

# Static and Dynamic Routing - Exploration s Verification

Submitted by:

Jom Joseph

24ubc137

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## PART A - Conceptual Grounding

### STATIC ROUTING

#### 1. What it means to *manually define a route*

Imagine you're giving turn-by-turn directions to a delivery driver.

You don't say "find the best way."

You say:

"Go straight, take the second left, then the highway, then exit 5."

That's exactly what static routing is.

When you manually define a route, you are telling the router:

- *If you want to reach Network X*
- *Send the packet through THIS next router*
- *No thinking, no checking alternatives*

The router does zero discovery.

It doesn't ask neighbours.

It doesn't learn from traffic.

It simply follows your instructions, every time.

You, the engineer, become the "brain" of the network.

## 2. Why static routes feel predictable but fragile

### Why they feel predictable

Static routes are comforting because:

- Traffic always takes the same path
- There are no surprises
- Troubleshooting is easy:
  - "Why did the packet go there?"  
→ Because I told it to

This makes them great for learning and for controlled environments.

### Why they are fragile

Now imagine that delivery route again.

What happens if:

- A road is closed?
- The highway is under construction?

The driver will still follow your directions — and get stuck.

That's static routing.

If:

- A link goes down
- A router fails
- A cable is unplugged

The static route:

- Does not change
- Does not reroute
- Does not warn you

Packets are silently dropped until a human fixes it.

So static routing is:

- Predictable
- Not resilient

It assumes the network never changes — which is rarely true.

### **3. Where static routing makes sense in real networks**

**Static routing is not “bad” — it’s just situational.**

#### **1. Small, simple networks**

Example:

- One router
- One ISP
- One path to the internet

Here, static routing is perfect:

- No complexity
- Nothing dynamic is needed
- Less CPU and memory usage

## 2. Edge or stub networks

A *stub network* is one that:

- Has only one way out

Example:

- A branch office connected to HQ
- A home router connected to ISP

Since there's no alternative path, dynamic routing adds no value.

Static route = clean and efficient.

## 3. Default routes (very common)

Most routers use a static default route:

"If you don't know where to send the packet — send it to the ISP"

This is static routing used intentionally and safely.

## 4. Security-sensitive paths

In some cases:

- You *don't want* the router to learn new paths
- You want strict control over traffic flow

Static routes:

- Prevent unexpected routing changes
- Reduce attack surfaces

## 2. Dynamic Routing - Letting Routers Learn

### 1. What changes when routers exchange routing information

With dynamic routing, routers stop being **obedient followers** and start becoming **decision-makers**.

Instead of you manually telling each router:

“Send traffic this way”

Routers begin to:

- Talk to their neighbours
- Share what networks they can reach
- Learn multiple possible paths
- Update their decisions over time

Think of it like **GPS navigation**.

Instead of fixed directions:

- The router asks: “*Who can get me there?*”
- Compares options
- Chooses the best available path
- Changes routes if conditions change

So the biggest change is this:

**The network starts adapting on its own, without human intervention.**

## 2. Why dynamic routing protocols exist

Static routing assumes:

- Links never fail
- Topology never changes
- Engineers are always watching

Real networks don't behave that way.

Dynamic routing protocols exist because:

- Networks grow large
- Links go up and down
- Devices fail
- Traffic patterns change

Manually updating routes in such environments becomes:

- Slow
- Error-prone
- Impossible at scale

Dynamic routing was created to **remove humans from constant route management** and let routers:

- Discover paths automatically
- Keep routing tables updated
- React faster than any person could

In short:

Dynamic routing exists because **networks are living systems**, not static diagrams.

### **3. What problems dynamic routing solves that static routes cannot**

#### **1. Automatic failure recovery**

If a link goes down:

- Static route → traffic dies
- Dynamic routing → routers detect the failure and **find another path**

This happens in seconds, sometimes milliseconds — no engineer required.

#### **2. Scalability**

In small networks, static routes are manageable.

In large networks:

- Hundreds of routers
- Thousands of networks

Manually defining routes would be a nightmare.

Dynamic routing:

- Learns routes automatically
- Distributes knowledge across the network
- Scales without exponential manual work

#### **3. Path selection and optimization**

Static routing:

- One path, whether it's good or bad

Dynamic routing:

- Multiple paths available
- Chooses better ones based on conditions
- Can shift traffic away from congestion or failures

The network becomes **responsive**, not rigid.

## 4. Reduced operational risk

Static routing relies heavily on:

- Human accuracy
- Manual updates
- Perfect documentation

Dynamic routing reduces:

- Configuration mistakes
- Forgotten routes
- Long outages caused by slow reaction times

Routers continuously **correct themselves**.

## Static vs Dynamic - A Thought Comparison

### Which one scales better?

Dynamic routing scales far better. As a network grows, static routing grows linearly with human effort — every new network or path requires manual updates on multiple routers. This quickly becomes unmanageable.

Dynamic routing scales because routers share knowledge automatically. Adding new networks doesn't require reconfiguring every device; the information propagates on its own. That's why large enterprise and ISP networks depend on dynamic routing.

### **Which one fails faster?**

**Static routing fails faster.** When a link or router goes down:

- Static routing keeps sending traffic into a dead path
- There is no correction or fallback
- Communication stops immediately

Dynamic routing may briefly reconverge, but it detects failures and adapts, often restoring connectivity without any human involvement. Static routing fails silently and stays broken until someone intervenes.

### **Which one requires more human effort?**

**Static routing requires more continuous human effort.**

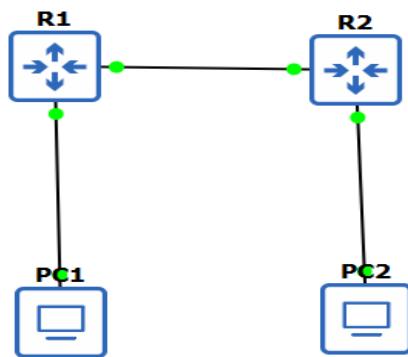
It may look simple at first, but:

- Every topology change needs manual updates
  - Troubleshooting depends on human awareness
  - Mistakes are easy and costly
- Dynamic routing requires more planning initially, but far less day-to-day effort. Once configured, routers handle discovery, updates, and recovery themselves.

## PART B - Static Routing Lab

### Circuit

Description: The topology consists of interconnected routers and LANs designed to demonstrate routing behavior. This setup helps analyze communication between different networks.



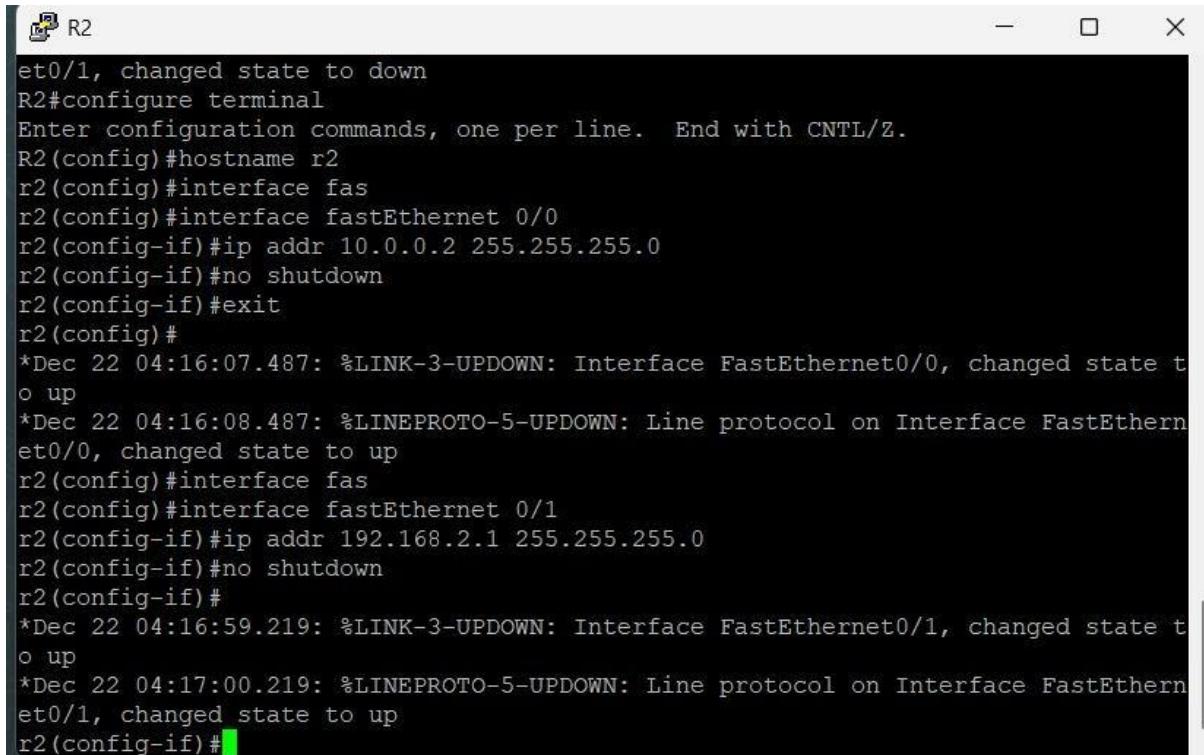
### Assigning IP's to 2 Router

```
R1#config terminal
Enter configuration commands, one per line. End with CNTL/Z.
R1(config)#interface fastethernet 0/1
R1(config-if)#ip addr 10.0.0.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#
*Feb 26 09:12:28.639: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Feb 26 09:12:29.639: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
R1(config-if)#interface fastethernet 0/0
R1(config-if)#ip addr 192.168.1.1 255.255.255.0
R1(config-if)#no shutdown
R1(config-if)#
*Feb 26 09:16:12.299: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Feb 26 09:16:13.299: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
R1(config-if)#[
```

Description: Router R1 was configured with appropriate IP addresses for its LAN interface and the inter-router link to ensure proper connectivity.

## R2

Description: Router R2 was assigned IP addresses for its LAN and the link connecting to Router R1, completing the addressing configuration.



A terminal window titled "R2" showing configuration commands. The window includes standard window controls (minimize, maximize, close) at the top right. The text area contains the following configuration:

```
et0/1, changed state to down
R2#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#hostname r2
r2(config)#interface fas
r2(config)#interface fastEthernet 0/0
r2(config-if)#ip addr 10.0.0.2 255.255.255.0
r2(config-if)#no shutdown
r2(config-if)#exit
r2(config)#
*Dec 22 04:16:07.487: %LINK-3-UPDOWN: Interface FastEthernet0/0, changed state to up
*Dec 22 04:16:08.487: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
r2(config)#interface fas
r2(config)#interface fastEthernet 0/1
r2(config-if)#ip addr 192.168.2.1 255.255.255.0
r2(config-if)#no shutdown
r2(config-if)#
*Dec 22 04:16:59.219: %LINK-3-UPDOWN: Interface FastEthernet0/1, changed state to up
*Dec 22 04:17:00.219: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/1, changed state to up
r2(config-if)#[
```

## PING from PC1

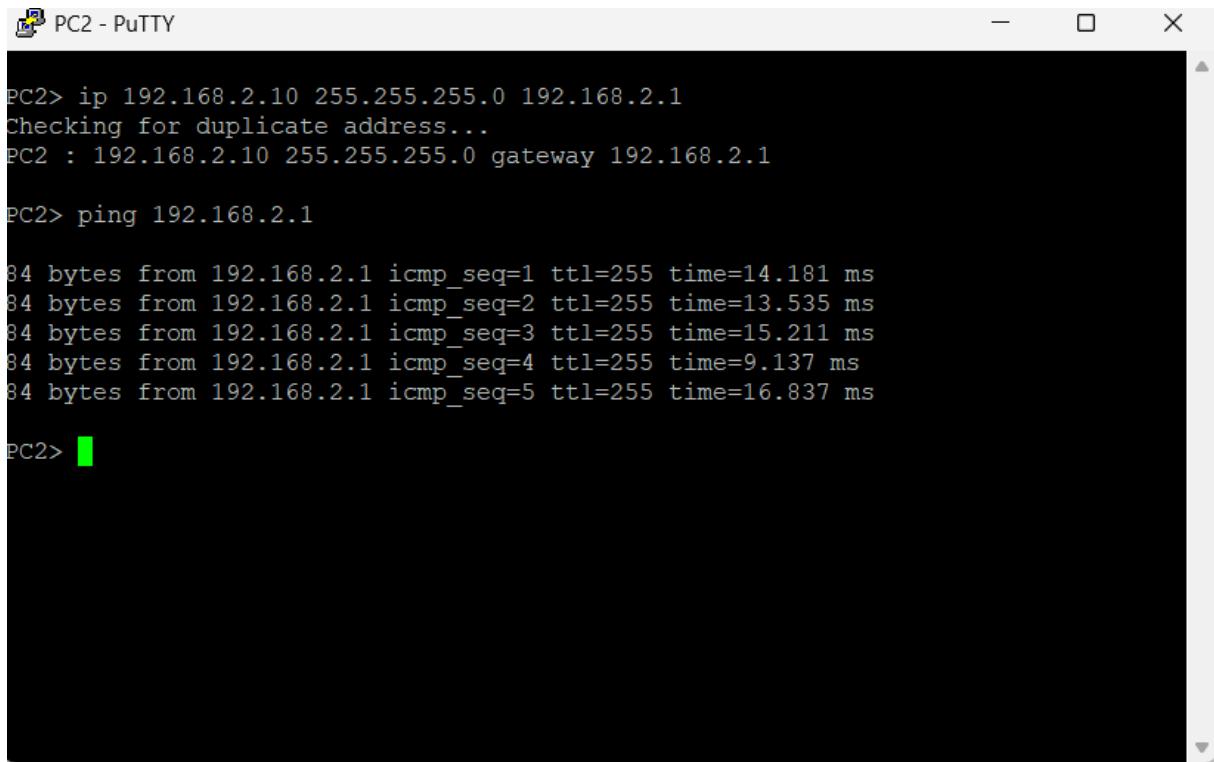
Description: A ping test from PC1 was performed to verify connectivity. Initial results showed communication with the gateway but not with the remote LAN until routing was configured.

PC1 - PuTTY

```
VPCS is free software, distributed under the terms of the "BSD" licence.  
Source code and license can be found at vpcs.sf.net.  
For more information, please visit wiki.freecode.com.cn.  
  
Press '?' to get help.  
  
Executing the startup file  
  
PC1> ip 192.168.1.10 255.255.255.0 192.168.1.1  
Checking for duplicate address...  
PC1 : 192.168.1.10 255.255.255.0 gateway 192.168.1.1  
  
PC1> ping 192.168.1.1  
  
84 bytes from 192.168.1.1 icmp_seq=1 ttl=255 time=202.983 ms  
84 bytes from 192.168.1.1 icmp_seq=2 ttl=255 time=33.735 ms  
84 bytes from 192.168.1.1 icmp_seq=3 ttl=255 time=24.944 ms  
84 bytes from 192.168.1.1 icmp_seq=4 ttl=255 time=29.315 ms  
84 bytes from 192.168.1.1 icmp_seq=5 ttl=255 time=38.565 ms  
  
PC1> ping 192.168.2.1
```

## From PC2

Description: A ping from PC2 confirmed local connectivity. Communication with the remote network failed before routing entries were added.



A screenshot of a PuTTY terminal window titled "PC2 - PuTTY". The window shows the following command-line session:

```
PC2> ip 192.168.2.10 255.255.255.0 192.168.2.1
Checking for duplicate address...
PC2 : 192.168.2.10 255.255.255.0 gateway 192.168.2.1

PC2> ping 192.168.2.1

84 bytes from 192.168.2.1 icmp_seq=1 ttl=255 time=14.181 ms
84 bytes from 192.168.2.1 icmp_seq=2 ttl=255 time=13.535 ms
84 bytes from 192.168.2.1 icmp_seq=3 ttl=255 time=15.211 ms
84 bytes from 192.168.2.1 icmp_seq=4 ttl=255 time=9.137 ms
84 bytes from 192.168.2.1 icmp_seq=5 ttl=255 time=16.837 ms

PC2> █
```

## From PC1 to R1

(Unreachable)

Description: This output indicates that packets to the remote network were dropped due to missing route entries in the routing table.

 PC1 - PuTTY  
PC1 : 192.168.1.10 255.255.255.0 gateway 192.168.1.1  
PC1> ping 192.168.1.1  
84 bytes from 192.168.1.1 icmp\_seq=1 ttl=255 time=202.983 ms  
84 bytes from 192.168.1.1 icmp\_seq=2 ttl=255 time=33.735 ms  
84 bytes from 192.168.1.1 icmp\_seq=3 ttl=255 time=24.944 ms  
84 bytes from 192.168.1.1 icmp\_seq=4 ttl=255 time=29.315 ms  
84 bytes from 192.168.1.1 icmp\_seq=5 ttl=255 time=38.565 ms  
  
PC1> ping 192.168.2.1  
\*192.168.1.1 icmp\_seq=1 ttl=255 time=29.463 ms (ICMP type:3, code:1, Destination host unreachable)  
\*192.168.1.1 icmp\_seq=2 ttl=255 time=10.489 ms (ICMP type:3, code:1, Destination host unreachable)  
\*192.168.1.1 icmp\_seq=3 ttl=255 time=13.838 ms (ICMP type:3, code:1, Destination host unreachable)  
\*192.168.1.1 icmp\_seq=4 ttl=255 time=6.990 ms (ICMP type:3, code:1, Destination host unreachable)  
\*192.168.1.1 icmp\_seq=5 ttl=255 time=17.414 ms (ICMP type:3, code:1, Destination host unreachable)  
  
PC1> █

S

## **Routing Table Before Static Routes**

Before configuring static routes, the routing table contained only directly connected networks.

On Router 1, the table showed:

- The local LAN network 192.168.1.0/24
- The router-to-router link 10.0.0.0/30

There was no entry for the remote LAN (192.168.2.0/24). Because of this, Router 1 had no knowledge of where to send packets destined for PC2's network, and communication between the two LANs failed.

## **Routing Table After Static Routes**

After adding static routes on both routers:

- Router 1 learned how to reach 192.168.2.0/24 via Router 2
- Router 2 learned how to reach 192.168.1.0/24 via Router 1

The routing table now included static (S) routes pointing to the next-hop IP address.

With this information available, routers were able to forward packets correctly, and end-to-end connectivity between PC1 and PC2 was successful.

## **What Happens If a Static Route Is Removed?**

When a static route is removed:

- The router immediately loses knowledge of the remote network
- Packets destined for that network are dropped
- Communication between the LANs fails again

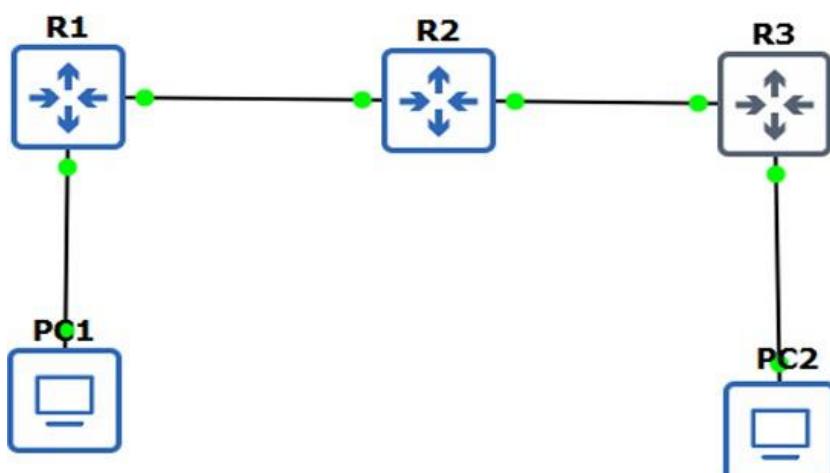
This shows that static routing depends entirely on manual configuration and does not provide automatic recovery.

## PART C - Dynamic Routing Lab

- A network topology with multiple routers and LANs was created using GNS3.
- IP addresses were assigned to all router interfaces and end devices.
- Basic connectivity between PCs and their default gateways was verified. • Static routing was first tested to understand manual route configuration.
- Dynamic routing using RIP was enabled on all routers.
- Routers automatically learned routes to remote networks through RIP.
- End-to-end connectivity between PCs was successfully verified.
- A link failure was simulated by shutting down a router interface.
- Routing tables updated automatically and connectivity was affected

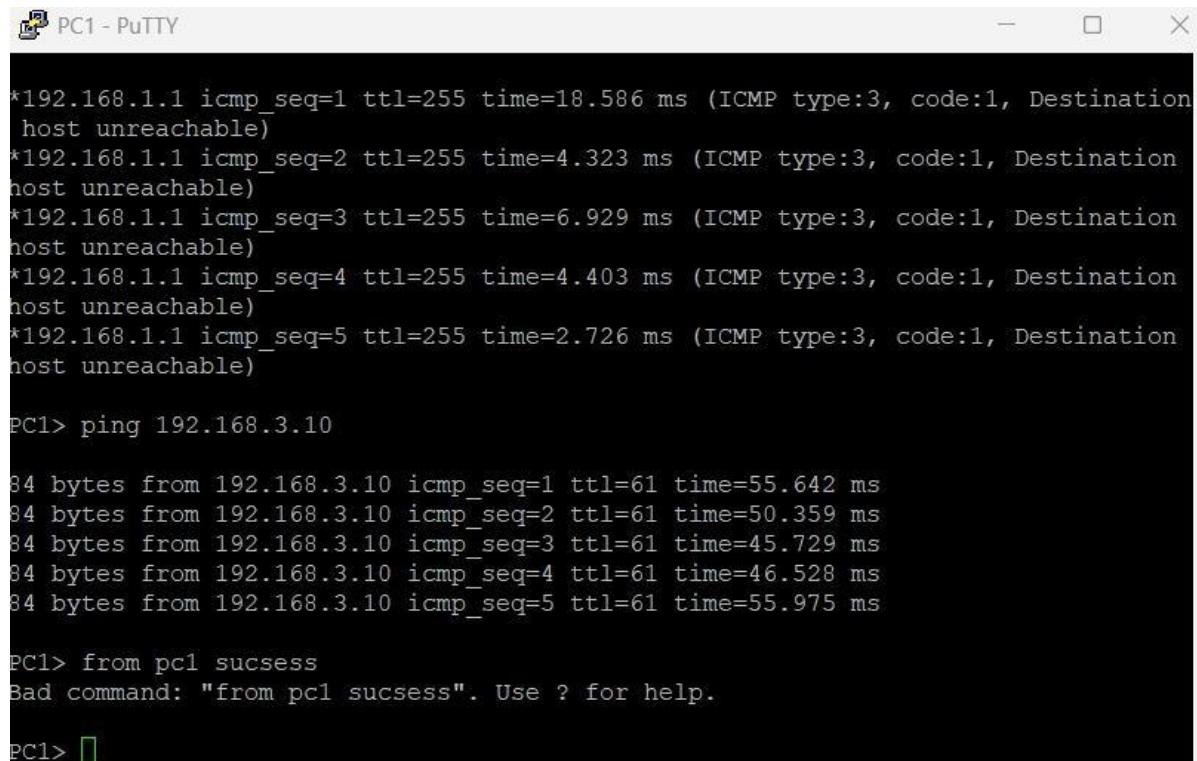
### Circuit

Description: The topology consists of interconnected routers and LANs designed to demonstrate routing behavior. This setup helps analyze communication between different networks.



## PING from PC1

Description: A ping test from PC1 was performed to verify connectivity. Initial results showed communication with the gateway but not with the remote LAN until routing was configured.



```
*192.168.1.1 icmp_seq=1 ttl=255 time=18.586 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.1.1 icmp_seq=2 ttl=255 time=4.323 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.1.1 icmp_seq=3 ttl=255 time=6.929 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.1.1 icmp_seq=4 ttl=255 time=4.403 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.1.1 icmp_seq=5 ttl=255 time=2.726 ms (ICMP type:3, code:1, Destination host unreachable)

PC1> ping 192.168.3.10

84 bytes from 192.168.3.10 icmp_seq=1 ttl=61 time=55.642 ms
84 bytes from 192.168.3.10 icmp_seq=2 ttl=61 time=50.359 ms
84 bytes from 192.168.3.10 icmp_seq=3 ttl=61 time=45.729 ms
84 bytes from 192.168.3.10 icmp_seq=4 ttl=61 time=46.528 ms
84 bytes from 192.168.3.10 icmp_seq=5 ttl=61 time=55.975 ms

PC1> from pc1 sucesss
Bad command: "from pc1 sucesss". Use ? for help.

PC1>
```

## Show IP Routes

Description: The routing table output displays directly connected routes and dynamically learned routes, confirming successful route exchange.

R1

```
FastEthernet0/1      10.0.0.1      YES manual up      up
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
      i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISPs
      a - application route
      + - replicated route, % - next hop override

Gateway of last resort is not set

  10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
C    10.0.0.0/30 is directly connected, FastEthernet0/1
L    10.0.0.1/32 is directly connected, FastEthernet0/1
R    10.0.0.4/30 [120/1] via 10.0.0.2, 00:00:21, FastEthernet0/1
  192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.1.0/24 is directly connected, FastEthernet0/0
L    192.168.1.1/32 is directly connected, FastEthernet0/0
R    192.168.3.0/24 [120/2] via 10.0.0.2, 00:00:21, FastEthernet0/1
R1#
```

```

R3#
R3#
R3#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
      i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
      a - application route
      + - replicated route, % - next hop override

Gateway of last resort is not set

  10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
R    10.0.0.0/30 [120/1] via 10.0.0.5, 00:00:26, FastEthernet0/0
C    10.0.0.4/30 is directly connected, FastEthernet0/0
L    10.0.0.6/32 is directly connected, FastEthernet0/0
R    192.168.1.0/24 [120/2] via 10.0.0.5, 00:00:26, FastEthernet0/0
      192.168.3.0/24 is variably subnetted, 2 subnets, 2 masks
C    192.168.3.0/24 is directly connected, FastEthernet0/1
L    192.168.3.1/32 is directly connected, FastEthernet0/1
R3#

```

## Shutdown Interface in R2

Description: The interface shutdown simulated a link failure. The routing protocol detected the failure and updated the routing table automatically.

```

R2#config terminal
Enter configuration commands, one per line. End with CNTL/Z.
R2(config)#interface f
R2(config)#interface fastEthernet 0/1
R2(config-if)#shutdown
R2(config-if)#exit
R2(config)#
*Dec 22 05:56:00.735: %LINK-5-CHANGED: Interface FastEthernet0/1, changed state
to administratively down
*Dec 22 05:56:01.735: %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthern
et0/1, changed state to down
R2(config)#

```

```

R2#
^
% Invalid input detected at '^' marker.

R2(config)#exit
R2#show ip interface brief
*Dec 22 05:24.967: %SYS-5-CONFIG_I: Configured from console by console
R2#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
      i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
      a - application route
      + - replicated route, % - next hop override

Gateway of last resort is not set

  10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C    10.0.0.0/30 is directly connected, FastEthernet0/0
L    10.0.0.2/32 is directly connected, FastEthernet0/0
R    192.168.1.0/24 [120/1] via 10.0.0.1, 00:00:10, FastEthernet0/0
R2#

```

## PART D - Static vs Dynamic Routing in Practice

### How routing tables differed between static and dynamic routing

In static routing, the routing table contained only directly connected networks and manually configured static routes. No new routes appeared unless they were added by the administrator. In dynamic routing, the routing table was populated automatically with routes learned from neighbouring routers, marked with the routing protocol, without manual configuration.

### What changed when a link failed

When a link failed in static routing, the routing table did not change and traffic was dropped immediately because no alternate path was available. In dynamic routing, the routing protocol detected the failure, removed the affected routes from the routing table, and restored connectivity automatically once the link was brought back up.

### Which approach felt more “alive”

Dynamic routing felt more “alive” because routers continuously exchanged information and adapted to network changes automatically. Static routing felt rigid and dependent on manual intervention.

### One real-world scenario where static routing is better

Static routing is better in small or simple networks such as a home network or a small branch office with only one path to the internet, where the network rarely changes.

## **One real-world scenario where dynamic routing is unavoidable**

Dynamic routing is unavoidable in large enterprise networks or ISP networks where multiple routers, redundant paths, and frequent topology changes require automatic route discovery and fast failure recovery.