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Distributed Computing Assignment

Language used for the Implementation

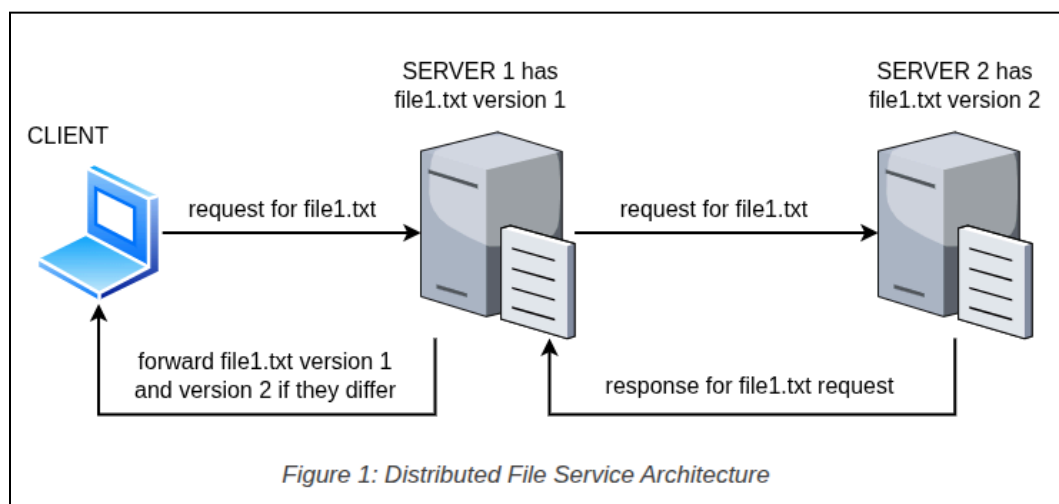
Python 3.

System Overview

We implemented the required client-server distributed file service with one client, SERVER1 (coordinator), and SERVER2 (peer file server). Both servers maintain a replica directory `~/file_storage`. Due to possible update delays, SERVER1 always cross-checks with SERVER2 before replying to the client.

Protocol

- Client → SERVER1 (TCP:5001): GET <pathname>\n
- SERVER1 → SERVER2 (TCP:5002): GET <pathname>\n
- SERVER2 → SERVER1:
 - FOUND <length>\n followed by <length> bytes, or
 - NOTFOUND\n.
- SERVER1 → Client:
 - OK ONE <length>\n followed by one file copy, or
 - OK BOTH <length1> <length2>\n followed by two file copies (SERVER1 then SERVER2), or
 - ERROR NOTFOUND\n when neither server has the file, or invalid request.

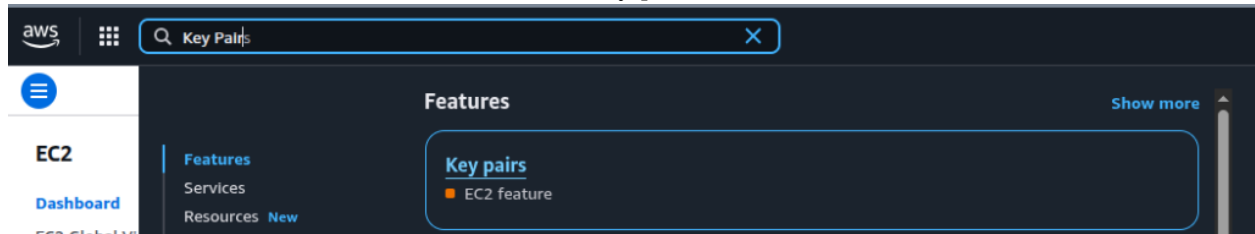


Step-by-Step Work Flow

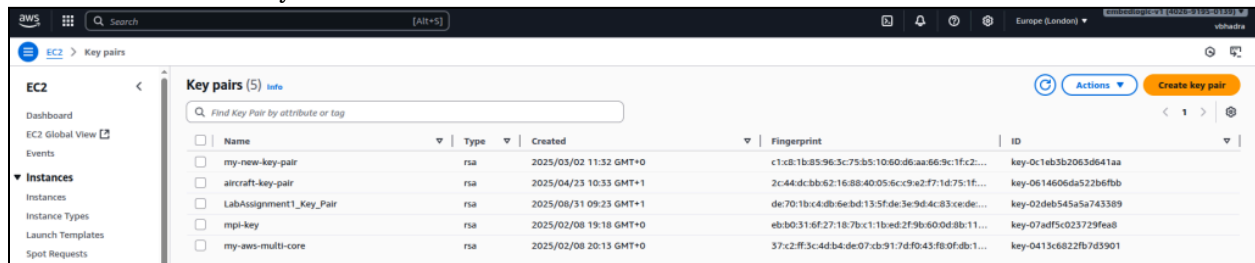
1) Setting up the AWS infrastructure

Create key pairs

- Go to the AWS dashboard and search for key pairs.



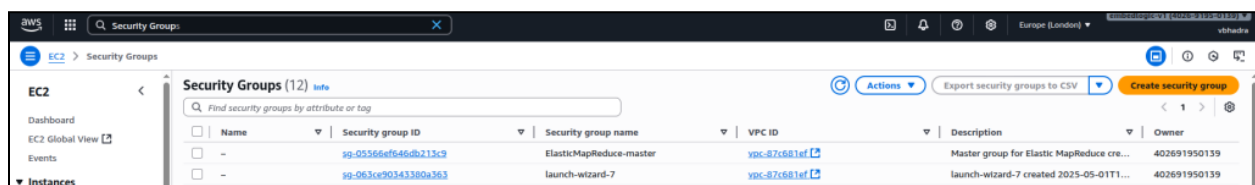
- Click on Create Key Pair.



- Name the key pair (e.g., MyFileSystemKeyPair). Leave the remaining fields at their default values and click Create key pair.
- Keep the .pem safe as this will be used to SSH into the AWS instances.

Create a Security Group

- Search for security groups. On the Security Group page, click on the Create security group button.



- Name the new security group (e.g., MyFileServerSecurityGroup).
- On the inbound rules, open TCP port 22 for SSH, TCP port 5001 (SERVER1), TCP port 5002 (SERVER2).
- For the demonstration, keep **Source = Anywhere**.

- On the outbound rules, allow all traffic.

Inbound rules Info

Type	Protocol	Port range	Source	Description - optional	Actions
SSH	TCP	22	Anywhere...	0.0.0.0/0	Delete
Custom TCP	TCP	5001	Anywhere...	0.0.0.0/0	Delete
Custom TCP	TCP	5002	Anywhere...	0.0.0.0/0	Delete

[Add rule](#)

Outbound rules Info

Type	Protocol	Port range	Destination	Description - optional	Actions
All traffic	All	All	Custom	0.0.0.0/0	Delete

[Add rule](#)

Tags - optional

A tag is a label that you assign to an AWS resource. Each tag consists of a key and an optional value. You can use tags to search and filter your resources or track your AWS costs.

No tags associated with the resource.

[Add new tag](#)

You can add up to 50 more tags

[Cancel](#) [Create security group](#)

- Create a security group. Once the group is created, it should look somewhat like the example shown below:

sg-0dd4a58da8a9aa8ad - MyFaileServerSecurityGroup [Actions](#)

Details

Security group name MyFaileServerSecurityGroup	Security group ID sg-0dd4a58da8a9aa8ad	Description Security group for distributed file server demo	VPC ID vpc-87c681ef
Owner 402691950139	Inbound rules count 3 Permission entries	Outbound rules count 1 Permission entry	

[Inbound rules](#) [Outbound rules](#) [Sharing - new](#) [VPC associations - new](#) [Tags](#)

Inbound rules (3) [Manage tags](#) [Edit inbound rules](#)

	Name	Security group rule ID	IP version	Type	Protocol	Port range	Source	Description
<input type="checkbox"/>	-	sgr-0673024e4bd815925	IPv4	Custom TCP	TCP	5001	0.0.0.0/0	-
<input type="checkbox"/>	-	sgr-002ad83a9555e9921	IPv4	SSH	TCP	22	0.0.0.0/0	-
<input type="checkbox"/>	-	sgr-0ed670c477fa1f498	IPv4	Custom TCP	TCP	5002	0.0.0.0/0	-

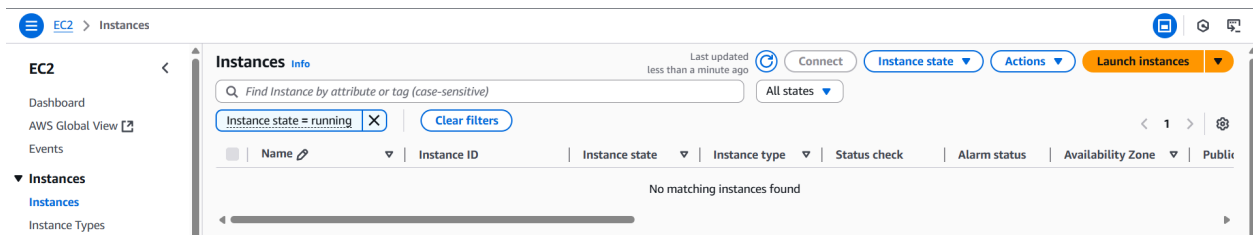
- This security group will be shared by Server 1, Server 2, and the Client.

Launch EC2 instances

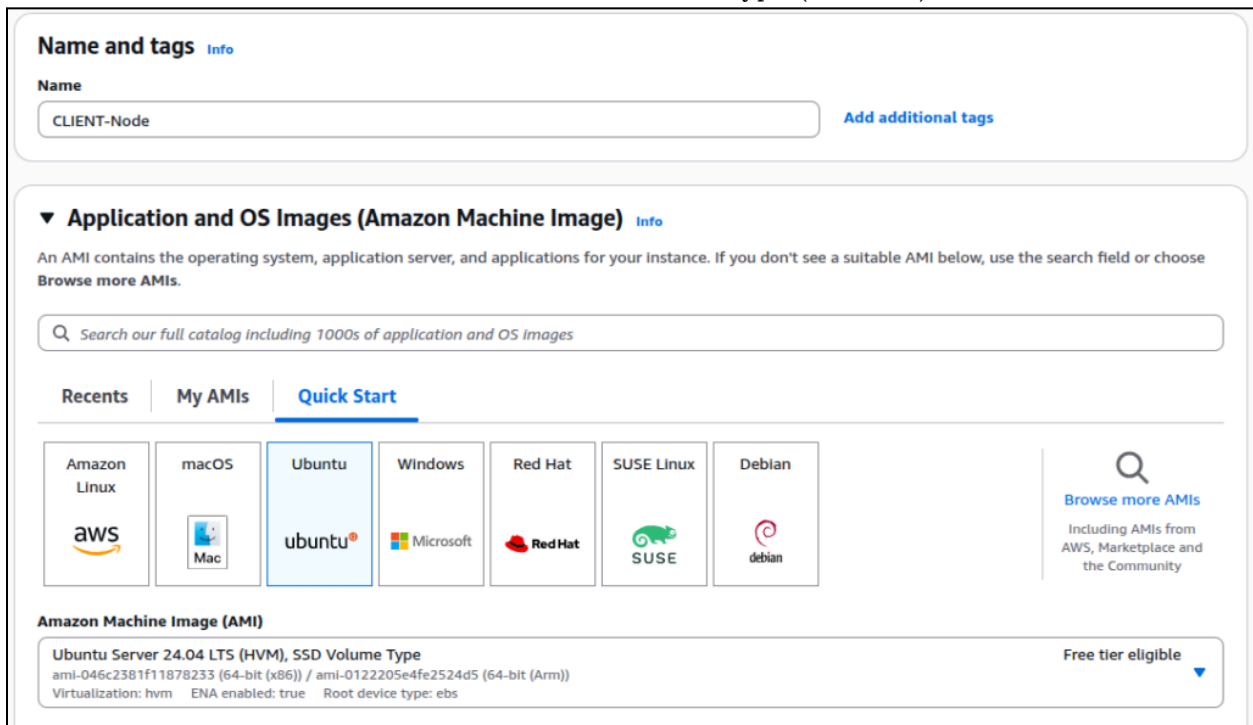
- We will need at least three EC2 instances—one for the client and one for each of the two servers.
- Let's create three identical EC2 instances with the following details:

```
Name(s): CLIENT-Node, SERVER1, SERVER2
Security Group: MyFaileServerSecurityGroup
Key Pair: MyFileSystemKeyPair
AWS ASI Type: Ubuntu 22.04 t3.micro or t2.micro
```

- Go to EC2 Dashboard -> Instances -> Launch Instance.



- Choose Ubuntu as the OS image.
- Select Ubuntu 24.04 as the AMI. Select the instance type (t3.micro).



- Select the previously created key pair.

▼ Instance type

Info | Get advice

Instance type

t3.micro

Family: t3

2 vCPU

1 GiB Memory

Current generation: true

On-Demand Linux base pricing: 0.0118 USD per Hour

Free tier eligible

On-Demand SUSE base pricing: 0.0118 USD per Hour

On-Demand Ubuntu Pro base pricing: 0.0153 USD per Hour

On-Demand RHEL base pricing: 0.0406 USD per Hour

On-Demand Windows base pricing: 0.021 USD per Hour

All generations

Compare instance types

Additional costs apply for AMIs with pre-installed software

▼ Key pair (login)

Info

You can use a key pair to securely connect to your instance. Ensure that you have access to the selected key pair before you launch the instance.

Key pair name - required

Select

Create new key pair

Q |

Proceed without a key pair (Not recommended)

Default value

my-new-key-pair

Type: rsa

aircraft-key-pair

Type: rsa

LabAssignment1_Key_Pair

Type: rsa

mpi-key

Type: rsa

MyFileSystemKeyPair

Type: rsa

my-aws-multi-core

Type: rsa

Edit

- Attach the created security group under Network settings.

▼ Network settings

Info

Network

Info

vpc-87c681ef

Subnet

Info

No preference (Default subnet in any availability zone)

Auto-assign public IP

Info

Enable

Additional charges apply when outside of free tier allowance

Firewall (security groups)

Info

A security group is a set of firewall rules that control the traffic for your instance. Add rules to allow specific traffic to reach your instance.

Create security group

Select existing security group

Common security groups

Info

Select security groups

Compare security group rules

Q

launch-wizard-7

VPC: vpc-87c681ef

sg-08c3b43d3080829

launch-wizard-6

VPC: vpc-87c681ef

sg-06bb2b4f1416f3f5d

launch-wizard-4

VPC: vpc-87c681ef

sg-08f9c085b6967063

launch-wizard-1

VPC: vpc-87c681ef

sg-0a9a725b8251db04a

MyFailleServerSecurityGroup

VPC: vpc-87c681ef

sg-0dd4a58da8a9aa8ad

default

VPC: vpc-87c681ef

sg-aa35fec8

MyFailleServerSecurityGroup

Advanced

The selected AMI contains instance store volumes, however the instance does not allow any instance store volumes. None of the instance store volumes from the AMI will be accessible from the instance

- Since we need three EC2 instances with the same base configurations, under Summary on the right hand side set the number of instances to 3.

▼ Summary

Number of instances | [Info](#)

3

When launching more than 1 instance, [consider EC2 Auto Scaling](#)

Software Image (AMI)

Canonical, Ubuntu, 24.04, amd64...[read more](#)
ami-02d26659fd82cf299

Virtual server type (instance type)

t3.micro

- Finally Click the Launch instance.

▼ Configure storage [Info](#)

Advanced

1x 8 GiB gp3 Root volume, 3000 IOPS, Not encrypted

Free tier eligible customers can get up to 30 GB of EBS General Purpose (SSD) or Magnetic storage

Add new volume

The selected AMI contains instance store volumes, however the instance does not allow any instance store volumes. None of the instance store volumes from the AMI will be accessible from the instance

Click refresh to view backup information

The tags that you assign determine whether the instance will be backed up by any Data Lifecycle Manager policies.

0 x File systems

Edit

► Advanced details [Info](#)

Firewall (security group)

-

Storage (volumes)

1 volume(s) - 8 GiB



Free tier: In your first year of opening an AWS account, you get 750 hours per month of t2.micro instance usage (or t3.micro where t2.micro isn't available) when used with free tier AMIs, 750 hours per month of public IPv4 address usage, 30 GiB of EBS storage, 2 million I/Os, 1 GB of snapshots, and 100 GB of bandwidth to the internet. Data transfer charges are not included as part of the free tier allowance.

Cancel

Launch instance

Preview code

- This will create three EC2 instances with the selected configurations.
- After the instances are created, go to the EC2 page. You should be able to see all three instances running.

Resources EC2 Global View  

You are using the following Amazon EC2 resources in the Europe (London) Region:

<u>Instances (running)</u>	3	<u>Auto Scaling Groups</u>	0	Capacity Reservations	0
Dedicated Hosts	0	Elastic IPs	0	Instances	3
Key pairs	6	Load balancers	0	Placement groups	0
Security groups	13	Snapshots	0	Volumes	3

- Name all the instances for easy identification.

Instances (3) Info Last updated less than a minute ago Connect Instance state Actions Launch instances

Find Instance by attribute or tag (case-sensitive) All states

Instance state = running Clear filters

<input type="checkbox"/>	Name	Instance ID	Instance state	Instance type	Status check	Alarm status	Availability Zone	Public IPv4 DNS	Public IPv4 ...	Elastic
<input type="checkbox"/>	SERVER2	i-04426b791a2547fb7	Running	t3.micro	3/3 checks passed	View alarms +	eu-west-2a	ec2-18-130-207-66.eu-...	18.130.207.66	-
<input type="checkbox"/>	CLIENT-Node	i-0077d39fa8de96a8c	Running	t3.micro	3/3 checks passed	View alarms +	eu-west-2a	ec2-18-130-101-24.eu-...	18.130.101.24	-
<input type="checkbox"/>	SERVER1	i-01f30a606983a0675	Running	t3.micro	3/3 checks passed	View alarms +	eu-west-2a	ec2-18-171-162-167.eu-...	18.171.162.167	-

Record Public & Private IPs for all instances (used in scripts)

- These addresses will be required later when we write the scripts to establish communication between the client and the servers.
- In this case, the following are the Private and Public IPs of each instance:

CLINET-Node:

Public IPv4 address: 18.130.101.24

Private IPv4 addresses: 172.31.24.111

SERVER1:

Public IPv4 address: 18.171.162.167

Private IPv4 addresses: 172.31.16.124

SERVER2:

Public IPv4 address: 18.130.207.66

Private IPv4 addresses: 172.31.26.202

SSH & Install the necessary tools

- First, we need to change the file permissions of the key pair file (downloaded in one of the previous steps) by running the following command.

```
chmod 400 ~/Downloads/MyFileSystemKeyPair.pem
```

- The sample SSH command will be lie:

```
ssh -i ~/Downloads/MyFileSystemKeyPair.pem ubuntu@<EC2 Public IPv4 Addr>
```

- Let's SSH into the Client-Node and install the necessary packages:

```
~$ ssh -i ~/Downloads/MyFileSystemKeyPair.pem ubuntu@18.130.101.24
ubuntu@ip-172-31-24-111:~$ sudo apt update
ubuntu@ip-172-31-24-111:~$ sudo apt install netcat-openbsd -y
ubuntu@ip-172-31-24-111:~$ which nc
/usr/bin/nc
```

- Similarly, SSH into the Server 1 instance and run the commands

```
~$ ssh -i ~/Downloads/MyFileSystemKeyPair.pem ubuntu@18.171.162.167
~$ sudo apt update
~$ sudo apt install netcat-openbsd -y
~$ which nc
/usr/bin/nc
```

- Follow the exact set of steps for Server 2 as well.

```
~$ ssh -i ~/Downloads/MyFileSystemKeyPair.pem ubuntu@18.130.207.66
~$ sudo apt update
~$ sudo apt install netcat-openbsd -y
~$ which nc
/usr/bin/nc
```

- Now, all three instances are configured and ready for a quick connectivity check.

Connectivity check

- Before we move into the actual File Service server implementation, let's check the connections between the instances to make sure everything is set up correctly.
- Run the following on SERVER1:

```
ubuntu@ip-172-31-26-202:~$ nc -l -p 5002
```

- Then run the following on the CLIENT:

```
ubuntu@ip-172-31-24-111:~$ echo "hello from CLIENT to SERVER1" | nc
172.31.16.124 5002
```

- You should be able to see the message from the client displayed on SERVER1:

```
ubuntu@ip-172-31-16-124:~$ nc -l -p 5002
```

hello from CLIENT to SERVER1

- This confirms that the connection between the CLIENT-Node and SERVER1 is working correctly. We could also have used port 5001, since both ports 5001 and 5002 are open for TCP connections.
- You can repeat the same steps to test the connection between SERVER1 and SERVER2.

2) Writing the CLIENT script

The `client.py` program is the interface for users to request files from our distributed file service. Its job is simple: connect to SERVER1 (the coordinator), request a file, and handle the response. It doesn't interact with SERVER2 directly — it trusts SERVER1 to coordinate and return the correct data.

Protocol Overview

When the client connects to SERVER1 on port 5001, it sends a request in the form:

```
GET filename
```

SERVER1 then processes the request — including checking with SERVER2 — and replies with a structured response, followed by file data if available. The client parses this response and prints the result.

Expected responses from SERVER1

- OK ONE <length> — a single version of the file follows.
- OK BOTH <length1> <length2> — two versions follow (from SERVER1 and SERVER2).
- ERROR NOTFOUND — the file doesn't exist on either server.

Code Overview

The script uses two helper functions:

- `recv_line(conn)`: Reads a line from the socket (used for headers).
- `recv_exact(conn, n)`: Reads exactly n bytes (used for file contents).

Main execution flow

1. Parses the filename from command-line args (defaults to "file1.txt").
2. Connects to SERVER1 over TCP.
3. Send a GET request.
4. Reads and interprets the response header.

5. Receives and displays file data based on the response type.

Source Code Listing

```
#!/usr/bin/env python3
# client.py
import socket, sys

SERVER1_IP = "172.31.16.124" # <-- PUT SERVER1 PRIVATE IP HERE
SERVER1_PORT = 5001
filename = sys.argv[1] if len(sys.argv) > 1 else "file1.txt"

def recv_line(conn):
    buf = bytearray()
    while True:
        b = conn.recv(1)
        if not b:
            break
        buf += b
        if buf.endswith(b"\n"):
            break
    return bytes(buf).decode(errors="replace").rstrip("\n")

def recv_exact(conn, n):
    buf = bytearray()
    while len(buf) < n:
        chunk = conn.recv(n - len(buf))
        if not chunk:
            raise ConnectionError("socket closed while reading body")
        buf += chunk
    return bytes(buf)

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.connect((SERVER1_IP, SERVER1_PORT))
    s.sendall(f"GET {filename}\n".encode())

    header = recv_line(s) # e.g., OK ONE <len> / OK BOTH <l1> <l2> / ERROR
    NOTFOUND
    parts = header.split()
    if parts[:2] == ["OK", "ONE"]:
        length = int(parts[2]); data = recv_exact(s, length)
        print("[CLIENT] Received ONE copy:")
        print(data.decode(errors="ignore"))
```

```

        # Optionally save:
        # open("out_one.txt", "wb").write(data)
    elif parts[:2] == ["OK", "BOTH"]:
        l1, l2 = int(parts[2]), int(parts[3])
        d1 = recv_exact(s, l1); d2 = recv_exact(s, l2)
        print("[CLIENT] Received BOTH copies:")
        print("\n--- SERVER1 version ---\n", d1.decode(errors="ignore"))
        print("\n--- SERVER2 version ---\n", d2.decode(errors="ignore"))
        # Optionally save:
        # open("out_server1.txt", "wb").write(d1)
        # open("out_server2.txt", "wb").write(d2)
    else:
        print("[CLIENT]", header)

```

3) Writing the SERVER1 script

The `server1.py` program is the coordinator of our small distributed file service. Its job is simple to explain: it waits for clients to connect on port 5001, checks if the requested file exists locally, always asks SERVER2 for the same file, and then decides what to send back. Think of it as the “middle manager” — it doesn’t just rely on its own copy but always double-checks with SERVER2 before answering the client.

How the conversation works

When a client connects, it sends a request like `GET file1.txt`. SERVER1 then talks to SERVER2 in exactly the same way. If SERVER2 replies that the file exists, it also sends the file contents back; if not, it says `NOTFOUND`. Based on this exchange, SERVER1 then prepares its response for the client.

Decision making

- If both SERVER1 and SERVER2 have the file and their contents are *identical*, SERVER1 keeps things efficient and returns just one copy.
- If both servers have the file but the contents are *different*, SERVER1 sends both versions so the client can see the mismatch.
- If only one of the two servers has the file, SERVER1 forwards that copy.
- If neither server has it, SERVER1 sends back a simple “not found” error.

Code Walkthrough

The script uses helper functions to keep things tidy. `read_local()` looks up the file under `~/file_storage` on SERVER1. `get_from_server2()` connects out to SERVER2, asks for the same file, and collects the result. Once both responses are in, SERVER1 compares them and

decides which of the `send_one()`, `send_both()`, or `send_error()` functions to use when replying to the client.

Safety and Reliability

The script is careful about what paths it accepts (so clients can't wander outside the storage folder), it checks that full files are received before making decisions, and it catches errors so that one misbehaving server doesn't crash the whole service. Logging messages such as "Versions differ → sent BOTH" make it easy to see what happened during each request.

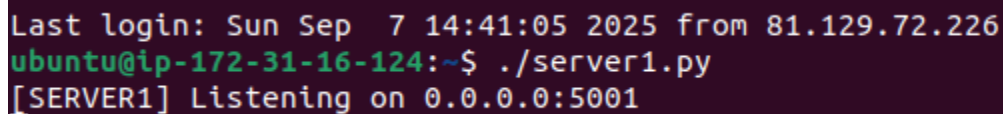
How to run it

Before starting, the `SERVER2_IP` variable needs to be updated to the private IP of `SERVER2`. Once `SERVER2` is already running, you can start this script on `SERVER1` with the following command on the command prompt:

```
ubuntu@ip-172-31-16-124:~$ ./server1.py
[SERVER1] Listening on 0.0.0.0:5001
```

It will sit listening on port `5001`, handle each incoming client request, and coordinate with `SERVER2` in the background. In short, `SERVER1` is the smart middle layer: it listens, checks both sides, makes a fair decision, and keeps the client informed.

Screenshot of running `server1.py` on EC2 instance:



```
Last login: Sun Sep  7 14:41:05 2025 from 81.129.72.226
ubuntu@ip-172-31-16-124:~$ ./server1.py
[SERVER1] Listening on 0.0.0.0:5001
```

Source Code Listing

```
#!/usr/bin/env python3
import socket, os

HOST = "0.0.0.0"
PORT = 5001
SERVER2_IP = "172.31.xx.yy" # <-- replace with SERVER2 private IP
SERVER2_PORT = 5002
ROOT = os.path.expanduser("~/file_storage")

def recv_line(conn):
    buf = bytearray()
    while True:
```

```

        b = conn.recv(1)
        if not b: break
        buf += b
        if buf.endswith(b"\n"): break
    return bytes(buf).decode(errors="replace").rstrip("\n")

def recv_exact(conn, n):
    buf = bytearray()
    while len(buf) < n:
        chunk = conn.recv(n - len(buf))
        if not chunk: raise ConnectionError("socket closed early")
        buf += chunk
    return bytes(buf)

def get_from_server2(filename: str) -> bytes | None:
    try:
        with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s2:
            s2.connect((SERVER2_IP, SERVER2_PORT))
            s2.sendall(f"GET {filename}\n".encode())
            header = recv_line(s2)
            if header == "NOTFOUND": return None
            if header.startswith("FOUND "):
                length = int(header.split()[1])
                return recv_exact(s2, length)
    except Exception as e:
        print("[SERVER1] Error contacting SERVER2:", e)
    return None

def read_local(filename: str) -> bytes | None:
    rel = filename.lstrip("/")
    path = os.path.normpath(os.path.join(ROOT, rel))
    if not path.startswith(ROOT): return None
    if os.path.isfile(path):
        with open(path, "rb") as f: return f.read()
    return None

def send_one(conn, data: bytes):
    conn.sendall(f"OK ONE {len(data)}\n".encode() + data)

def send_both(conn, d1: bytes, d2: bytes):
    conn.sendall(f"OK BOTH {len(d1)} {len(d2)}\n".encode() + d1 + d2)

def send_error(conn, msg="ERROR NOTFOUND"):

```

```

conn.sendall((msg + "\n").encode())

def handle_client(conn, addr):
    try:
        line = recv_line(conn)
        if not line.startswith("GET "):
            send_error(conn, "ERROR BADREQUEST"); return
        filename = line[4:].strip()
        print(f"[SERVER1] CLIENT {addr} requested {filename}")

        local = read_local(filename)
        remote = get_from_server2(filename)

        if local and remote:
            if local == remote:
                send_one(conn, local)
                print("[SERVER1] Both matched → sent ONE")
            else:
                send_both(conn, local, remote)
                print("[SERVER1] Versions differ → sent BOTH")
        elif local:
            send_one(conn, local)
            print("[SERVER1] Only SERVER1 had it → sent ONE")
        elif remote:
            send_one(conn, remote)
            print("[SERVER1] Only SERVER2 had it → sent ONE")
        else:
            send_error(conn)
            print("[SERVER1] Not found on either")
    except Exception as e:
        print("[SERVER1] Error:", e)
        try: send_error(conn, "ERROR INTERNAL")
        except: pass

def main():
    with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s1:
        s1.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
        s1.bind((HOST, PORT))
        s1.listen()
        print(f"[SERVER1] Listening on {HOST}:{PORT}")
        while True:
            conn, addr = s1.accept()
            with conn: handle_client(conn, addr)

```



```
if __name__ == "__main__":  
    main()
```

4) Writing the SERVER2 script

The `server2.py` program is a peer server. Its sole purpose is to serve file content to Server 1 when requested. It doesn't communicate with the client directly, but rather acts as a data source within the distributed network. It listens for requests from server1 on port 5002.

Code Walkthrough

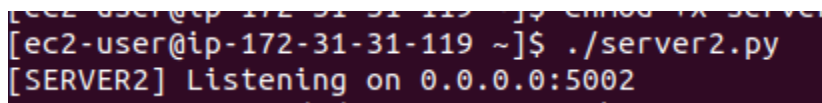
The script uses helper functions for the smooth and error free execution. It uses a `recv_line` function, which is used to receive the request from server1 and send the request as a string to the handle function which is responsible for reading the file path from the `recv_line` function and checks for the filename if it exists. `Send_found` responsible for sending the file to server1 if found and `send_notfound` to let server1 know no such file exists in server2.

How to run it

SERVER2 is defined to be running on port 5002, you can start this script on SERVER2 with the following command on the command prompt:

```
ubuntu@ip-172-31-31-119:~$ ./server2.py  
[SERVER2] Listening on 0.0.0.0:5002
```

It will sit listening on port 5002, handle each incoming server1 request
Screenshot of running SERVER2.py on EC2 instance:



```
[ec2-user@ip-172-31-31-119 ~]$ ./server2.py  
[SERVER2] Listening on 0.0.0.0:5002
```

Source Code Listing

```
#!/usr/bin/env python3  
import socket, os  
HOST = "0.0.0.0"  
PORT = 5002  
ROOT = os.path.expanduser("~/file_storage")  
  
def recv_line(conn):
```

```

buf = bytearray()
while True:
    b = conn.recv(1)
    if not b: break
    buf += b
    if buf.endswith(b"\n"): break
return bytes(buf).decode(errors="replace").rstrip("\n")

def send_found(conn, data: bytes):
    header = f"FOUND {len(data)}\n".encode()
    conn.sendall(header + data)

def send_notfound(conn):
    conn.sendall(b"NOTFOUND\n")

def handle(conn, addr):
    try:
        line = recv_line(conn)
        if not line.startswith("GET "):
            send_notfound(conn); return
        rel = line[4:].strip().lstrip("/")
        path = os.path.normpath(os.path.join(ROOT, rel))

        if not path.startswith(ROOT):
            send_notfound(conn); return
        if os.path.isfile(path):
            with open(path, "rb") as f: data = f.read()
            send_found(conn, data)
            print(f"[SERVER2] Sent {rel} ({len(data)} bytes) to {addr}")
        else:
            send_notfound(conn)
            print(f"[SERVER2] {rel} not found for {addr}")
        elif local:
            send_one(conn, local)
            print("[SERVER1] Only SERVER1 had it → sent ONE")
    except Exception as e:
        print("[SERVER2] Error:", e)

def main():
    with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
        s1.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
        s1.bind((HOST, PORT))
        s1.listen()

```

```
print(f"[SERVER1] Listening on {HOST}:{PORT}")
while True:
    conn, addr = s.accept()
    with conn: handle_client(conn, addr)

if __name__ == "__main__":
    main()
```

5) Testing

Test Setup

- Different files on SERVER1 and SERVER2 (initial state) → client receives BOTH copies (shows each version).
- Identical files on both servers (edit SERVER2's file to match SERVER1) → client receives ONE copy.
- Nested path provided by client (e.g., docs/report.txt with different contents) → client receives BOTH copies.

Client Machine Setup

- Configured client machine with the PKF file.
- Created a file client.py in /home/ubuntu on the client node.

```
ubuntu@ip-172-31-34-69: ~  
login as: ubuntu  
Authenticating with public key "DCFileSystemKeyPair070925"  
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1011-aws x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/pro  
  
System information as of Sat Sep 13 06:59:28 UTC 2025  
  
System load:  0.09           Temperature:   -273.1 C  
Usage of /:   29.7% of 6.71GB Processes:      113  
Memory usage: 22%           Users logged in: 0  
Swap usage:   0%            IPv4 address for ens5: 172.31.34.69  
  
* Ubuntu Pro delivers the most comprehensive open source security and  
  compliance features.  
  
  https://ubuntu.com/aws/pro  
  
Expanded Security Maintenance for Applications is not enabled.  
  
19 updates can be applied immediately.  
17 of these updates are standard security updates.  
To see these additional updates run: apt list --upgradable  
  
Enable ESM Apps to receive additional future security updates.  
See https://ubuntu.com/esm or run: sudo pro status  
  
Last login: Sun Sep  7 14:30:04 2025 from 122.172.80.6  
ubuntu@ip-172-31-34-69:~$
```

```
ubuntu@ip-172-31-34-69: ~  
ubuntu@ip-172-31-34-69:~$ pwd  
/home/ubuntu  
ubuntu@ip-172-31-34-69:~$ ls -ltrh  
total 4.0K  
-rwxrwxrwx 1 ubuntu ubuntu 1.7K Sep  7 14:54 client.py  
ubuntu@ip-172-31-34-69:~$
```

Server1 Setup

1. Configured Server1 using the PKF file.
2. Created a file server1.py in /home/ubuntu.
3. Created a directory file_storage in /home/ubuntu.
4. Created a file file1.txt inside /home/ubuntu/file_storage.

ubuntu@ip-172-31-34-27: ~

login as: ubuntu

Authenticating with public key "DCFileSystemKeyPair070925"

Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1011-aws x86_64)

* Documentation: <https://help.ubuntu.com>
* Management: <https://landscape.canonical.com>
* Support: <https://ubuntu.com/pro>

System information as of Sat Sep 13 07:16:15 UTC 2025

System load:	0.0	Temperature:	-273.1 C
Usage of /:	28.1% of 6.71GB	Processes:	111
Memory usage:	22%	Users logged in:	0
Swap usage:	0%	IPv4 address for ens5:	172.31.34.27

* Ubuntu Pro delivers the most comprehensive open source security and compliance features.

<https://ubuntu.com/aws/pro>

Expanded Security Maintenance for Applications is not enabled.

0 updates can be applied immediately.

Enable ESM Apps to receive additional future security updates.
See <https://ubuntu.com/esm> or run: `sudo pro status`

The list of available updates is more than a week old.
To check for new updates run: `sudo apt update`

Last login: Sun Sep 7 14:35:03 2025 from 122.172.80.6
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@ip-172-31-34-27:~\$

ubuntu@ip-172-31-34-27: ~

ubuntu@ip-172-31-34-27:~\$ ls

file_storage server1.py

ubuntu@ip-172-31-34-27:~\$

ubuntu@ip-172-31-34-27: ~/file_storage


```
ubuntu@ip-172-31-34-27:~$ ls
file_storage  server1.py
ubuntu@ip-172-31-34-27:~$ pwd
/home/ubuntu
ubuntu@ip-172-31-34-27:~$ ls
file_storage  server1.py
ubuntu@ip-172-31-34-27:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 3.2K Sep  7 14:43 server1.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 07:35 file_storage
ubuntu@ip-172-31-34-27:~$ cd file_storage/
ubuntu@ip-172-31-34-27:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$
```


ubuntu@ip-172-31-34-27: ~/file_storage


```
Content: "Report version from SERVER1"
~
~
~
```

Server2 Setup

1. Configured Server2 using the PKF file.
2. Created a file server2.py in /home/ubuntu.
3. Created a directory file_storage in /home/ubuntu.
4. Created a file file1.txt inside /home/ubuntu/file_storage.

 ubuntu@ip-172-31-45-10: ~

 login as: ubuntu

 Authenticating with public key "DCFileSystemKeyPair070925"

Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1011-aws x86_64)

* Documentation: <https://help.ubuntu.com>
* Management: <https://landscape.canonical.com>
* Support: <https://ubuntu.com/pro>

System information as of Sat Sep 13 07:16:57 UTC 2025

System load:	0.0	Temperature:	-273.1 C
Usage of /:	34.4% of 6.71GB	Processes:	108
Memory usage:	31%	Users logged in:	0
Swap usage:	0%	IPv4 address for ens5:	172.31.45.10

* Ubuntu Pro delivers the most comprehensive open source security and compliance features.

<https://ubuntu.com/aws/pro>

Expanded Security Maintenance for Applications is not enabled.

2 updates can be applied immediately.

To see these additional updates run: `apt list --upgradable`


Enable ESM Apps to receive additional future security updates.

See <https://ubuntu.com/esm> or run: `sudo pro status`

*** System restart required ***

Last login: Sun Sep 7 14:33:13 2025 from 122.172.80.6

ubuntu@ip-172-31-45-10:~\$ █

 ubuntu@ip-172-31-45-10: ~

ubuntu@ip-172-31-45-10:~\$ `pwd`

/home/ubuntu

ubuntu@ip-172-31-45-10:~\$ `ls`

file_storage server2.py

ubuntu@ip-172-31-45-10:~\$ █

```
ubuntu@ip-172-31-45-10: ~/file_storage
ubuntu@ip-172-31-45-10:~$ pwd
/home/ubuntu
ubuntu@ip-172-31-45-10:~$ ls
file_storage  server2.py
ubuntu@ip-172-31-45-10:~$ cd file_storage/
ubuntu@ip-172-31-45-10:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-45-10:~/file_storage$
```

```
ubuntu@ip-172-31-45-10: ~/file_storage
Content: "Report version from SERVER2"
~
~
~
```

Update the SERVER2_IP variable in the server1.py script with the private IP address of Server2.


```

ubuntu@ip-172-31-34-27: ~
#!/usr/bin/env python3
import socket, os

HOST = "0.0.0.0"
PORT = 5001
SERVER2_IP = "172.31.45.10" # <-- replace with SERVER2 private IP
SERVER2_PORT = 5002
ROOT = os.path.expanduser("~/file_storage")

def recv_line(conn):
    buf = bytearray()
    while True:
        b = conn.recv(1)
        if not b: break
        buf += b
        if buf.endswith(b"\n"): break
    return bytes(buf).decode(errors="replace").rstrip("\n")

def recv_exact(conn, n):
    buf = bytearray()
    while len(buf) < n:
        chunk = conn.recv(n - len(buf))
        if not chunk: raise ConnectionError("socket closed early")
        buf += chunk
    return bytes(buf)

def get_from_server2(filename: str) -> bytes | None:
    try:
        with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s2:
            s2.connect((SERVER2_IP, SERVER2_PORT))
            s2.sendall(f"GET {filename}\n".encode())
            header = recv_line(s2)
            if header == "NOTFOUND": return None
            if header.startswith("FOUND "):
                length = int(header.split()[1])
                return recv_exact(s2, length)
    except Exception as e:
        print("[SERVER1] Error contacting SERVER2:", e)
    return None

def read_local(filename: str) -> bytes | None:
    rel = filename.lstrip("/")
    path = os.path.normpath(os.path.join(ROOT, rel))

```

Update the SERVER1_IP variable in the client.py script with the private IP address of Server1.

```

ubuntu@ip-172-31-34-69: ~
#!/usr/bin/env python3
# client.py
import socket, sys

SERVER1_IP = "172.31.34.27" # <-- PUT SERVER1 PRIVATE IP HERE
SERVER1_PORT = 5001
filename = sys.argv[1] if len(sys.argv) > 1 else "file1.txt"

def recv_line(conn):
    buf = bytearray()
    while True:
        b = conn.recv(1)
        if not b:
            break
        buf += b
        if buf.endswith(b"\n"):
            break
    return bytes(buf).decode(errors="replace").rstrip("\n")

def recv_exact(conn, n):
    buf = bytearray()
    while len(buf) < n:
        chunk = conn.recv(n - len(buf))
        if not chunk:
            raise ConnectionError("socket closed while reading body")
        buf += chunk
    return bytes(buf)

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as s:
    s.connect((SERVER1_IP, SERVER1_PORT))
    s.sendall(f"GET {filename}\n".encode())

    header = recv_line(s) # e.g., OK ONE <len> / OK BOTH <l1> <l2> / ERROR NOTFOUND
    parts = header.split()
    if parts[:2] == ["OK", "ONE"]:
        length = int(parts[2]); data = recv_exact(s, length)
        print("[CLIENT] Received ONE copy:")
        print(data.decode(errors="ignore"))
        # Optionally save:
        # open("out_one.txt", "wb").write(data)
    elif parts[:2] == ["OK", "BOTH"]:
        l1, l2 = int(parts[2]), int(parts[3])
        d1 = recv_exact(s, l1); d2 = recv_exact(s, l2)

```

Test Case1

End-to-End Verification of Client-Server File Sync

- **Precondition**

- Server1 (server1.py) and Server2 (server2.py) are deployed and accessible from the Client.
- client.py is configured to connect to both servers.
- Test files are available on both the servers .

- **Test Steps**

- Start **Server1** by running server1.py.
- Start **Server2** by running server2.py.
- Start the **Client** by running client.py.

- Initiate file synchronization from the client.

- **Expected Result**

- The client should successfully connect to both **Server1** and **Server2**.
- Files from the servers should be visible in the client's file system after sync.
- When file conflicts exist (e.g., identical files on both servers), synchronization should complete without data loss.

```
ubuntu@ip-172-31-45-10: ~  
ubuntu@ip-172-31-45-10:~$ pwd  
/home/ubuntu  
ubuntu@ip-172-31-45-10:~$ ls  
file_storage  server2.py  
ubuntu@ip-172-31-45-10:~$ cd file_storage/  
ubuntu@ip-172-31-45-10:~/file_storage$ ls  
file1.txt  
ubuntu@ip-172-31-45-10:~/file_storage$ vi file1.txt  
ubuntu@ip-172-31-45-10:~/file_storage$ ls  
file1.txt  
ubuntu@ip-172-31-45-10:~/file_storage$ cd ..  
ubuntu@ip-172-31-45-10:~$ ls  
file_storage  server2.py  
ubuntu@ip-172-31-45-10:~$ vi server2.py  
ubuntu@ip-172-31-45-10:~$ ./server2.py  
[SERVER2] Listening on 0.0.0.0:5002
```

```
ubuntu@ip-172-31-34-27: ~  
ubuntu@ip-172-31-34-27:~/file_storage$ ls  
file1.txt  
ubuntu@ip-172-31-34-27:~/file_storage$ cd ..  
ubuntu@ip-172-31-34-27:~$ ls  
file_storage  server1.py  
ubuntu@ip-172-31-34-27:~$ vi server1.py  
ubuntu@ip-172-31-34-27:~$ ./server1.py  
[SERVER1] Listening on 0.0.0.0:5001
```

```
ubuntu@ip-172-31-34-69: ~  
ubuntu@ip-172-31-34-69:~$ ls -ltrh  
total 4.0K  
-rwxrwxrwx 1 ubuntu ubuntu 1.7K Sep  7 14:54 client.py  
ubuntu@ip-172-31-34-69:~$ ./client.py  
[CLIENT] Received BOTH copies:  
  
--- SERVER1 version ---  
Content: "Report version from SERVER1"  
  
--- SERVER2 version ---  
Content: "Report version from SERVER2"  
  
ubuntu@ip-172-31-34-69:~$
```

Test Case2

File Read Operation with Missing File on One Server

- **Precondition**

1. file1.txt exists on both Server1 and Server2.
2. Client, Server1, and Server2 are configured properly with the Python scripts.

- **Test Steps**

1. Remove file1.txt from **Server1**.
2. Execute the Python script ([client.py](#)) from **Client**.
3. Execute the Python script ([server1.py](#)) from **Server1**.
4. Execute the Python script ([server2.py](#)) from **Server2**.

- **Expected Result**

Since file1.txt is removed from Server1, the client should successfully read the file content from Server2 as per the configuration.

```
ubuntu@ip-172-31-34-27: ~
* Management:      https://landscape.canonical.com
* Support:         https://ubuntu.com/pro

System information as of Sun Sep 14 06:49:03 UTC 2025

System load:  0.07           Temperature:   -273.1 C
Usage of /:   34.5% of 6.71GB Processes:      120
Memory usage: 29%           Users logged in: 0
Swap usage:   0%            IPv4 address for ens5: 172.31.34.27

* Ubuntu Pro delivers the most comprehensive open source security and
  compliance features.

  https://ubuntu.com/aws/pro

Expanded Security Maintenance for Applications is not enabled.

9 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

*** System restart required ***
Last login: Sat Sep 13 11:18:39 2025 from 122.172.87.11
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo root" for details.

ubuntu@ip-172-31-34-27:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 3.2K Sep  7 14:43 server1.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 08:04 file_storage
ubuntu@ip-172-31-34-27:~$ cd file_storage/
ubuntu@ip-172-31-34-27:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ rm -rf file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ ls
```

```
ubuntu@ip-172-31-45-10: ~  
login as: ubuntu  
Authenticating with public key "DCFileSystemKeyPair070925"  
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1011-aws x86_64)  
  
* Documentation:  https://help.ubuntu.com  
* Management:    https://landscape.canonical.com  
* Support:       https://ubuntu.com/pro  
  
System information as of Sun Sep 14 06:49:13 UTC 2025  
  
System load: 0.0           Temperature: -273.1 C  
Usage of /: 34.5% of 6.71GB Processes: 110  
Memory usage: 31%         Users logged in: 0  
Swap usage: 0%           IPv4 address for ens5: 172.31.45.10  
  
* Ubuntu Pro delivers the most comprehensive open source security and  
  compliance features.  
  
  https://ubuntu.com/aws/pro  
  
Expanded Security Maintenance for Applications is not enabled.  
  
9 updates can be applied immediately.  
To see these additional updates run: apt list --upgradable  
  
Enable ESM Apps to receive additional future security updates.  
See https://ubuntu.com/esm or run: sudo pro status  
  
*** System restart required ***  
Last login: Sat Sep 13 11:19:17 2025 from 122.172.87.11  
ubuntu@ip-172-31-45-10:~$ ls -ltrh  
total 8.0K  
-rwxrwxr-x 1 ubuntu ubuntu 1.6K Sep  7 14:33 server2.py  
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 08:10 file_storage  
ubuntu@ip-172-31-45-10:~$ ./server2.py  
[SERVER2] Listening on 0.0.0.0:5002  
[SERVER2] Sent file1.txt (39 bytes) to ('172.31.34.27', 41946)
```

```
ubuntu@ip-172-31-34-27: ~
* Management:      https://landscape.canonical.com
* Support:         https://ubuntu.com/pro

System information as of Sun Sep 14 06:49:03 UTC 2025

System load: 0.07          Temperature: -273.1 C
Usage of /: 34.5% of 6.71GB Processes: 120
Memory usage: 29%        Users logged in: 0
Swap usage: 0%           IPv4 address for ens5: 172.31.34.27

* Ubuntu Pro delivers the most comprehensive open source security and
  compliance features.

  https://ubuntu.com/aws/pro

Expanded Security Maintenance for Applications is not enabled.

9 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

*** System restart required ***
Last login: Sat Sep 13 11:18:39 2025 from 122.172.87.11
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@ip-172-31-34-27:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 3.2K Sep  7 14:43 server1.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 08:04 file_storage
ubuntu@ip-172-31-34-27:~$ cd file_storage/
ubuntu@ip-172-31-34-27:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ rm -rf file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ ls
ubuntu@ip-172-31-34-27:~/file_storage$ cd ..
ubuntu@ip-172-31-34-27:~$ ./server1.py
[SERVER1] Listening on 0.0.0.0:5001
[SERVER1] CLIENT ('172.31.34.69', 50420) requested file1.txt
[SERVER1] Only SERVER2 had it → sent ONE
```

```
ubuntu@ip-172-31-34-69: ~
login as: ubuntu
Authenticating with public key "DCFileSystemKeyPair070925"
Welcome to Ubuntu 24.04.3 LTS (GNU/Linux 6.14.0-1011-aws x86_64)

* Documentation:  https://help.ubuntu.com
* Management:    https://landscape.canonical.com
* Support:        https://ubuntu.com/pro

System information as of Sun Sep 14 06:48:47 UTC 2025

System load:  0.0           Temperature:   -273.1 C
Usage of /:   34.5% of 6.71GB Processes:     110
Memory usage: 30%          Users logged in: 0
Swap usage:   0%           IPv4 address for ens5: 172.31.34.69

Expanded Security Maintenance for Applications is not enabled.

6 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

*** System restart required ***
Last login: Sat Sep 13 11:18:26 2025 from 132.172.87.11
ubuntu@ip-172-31-34-69:~$ ./client.py
[CLIENT] Received ONE copy:
Content: "Report version from SERVER2"

ubuntu@ip-172-31-34-69:~$
```

Test Case3

File Read Operation When File Missing on Both Servers

- **Precondition**
 - file1.txt is **not present** on either Server1 or Server2.
 - Client, Server1, and Server2 are configured properly with the Python scripts.
- **Test Steps**
 - Ensure file1.txt is deleted from **Server1**.
 - Ensure file1.txt is deleted from **Server2**.
 - Execute the Python script from the **Client** machine.

- **Expected Result**

- The client script should fail to retrieve the file from either server.
- The client should display an error message “[CLIENT] ERROR NOTFOUND”.

```
ubuntu@ip-172-31-34-27: ~
* Management:      https://landscape.canonical.com
* Support:         https://ubuntu.com/pro

System information as of Sun Sep 14 06:49:03 UTC 2025

System load:  0.07           Temperature:    -273.1 C
Usage of /:   34.5% of 6.71GB Processes:      120
Memory usage: 29%           Users logged in: 0
Swap usage:   0%            IPv4 address for ens5: 172.31.34.27

* Ubuntu Pro delivers the most comprehensive open source security and
  compliance features.

  https://ubuntu.com/aws/pro

Expanded Security Maintenance for Applications is not enabled.

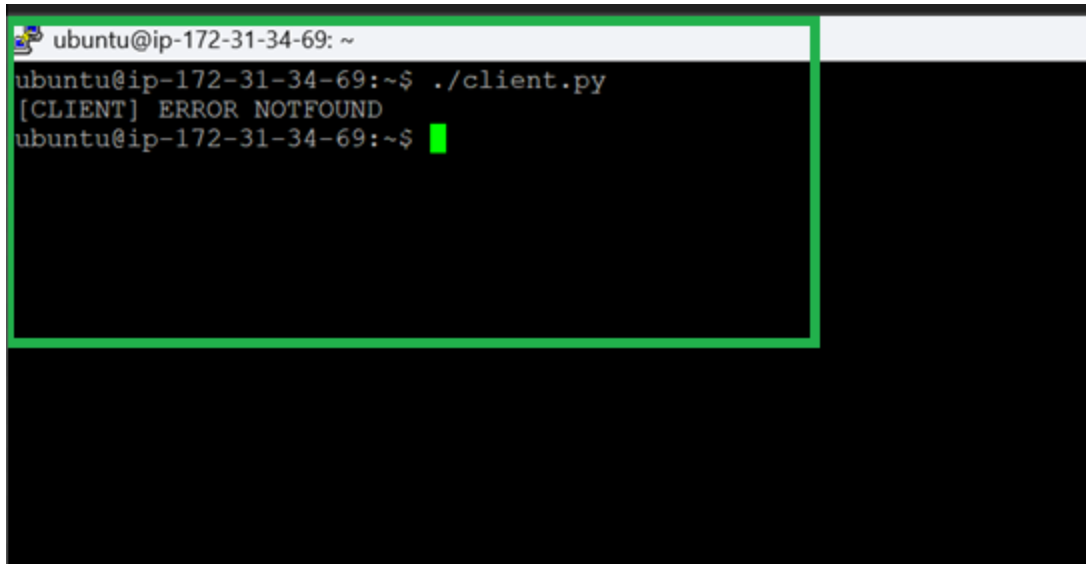
9 updates can be applied immediately.
To see these additional updates run: apt list --upgradable

Enable ESM Apps to receive additional future security updates.
See https://ubuntu.com/esm or run: sudo pro status

*** System restart required ***
Last login: Sat Sep 13 11:18:39 2025 from 122.172.87.11
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ubuntu@ip-172-31-34-27:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 3.2K Sep  7 14:43 server1.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 08:04 file_storage
ubuntu@ip-172-31-34-27:~$ cd file_storage/
ubuntu@ip-172-31-34-27:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ rm -rf file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ ls

ubuntu@ip-172-31-45-10: ~
ubuntu@ip-172-31-45-10:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 1.6K Sep  7 14:33 server2.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 13 08:10 file_storage
ubuntu@ip-172-31-45-10:~$ cd file_storage/
ubuntu@ip-172-31-45-10:~/file_storage$ ls
file1.txt
ubuntu@ip-172-31-45-10:~/file_storage$ rm -rf file1.txt
ubuntu@ip-172-31-45-10:~/file_storage$ cd ../
ubuntu@ip-172-31-45-10:~$ ./server2.py
[SERVER2] Listening on 0.0.0.0:5002
[SERVER2] file1.txt not found for ('172.31.34.27', 51210)
```

A terminal window with a black background and green text. The window title is 'ubuntu@ip-172-31-34-69: ~'. The command prompt shows 'ubuntu@ip-172-31-34-69:~\$./client.py'. The output is '[CLIENT] ERROR NOTFOUND'. The prompt is followed by a green cursor.

```
ubuntu@ip-172-31-34-69: ~
ubuntu@ip-172-31-34-69:~$ ./client.py
[CLIENT] ERROR NOTFOUND
ubuntu@ip-172-31-34-69:~$
```

Test Case4

File Read Operation When Servers Have Identical File

Single Copy Sent by Server1 to client if files are identical both on Server 1 and Server 2.

- **Precondition**
 - `file1.txt` exists on both **Server1** and **Server2** with identical content.
 - Client, Server1, and Server2 are configured properly with the Python scripts.
- **Test Steps**
 - Keep `file1.txt` on **Server1** and **Server2** with the same content.
 - Execute the Python script from the **Client** machine.
 - Server1 should handle the client request and send **one copy** of `file1.txt`.
- **Expected Result**
 - The client should successfully receive and read the file content from **Server1**.
 - The client should **not** receive duplicate copies, even though the file also exists on Server2.
 - Output should show the file content exactly **once**.

Server1 Content:

```
ubuntu@ip-172-31-34-27: ~/file_storage
ubuntu@ip-172-31-34-27:~$ cd file_storage/
ubuntu@ip-172-31-34-27:~/file_storage$ ls
ubuntu@ip-172-31-34-27:~/file_storage$ touch file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ vi file1.txt
ubuntu@ip-172-31-34-27:~/file_storage$ cat file1.txt
Hello, this is the test file.
This file is identical on both Server1 and Server2.
Only one copy should be sent to the client.

ubuntu@ip-172-31-34-27:~/file_storage$ █
```

Server2 Content:

```
ubuntu@ip-172-31-45-10: ~/file_storage
ubuntu@ip-172-31-45-10:~$ pwd
/home/ubuntu
ubuntu@ip-172-31-45-10:~$ ls -ltrh
total 8.0K
-rwxrwxr-x 1 ubuntu ubuntu 1.6K Sep  7 14:33 server2.py
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 14 07:06 file_storage
ubuntu@ip-172-31-45-10:~$ cd file_storage/
ubuntu@ip-172-31-45-10:~/file_storage$ ls
ubuntu@ip-172-31-45-10:~/file_storage$ vi file1.txt
ubuntu@ip-172-31-45-10:~/file_storage$ cat file1.txt
Hello, this is the test file.
This file is identical on both Server1 and Server2.
Only one copy should be sent to the client.

ubuntu@ip-172-31-45-10:~/file_storage$ █
```

Execute scripts [client.py](#), [server1.py](#) & [server2.py](#)

```
ubuntu@ip-172-31-45-10: ~  
ubuntu@ip-172-31-45-10:~$ pwd  
/home/ubuntu  
ubuntu@ip-172-31-45-10:~$ ls -ltrh  
total 8.0K  
-rwxrwxr-x 1 ubuntu ubuntu 1.6K Sep  7 14:33 server2.py  
drwxrwxr-x 2 ubuntu ubuntu 4.0K Sep 14 07:06 file_storage  
ubuntu@ip-172-31-45-10:~$ cd file_storage/  
ubuntu@ip-172-31-45-10:~/file_storage$ ls  
ubuntu@ip-172-31-45-10:~/file_storage$ vi file1.txt  
ubuntu@ip-172-31-45-10:~/file_storage$ cat file1.txt  
Hello, this is the test file.  
This file is identical on both Server1 and Server2.  
Only one copy should be sent to the client.  
  
ubuntu@ip-172-31-45-10:~/file_storage$ cd ..  
ubuntu@ip-172-31-45-10:~$ ./server2.py  
[SERVER2] Listening on 0.0.0.0:5002  
[SERVER2] Sent file1.txt (127 bytes) to ('172.31.34.27', 44882)
```

```
ubuntu@ip-172-31-34-27: ~  
ubuntu@ip-172-31-34-27:~$ cd file_storage/  
ubuntu@ip-172-31-34-27:~/file_storage$ ls  
ubuntu@ip-172-31-34-27:~/file_storage$ touch file1.txt  
ubuntu@ip-172-31-34-27:~/file_storage$ vi file1.txt  
ubuntu@ip-172-31-34-27:~/file_storage$ cat file1.txt  
Hello, this is the test file.  
This file is identical on both Server1 and Server2.  
Only one copy should be sent to the client.  
  
ubuntu@ip-172-31-34-27:~/file_storage$ cd ..  
ubuntu@ip-172-31-34-27:~$ ./server1.py  
[SERVER1] Listening on 0.0.0.0:5001  
[SERVER1] CLIENT ('172.31.34.69', 60126) requested file1.txt  
[SERVER1] Both matched → sent ONE
```

```
ubuntu@ip-172-31-34-69: ~  
ubuntu@ip-172-31-34-69:~$ ./client.py  
[CLIENT] Received ONE copy:  
Hello, this is the test file.  
This file is identical on both Server1 and Server2.  
Only one copy should be sent to the client.  
  
ubuntu@ip-172-31-34-69:~$ █
```