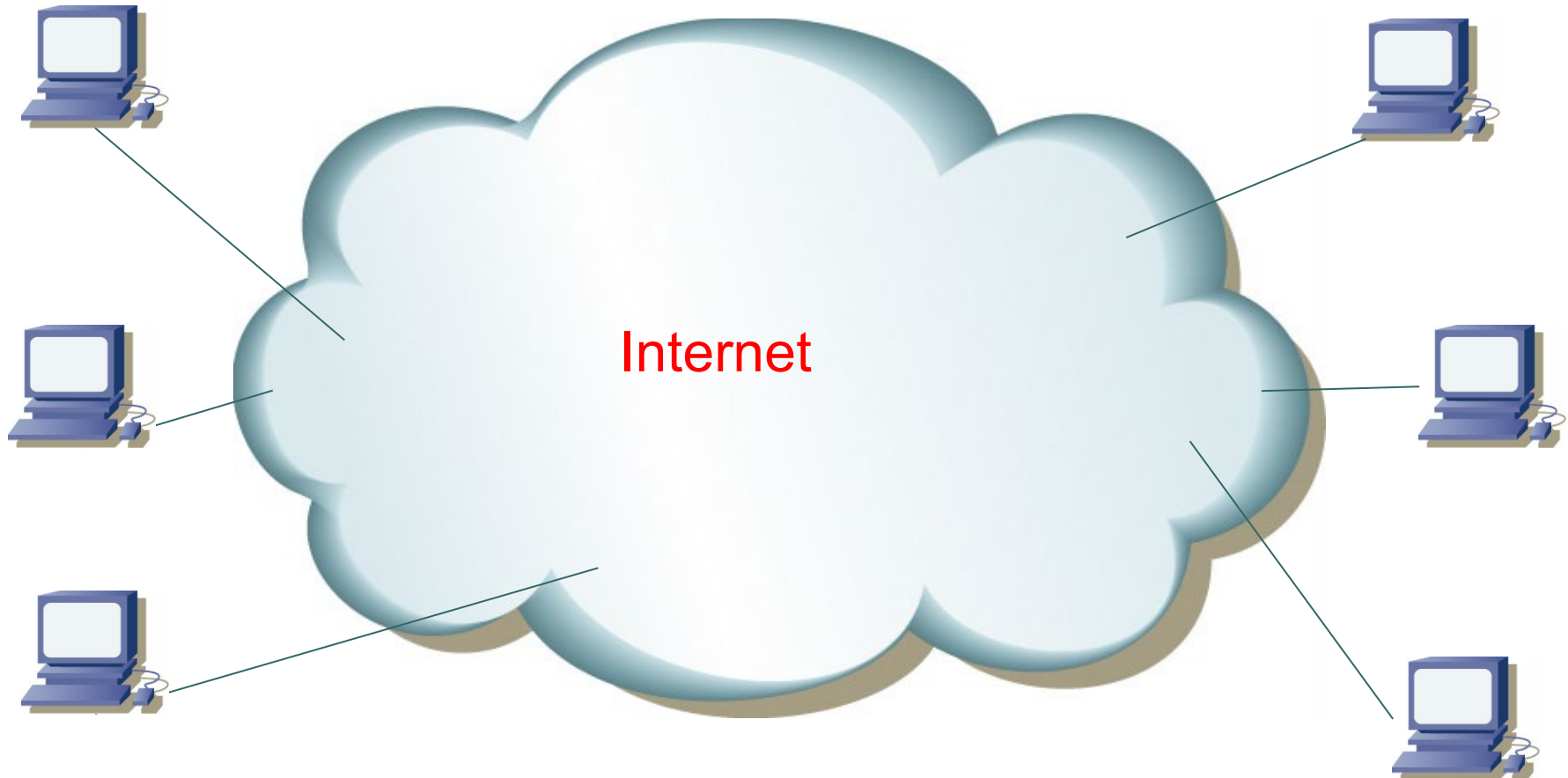
are the

core

of

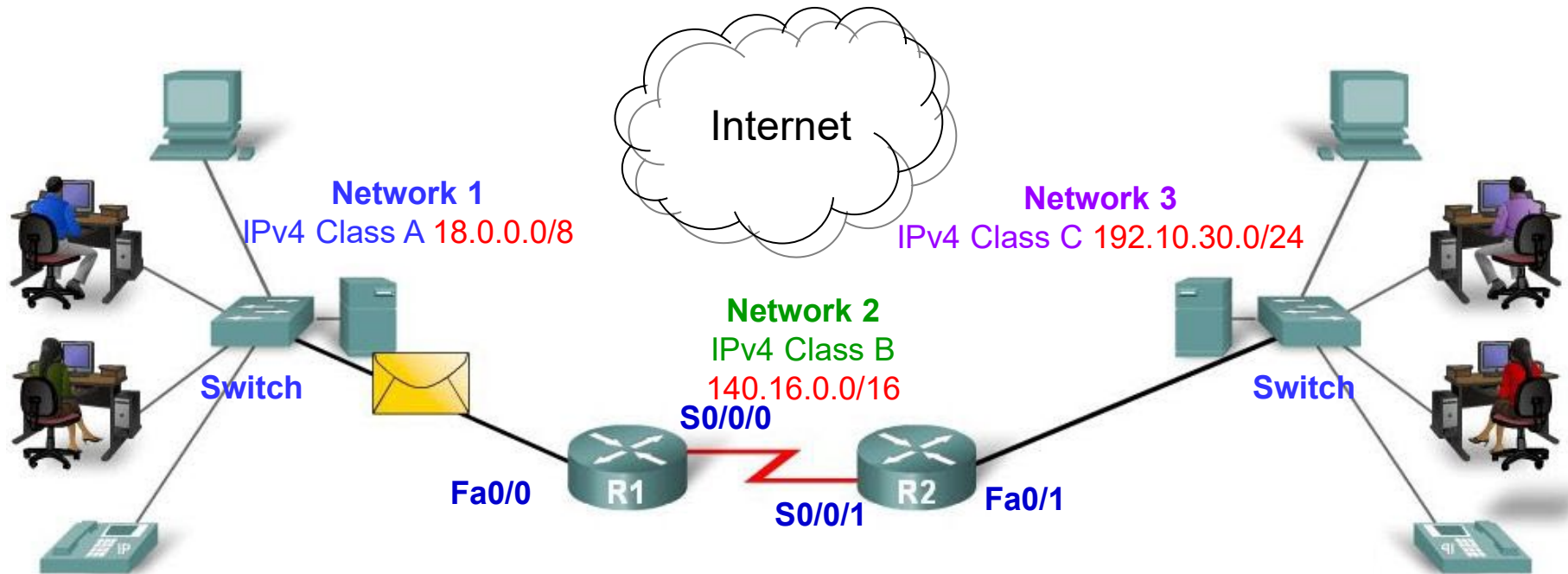
The Internet

- The **Internet** is **too large** to have all hosts together as one network, it is **subdivided**



Routers connect Networks

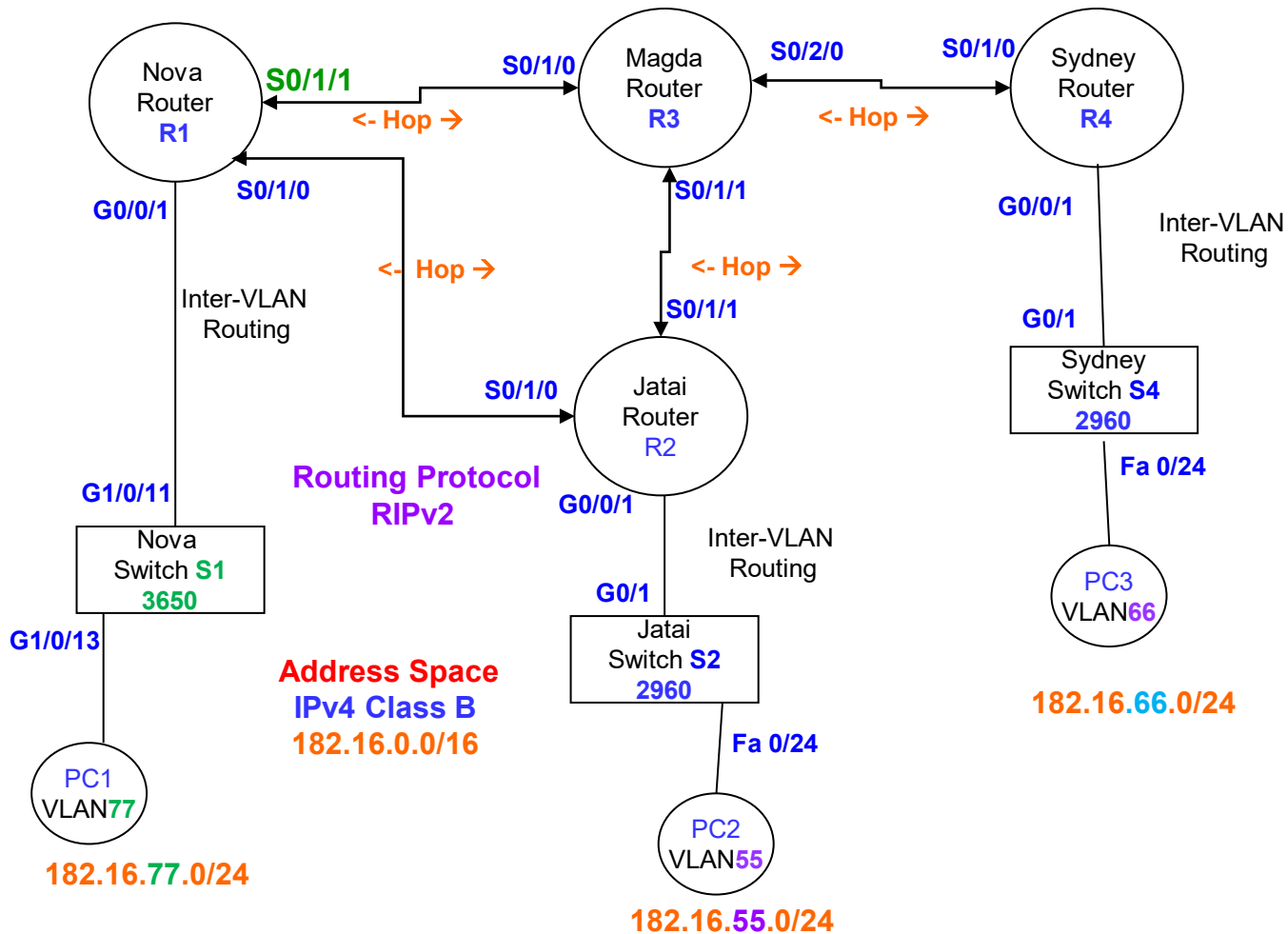
- The **Internet** is subdivided into **many separate** networks.
- Each **router interface** Fa0/0, S0/0/0, etc is a **Gateway** to another a network





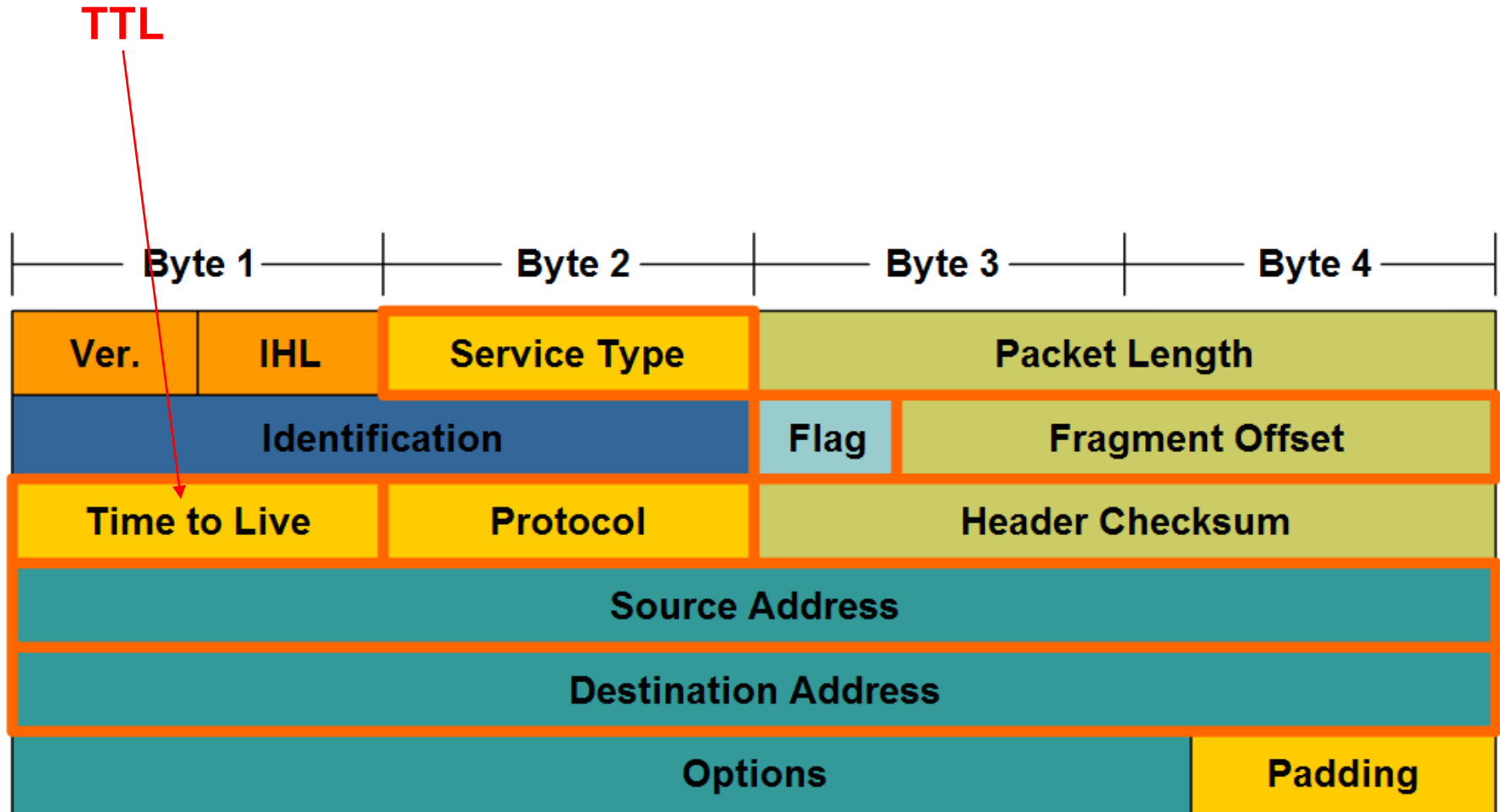
- 1) The router, routes IP packets to the intended destination
- 2) The router, drops IP packets to reduce congestion
 - Setting Time to Live (TTL) to 10 hops, means if the packet cannot reach its destination within 10 hops, it will be dropped
 - When a packet enters a router, deduct 1 from TTL
 - IF TTL = 0 the packet will be dropped

Network Topology





IPv4 Packet Header Fields





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

1. Makes a **Best Match** Decision

- It determines the **Best 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 Match Decision



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

Best Match is the Preferred Route

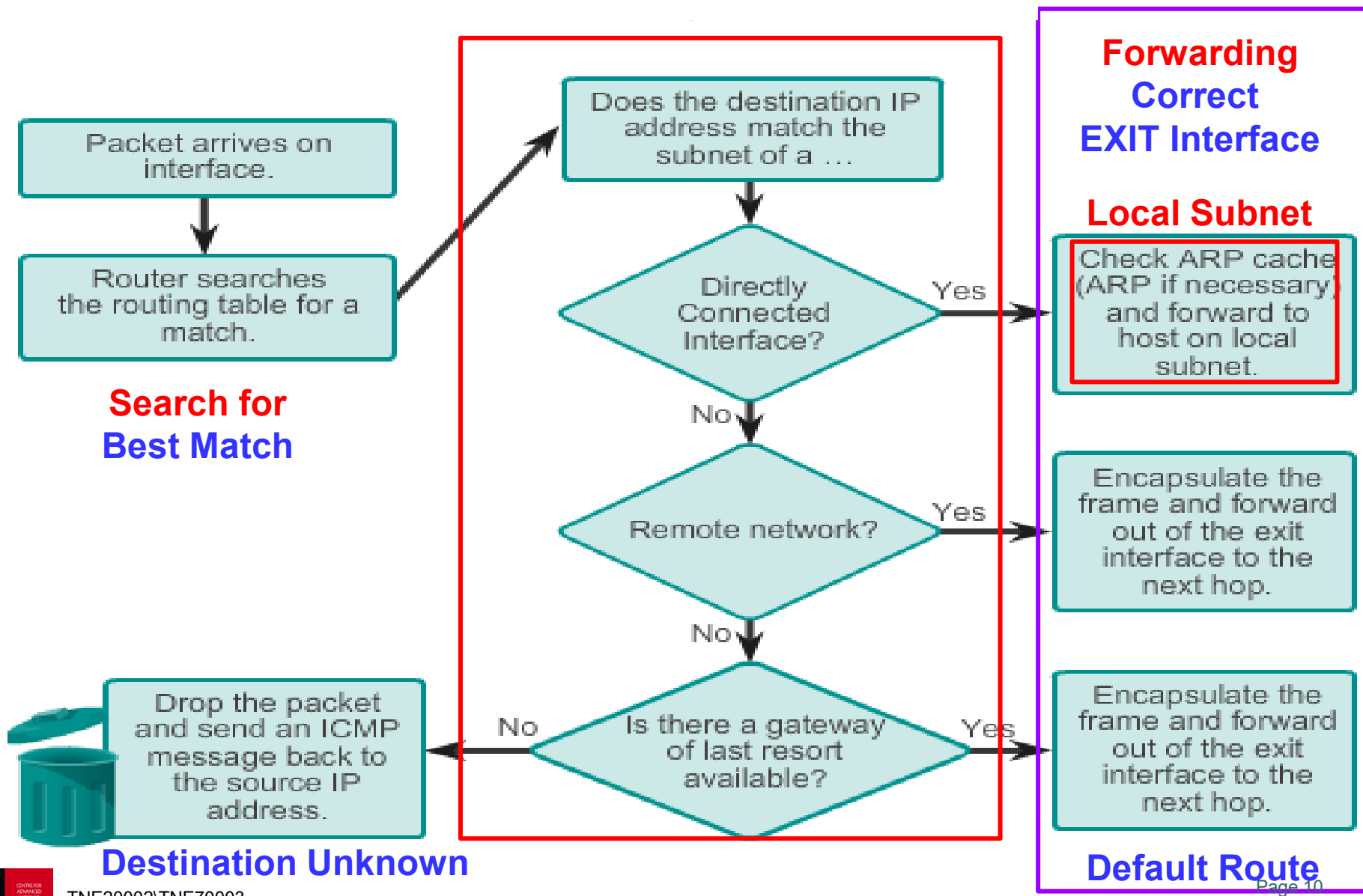
26 bits IP Packet Destination	172.16.0.10	10101100.00010000.00000000.00001010
12 bits Route 1	172.16.0.0/12	10101100.00010000.00000000.00000000
18 bits Route 2	172.16.0.0/18	10101100.00010000.00000000.00000000
26 bits Route 3	172.16.0.0/26	10101100.00010000.00000000.00000000

Best Match to IP Packet Destination

26 bits Match



Routing Decisions – Flow Chart



Router ARP Table – Local Subnets

Forwarding a packet through FastEthernet Interfaces



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

Cisco Packet Tracer

Help

New Cluster Move Object Set Tiled Background

Router-PT Router0

PC-PT PC0

34.25

Switch-PT Switch0

PC-PT PC1

44.10

Two Local Subnets

100.25.34.0/24

100.25.44.0/24

Router0

Physical Config CLI

IOS Command Line Interface

```
Router(config-if)#int f1/1
Router(config-if)#int f1/1
%Invalid interface type and number
Router(config)#int f1/0
Router(config-if)#ip add
Router(config-if)#ip address 100.25.44.1 255.255.255.0
Router(config-if)#no shut

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet1/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up

Router(config-if)#
Router(config-if)#
Router(config-if)#
Router(config-if)#do show arp
```

Protocol	Address	Age (min)	Hardware Addr	Type	Interface
Internet	100.25.34.1	-	0010.112B.5E2C	ARPA	FastEthernet0/0
Internet	100.25.34.25	0	0060.7026.A3C6	ARPA	FastEthernet0/0
Internet	100.25.44.1	-	000A.41DC.7757	ARPA	FastEthernet1/0
Internet	100.25.44.10	0	0090.0CE3.EBB2	ARPA	FastEthernet1/0

Router(config-if)#

Copy Paste

PC ARP Table



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

```
Windows PowerShell
Copyright (C) 2013 Microsoft Corporation. All rights reserved.

PS C:\Users\Peter> arp -a

Interface: 10.0.0.20 --- 0x4
Internet Address      Physical Address      Type
10.0.0.3              e8-40-f2-31-e1-a5    dynamic
10.0.0.6              00-1b-a9-f2-e7-67    dynamic
10.0.0.137            0a-76-ff-4e-d9-b5    dynamic
10.0.0.138            08-76-ff-4e-d9-b5    dynamic
10.0.0.255            ff-ff-ff-ff-ff-ff    static
224.0.0.22            01-00-5e-00-00-16    static
224.0.0.251           01-00-5e-00-00-fb    static
224.0.0.252           01-00-5e-00-00-fc    static
239.255.255.250       01-00-5e-7f-ff-fa    static
239.255.255.253       01-00-5e-7f-ff-fd    static
255.255.255.255       ff-ff-ff-ff-ff-ff    static

PS C:\Users\Peter>
```



The Routing Protocol



Path Determination - Least Cost Path

- The **Least Cost Path** to a given network is determined by a **routing protocol** calculating the **cost**.
- The **cost calculation** can involve a number of **metrics**.
- The **Least Cost Path** to a network is the path with the **lowest cost**.



- **Hop Count**: counts the number of routers a (IP) packet must traverse
- **Bandwidth**: Influences path selection by **preferring** the path with the **highest** bandwidth
- **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**



The
COST
is
calculated
based on the
metrics
used by the
Routing
protocol



Routing Information Protocol

RIP

cost

based on metric

Hop count



Open Shortest Path First

OSPF

cost

based on metric

bandwidth

from source to destination



Enhanced Interior Gateway Routing Protocol

EIGRP

cost

based on metrics

Bandwidth, delay, load, reliability



Routing Table - Least Cost Paths

Only the
Least Cost paths
to given destination networks,
as determined by a routing protocol,
are placed in
the routing table

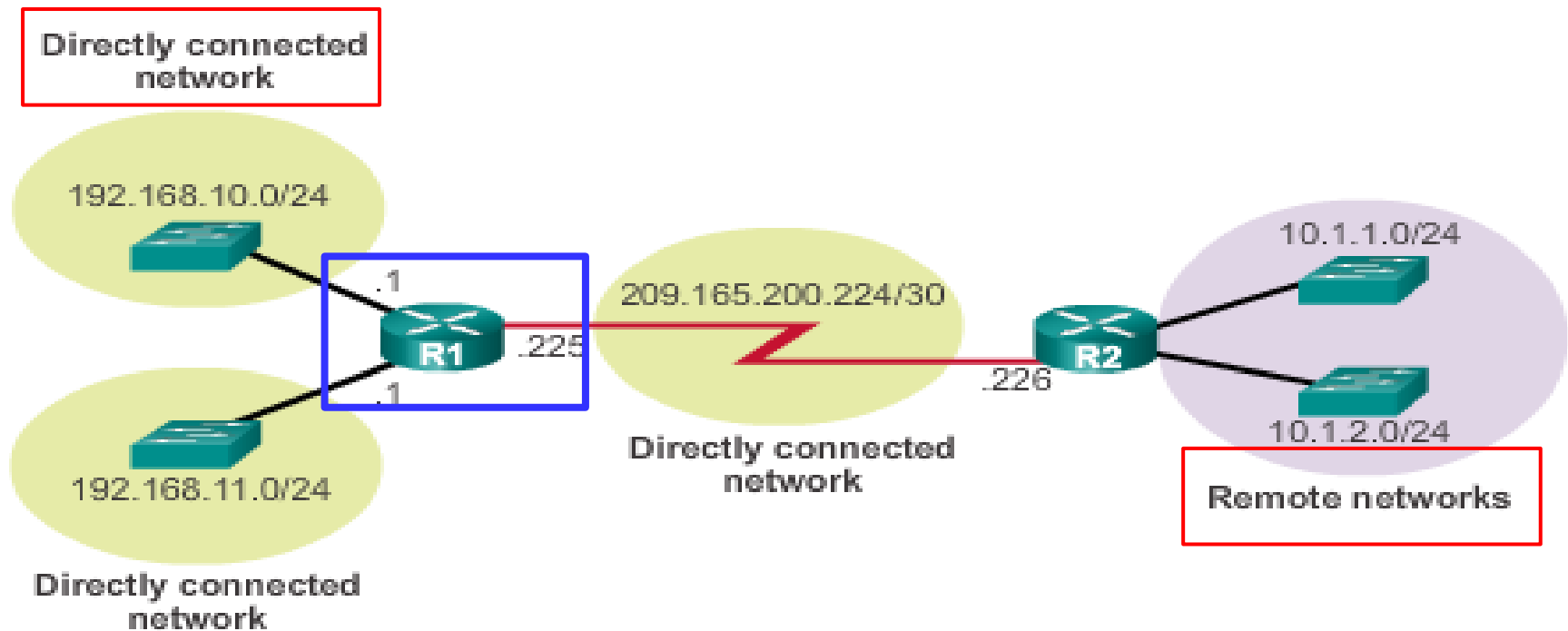


The Routing Table

The Routing Table – R1

A routing **table** for **R1** is a file stored in **RAM** that contains information about:

- **Directly connected** routes
- **Remote** routes (learnt via routing protocol)
- **Next hop** associations



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.

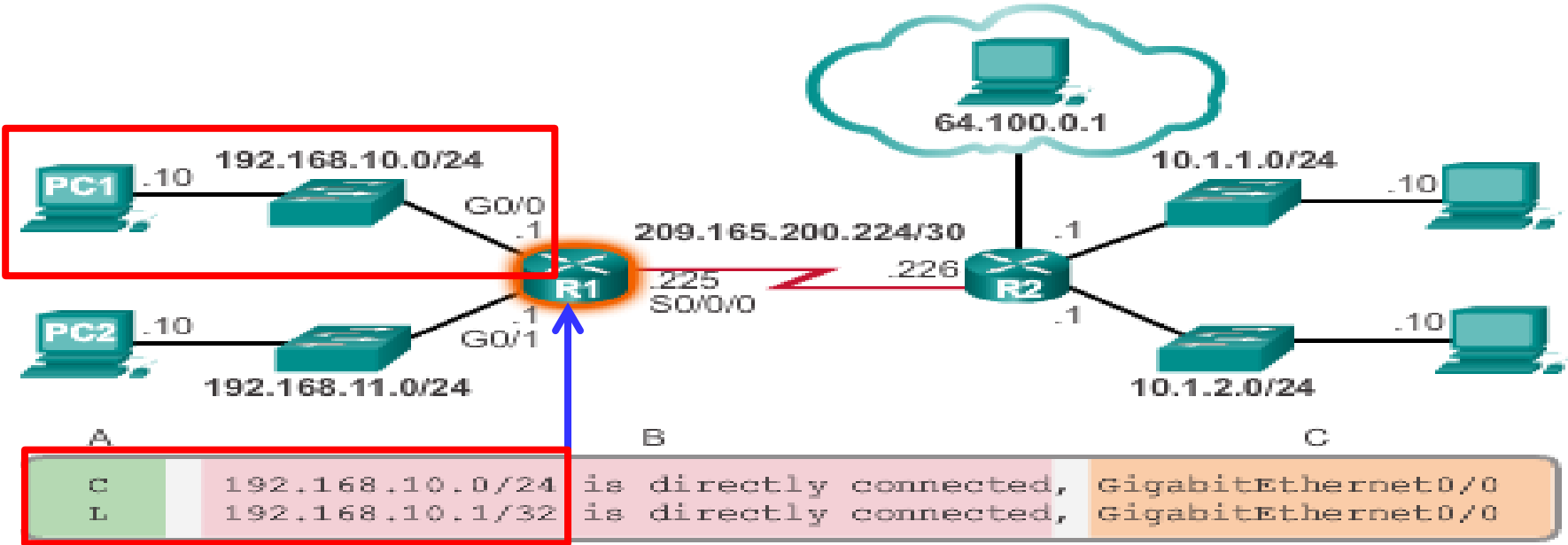
Directly Connected Routes – R1



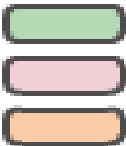
An **active**, configured, directly connected interface creates **two routing table** entries:

- **Link Local (L)** and **Connected (C)**

Directly Connected Network Entry Identifiers



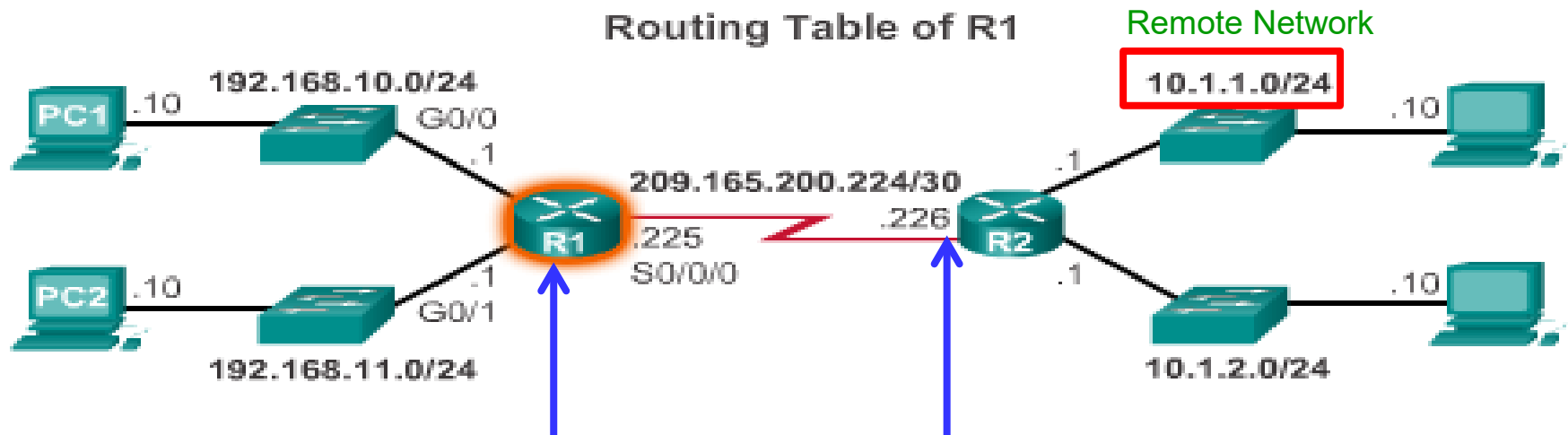
Legend



- Identifies how the network was learned by the router.
- Identifies the destination network and how it is connected.
- Identifies the interface on the router connected to the destination network.



Routing Table Entries – R1: Remote Network



```
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
```

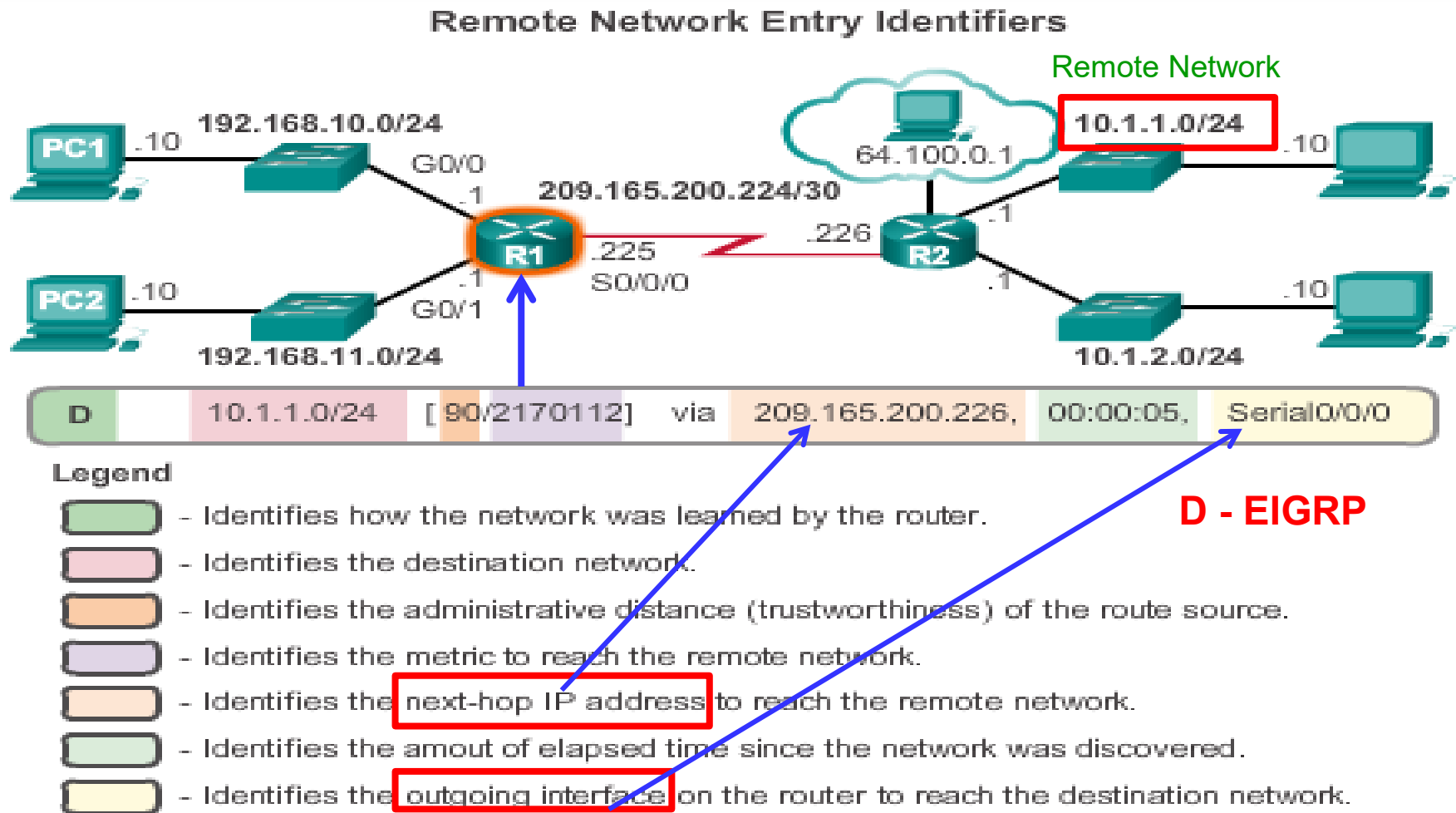
```
10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
```

```
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.





THE END