Experiment - 7

Aim: To develop a simple IoT-based device control system using Flask as a web framework and ngrok for exposing the local server to the internet, allowing remote control of an LED-like device.

Objectives

- To implement a web-based interface for controlling an IoT device (LED).
- To use **Flask** to create a lightweight API for device control.
- To expose the local Flask server to the internet using **ngrok**.
- To enable remote control of the device via API calls.

Tools Used

- **Python** (Version 3.x)
- **Flask** (for creating the web server)
- **ngrok** (for exposing Flask to the internet)
- **pip** (Python package manager)
- **Web Browser** (for testing API)
- **Postman** (optional, for API testing)
- **Command Prompt/Terminal** (for running the server)

Theory

Introduction to IoT and Web-based Control

The Internet of Things (IoT) enables physical devices, such as sensors and actuators, to be controlled remotely via the internet. In this experiment, we simulate an IoT device (an LED) that can be turned **ON** or **OFF** using a **Flask web server** and control it remotely through **ngrok**.

The main components of this system include:

- **Flask (Python-based Web Framework)**: Handles HTTP requests and processes commands.
- **ngrok (Tunneling Tool)**: Exposes the locally running Flask application to the public internet, allowing remote control.
- **REST API (GET Requests)**: Allows users to send commands to control the LED state.

Why Use Flask?

Flask is a **lightweight and easy-to-use** web framework that allows:

- Handling **HTTP requests** efficiently.
- Creating **RESTful APIs** to interact with IoT devices.
- Providing **JSON-based responses** that can be used in mobile apps or web dashboards.

Understanding Flask API Endpoints

APIs allow **external systems** (e.g., web apps, mobile apps, or othercomputers) to interact with our IoT device.

In this experiment, we define three **Flask API endpoints**:

Endpoint	**Method**	**Description**
`/`	`GET`	Displays instructions on how to use the API.
`/control?device=LED &state=ON`	`GET`	Turns the LED ON.
`/control?device=LED &state=OFF`	`GET`	Turns the LED OFF.
`/status`	`GET`	Returns the current state of the LED.

Role of ngrok

Flask runs on a **local server** (`127.0.0.1:5000`), which is only accessible on the local machine. To control the LED **from outside the local network**, we need **ngrok**.

ngrok provides:

A Public URL for Flask Server

- ●Converts `http://127.0.0.1:5000 → http://your-ngrok-url.ngrok.io`
- ●**Secure Tunneling**
- ●No need to configure **firewalls or routers**.
- ●**Remote Access**
- ●Users can send API requests from **any device**, anywhere in the world.

How Flask and ngrok Work Together

- ●Flask starts a local web server on 127.0.0.1:5000.
- ●ngrok creates a public URL, forwarding all requests to the Flask server.
- ●Users send HTTP requests (via a web browser or API tools like Postman) to control the LED.
- ●Flask processes the requests and updates the LED state.
- ●Flask sends a response confirming the action.

Program Code cum Procedure

Step 1: Install Required Packages

Before running the program, install dependencies:

```
pip install flask pyngrok
```

Step 2: Save the Flask Code as app.py

code :

```
from flask import Flask, request, jsonify
app = Flask(__name__)
device_state = {"LED": "OFF"} # Initial state of the
virtual IoT device @app.route('/')
def home():
 return "<h1>IoT Device Control</h1><p>Use
/control?device=LED&state=ON  to control the device.</p>"
@app.route('/control', methods=['GET'])
def control_device():
 device = request.args.get('device')
 state = request.args.get('state')
 if device in device_state and state in
["ON", "OFF"]:  device_state[device] =
state
```

```
 return jsonify({"message": f"{device} turned
{state}"})  else:
 return jsonify({"error": "Invalid device
or state"}) @app.route('/status',
methods=['GET'])
def device_status():
 return jsonify(device_state)
if __name__ == '__main__':
 app.run(host='0.0.0.0', port=5000)
```

Step 3: Run Flask Server

Open Command Prompt (Windows) or Terminal (Linux/Mac) and navigate to the directory where `app.py` is saved:

```
python app.py
```

Output:

```
Running on http://127.0.0.1:5000/
```

Step 4: Start ngrok

In a new terminal window, run:

```
ngrok http 5000
```

It will generate a **public URL**, e.g.:

```
http://your-ngrok-url.ngrok.io -> http://127.0.0.1:5000
```

Step 5: Test the API

Use your browser or Postman to access the following URLs:

Home Page

```
http://your-ngrok-url.ngrok.io/
```

Expected Output:

```
<h1>IoT Device Control</h1><p>Use
/control?device=LED&state=ON to control  the device.</p>
```

Turn LED ON

`http://your-ngrok-url.ngrok.io/control?de`
`vice=LED&state=ON` **Expected JSON Response**:

```
{"message": "LED turned ON"}
```

Turn LED OFF

`http://your-ngrok-url.ngrok.io/control?dev`
`ice=LED&state=OFF` **Expected JSON Response**:

```
{"message": "LED turned OFF"}
```

Check LED Status

```
http://your-ngrok-url.ngrok.io/status
```

Expected JSON Response:

```
{"LED": "ON"} # or "OFF" depending on last action
```

Explanation of the Program

Import Required Modules

```
from flask import Flask, request, jsonify
```

- `Flask`: Used to create a web server.
- `request`: Extracts parameters from API requests.
- `jsonify`: Formats responses in **JSON** format.

Initialize Flask App

```
app = Flask(__name__)
```

- `Flask(__name__)` initializes a **Flask web application**.

Define the LED State

```
  device_state = {"LED": "OFF"} # Initial state of the
  virtual IoT device
```

● A **dictionary** (`device_state`) stores the LED's status.

- Initially, the **LED is OFF**.

Define the Home Route (/)

```
@app.route('/')
def home():
return "<h1>IoT Device Control</h1><p>Use
/control?device=LED&state=ON  to control the device.</p>"
```

- Displays instructions for using the API when accessed.

Define the Control Route (`/control`)

```
@app.route('/control', methods=['GET'])
def control_device():
 device = request.args.get('device') # Get 'device'
parameter from URL  state = request.args.get('state') #
Get 'state' parameter from URL  if device in device_state
and state in ["ON", "OFF"]:  device_state[device] = state
# Update the LED state  return jsonify({"message":
f"{device} turned {state}"})  else:
 return jsonify({"error": "Invalid device
or state"})
```

How It Works:

- Extracts **device name** (`LED`) and **desired state** (`ON` or

`OFF`) from the **query parameters**.

●If valid, it **updates the device state** and returns a confirmation message. ● If invalid, it returns an **error message**.

Example Usage:

```
http://127.0.0.1:5000/control?device=LED&state=ON
```

Response:

```
{"message": "LED turned ON"}
```

```
http://127.0.0.1:5000/control?device=LED&state=OFF
```

Response:

```
{"message": "LED turned OFF"}
```

Define the Status Route (`/status`)

```
@app.route('/status', methods=['GET'])
def device_status():
 return jsonify(device_state) # Returns the current
  state of the LED
```

● Returns the current state of the LED in JSON format.

●Example Usage:

```
http://127.0.0.1:5000/status
{"LED": "ON"}
```

Start the Flask Server

```
if __name__ == '__main__':
 app.run(host='0.0.0.0', port=5000)
```

●Runs Flask on port 5000.

●host='0.0.0.0' allows access from any network.

Exposing Flask via ngrok

After starting Flask, we need to **expose it to the internet**:

Run this command in a new terminal window:

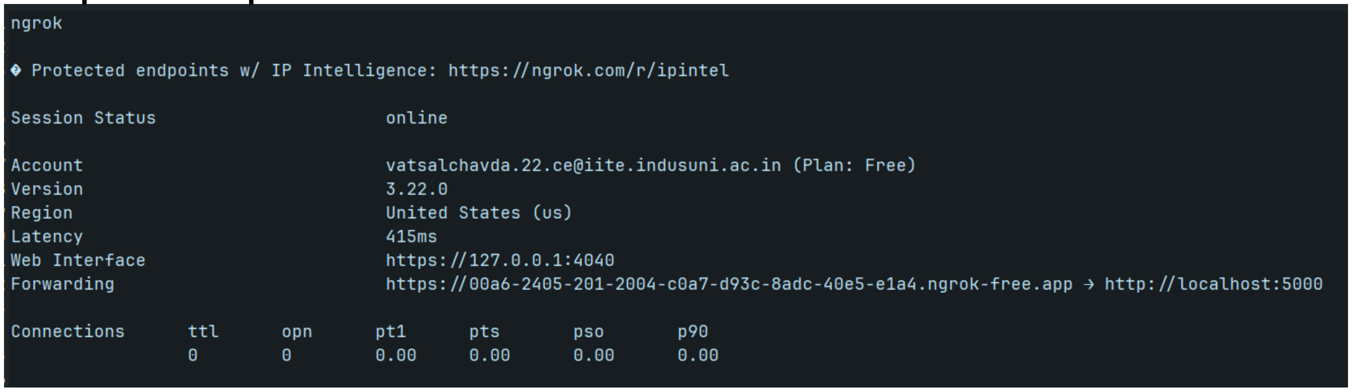
```
ngrok http 5000
```

Expected output:

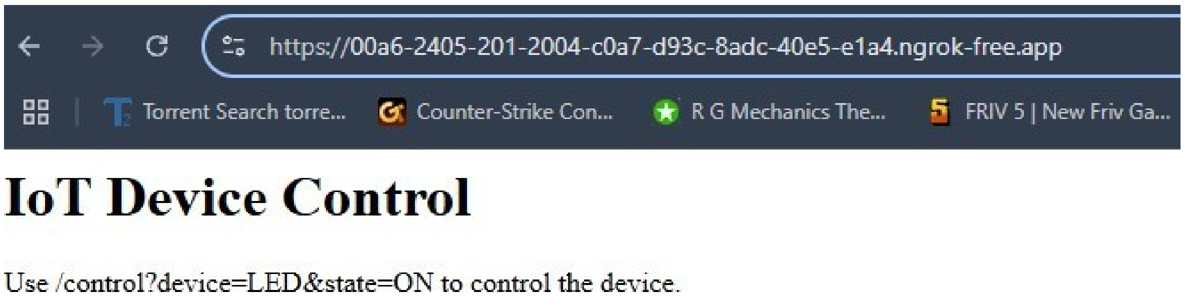
```
Forwarding http://your-ngrok-url.ngrok.io ->
http://127.0.0.1:5000
```

Now, use the **ngrok URL** to access the API from **anywhere**.

Expected Outputs:

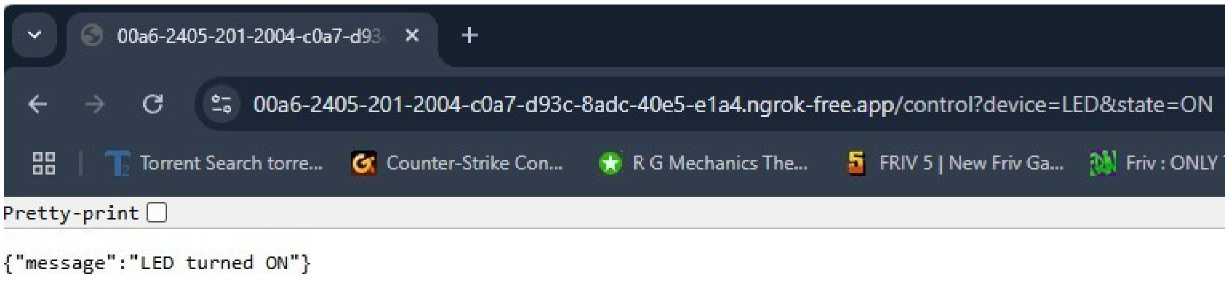


```
ngrok

� Protected endpoints w/ IP Intelligence: https://ngrok.com/r/ipintel

Session Status                online

Account                       vatsalchavda.22.ce@iite.indusuni.ac.in (Plan: Free)
Version                       3.22.0
Region                        United States (us)
Latency                       415ms
Web Interface                 https://127.0.0.1:4040
Forwarding                    https://00a6-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app → http://localhost:5000

Connections       ttl     opn     pt1     pts     pso     p90
                  0       0       0.00    0.00    0.00    0.00
```



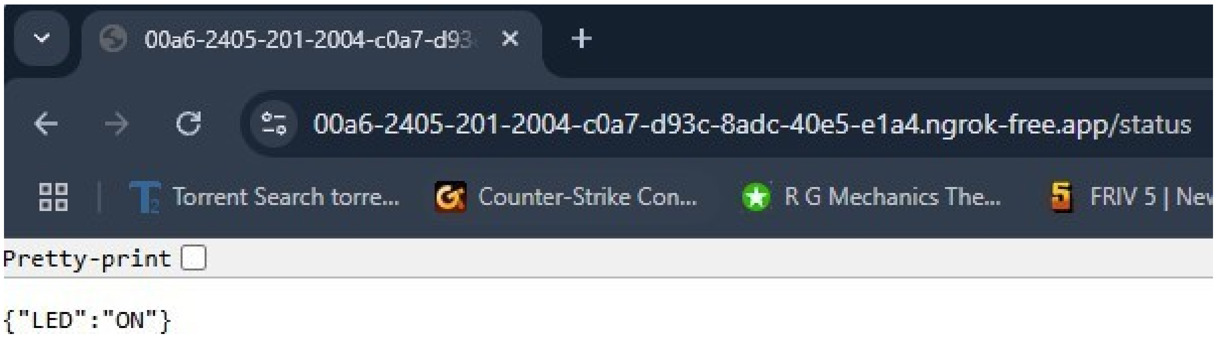
IoT Device Control

Use /control?device=LED&state=ON to control the device.



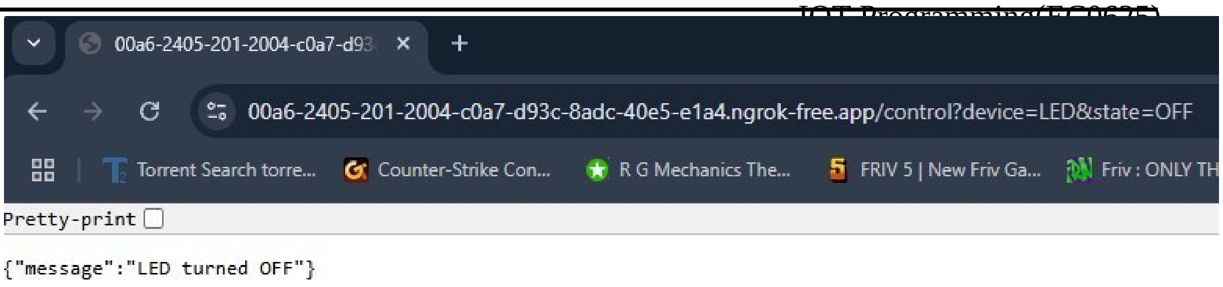
00a6-2405-201-2004-c0a7-d93
00a6-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app/control?device=LED&state=ON
Torrent Search torre...
Counter-Strike Con...
R G Mechanics The...
FRIV 5 | New Friv Ga...
Friv : ONLY
Pretty-print

```
{"message":"LED turned ON"}
```



00a6-2405-201-2004-c0a7-d93
00a6-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app/status
Torrent Search torre...
Counter-Strike Con...
R G Mechanics The...
FRIV 5 | New
Pretty-print

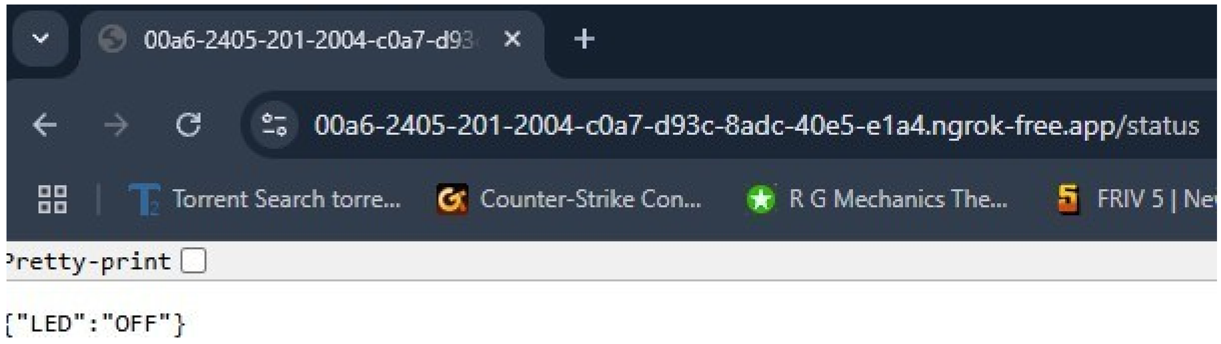
```
{"LED":"ON"}
```



00a6-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app/control?device=LED&state=OFF

Pretty-print

```
{"message":"LED turned OFF"}
```



00a6-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app/status

Pretty-print

```
{"LED":"OFF"}
```

Conclusion:

This experiment successfully demonstrates remote control of an IoT device using Flask and ngrok. Flask provides a lightweight, easy-to-use API for controlling the LED.ngrok allows secure remote access without configuring firewalls.This approach can be extended to control real IoT hardware (Raspberry Pi, Arduino, ESP32, etc.).

Homework

Task: Extend the program by adding another virtual IoT device (e.g., a fan) and allow users to control its state.

Objectives

●To implement a web-based interface for controlling an IoT device (LED & FAN). ● To use **Flask** to create a lightweight API for device control.
●To expose the local Flask server to the internet using **ngrok**.
●To enable remote control of the device via API calls.

Tools Used

●**Python** (Version 3.x)
●**Flask** (for creating the web server)
●**ngrok** (for exposing Flask to the internet)
●**pip** (Python package manager)
●**Web Browser** (for testing API)
●**Postman** (optional, for API testing)
●**Command Prompt/Terminal** (for running the server

Understanding Flask API Endpoints

APIs allow **external systems** (e.g., web apps, mobile apps, or other computers) to interact with our IoT device.

In this experiment, we define three **Flask API endpoints**:

Endpoint	Method	Description
/	GET	Displays instructions on how to use the API.
/control?device= FAN &state=ON	GET	Turns the FAN ON.
/control?device= FAN &state=OFF	GET	Turns the FAN OFF.
/status	GET	Returns the current state of the LED & FAN.

Program Code cum Procedure

Step 1: Install Required Packages

Before running the program, install dependencies:

```
pip install flask pyngrok
```

Step 2: Save the Flask Code as app.py

code :

```
from flask import Flask, request, jsonify
app = Flask(__name__)
device_state = {"LED": "OFF", "Fan": "OFF"} # Initial
state of LED and Fan @app.route('/')
def home():
    return "<h1>IoT Device Control</h1><p>Use
/control?device=FAN&state=ON  to control the device.</p>"
@app.route('/control', methods=['GET'])
```

```
def control_device():
    device = request.args.get('device')
    state = request.args.get('state')
    if device in device_state and state in ["ON", "OFF"]:
        device_state[device] = state
        return jsonify({"message": f"{device} turned {state}"})
    else:
        return jsonify({"error": "Invalid device or state"})
@app.route('/status', methods=['GET'])
def device_status():
    return jsonify(device_state)
if __name__ == '__main__':
    app.run(host='0.0.0.0', port=5000)
```

Step 3: Run Flask Server

Open Command Prompt (Windows) or Terminal (Linux/Mac) and navigate to the directory where `app.py` is saved:

```
python app.py
Running on http://127.0.0.1:5000/
```

Step 4: Start ngrok

In a new terminal window, run:

```
ngrok http 5000
```

It will generate a **public URL**, e.g.:

```
http://your-ngrok-url.ngrok.io -> http://127.0.0.1:5000
```

Step 5: Test the API

Use your browser or Postman to access the following URLs:

Home Page

```
http://your-ngrok-url.ngrok.io/
```

Expected Output:

```
<h1>IoT Device Control</h1><p>Use
/control?device=FAN&state=ON to control  the device.</p>
```

Turn FAN ON

```
http://your-ngrok-url.ngrok.io/control?device=FAN&state=ON
```

Expected JSON Response:

```
{"message": "FAN turned ON"}
```

Turn FAN OFF

```
http://your-ngrok-url.ngrok.io/control?device=FAN&state=OFF
```

Expected JSON Response:

```
{"message": "FAN turned OFF"}
```

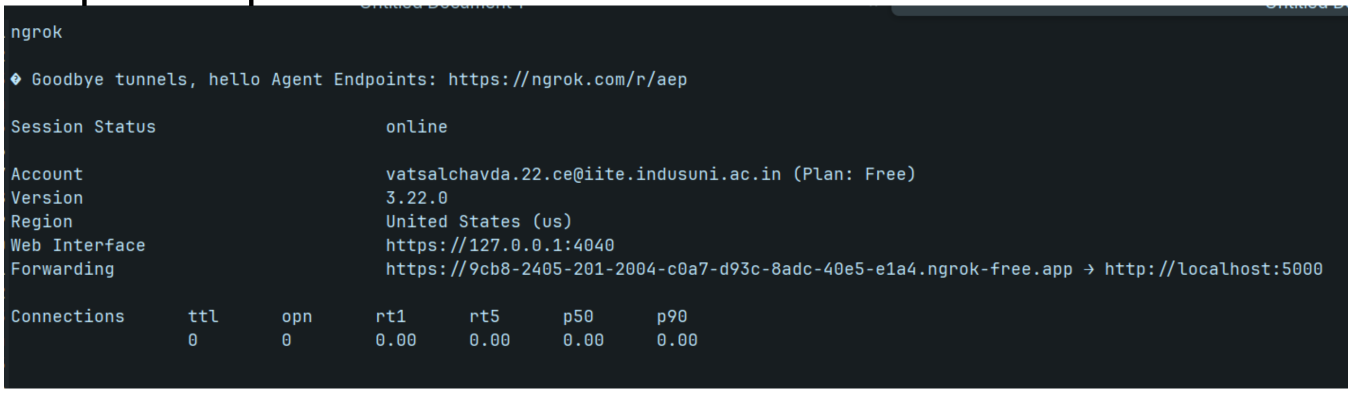
Check FAN Status

```
http://your-ngrok-url.ngrok.io/status
```

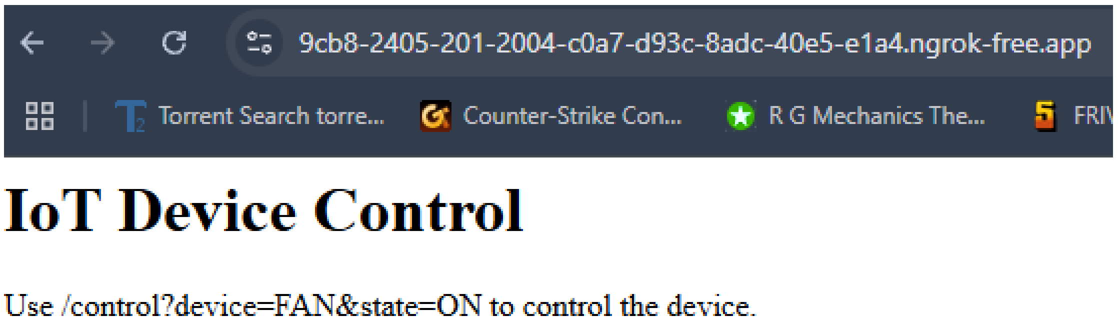
Expected JSON Response:

```
{"FAN": "ON"} # or "OFF" depending on last action
```

Expected Outputs:

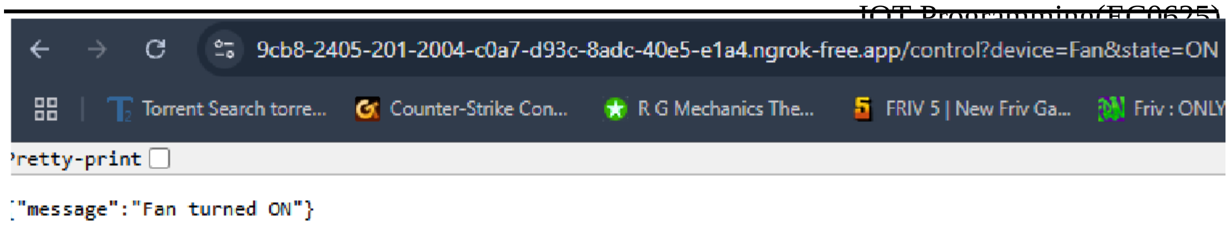


```
ngrok

� Goodbye tunnels, hello Agent Endpoints: https://ngrok.com/r/aep

Session Status                online

Account                       vatsalchavda.22.ce@iite.indusuni.ac.in (Plan: Free)
Version                       3.22.0
Region                        United States (us)
Web Interface                 https://127.0.0.1:4040
Forwarding                    https://9cb8-2405-201-2004-c0a7-d93c-8adc-40e5-e1a4.ngrok-free.app -> http://localhost:5000

Connections       ttl     opn     rt1     rt5     p50     p90
                  0       0       0.00    0.00    0.00    0.00
```

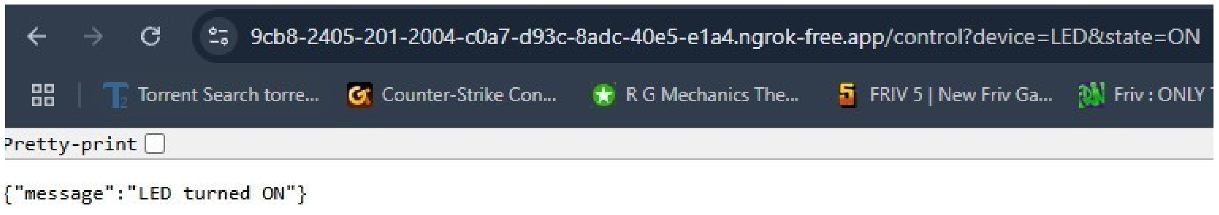


IoT Device Control

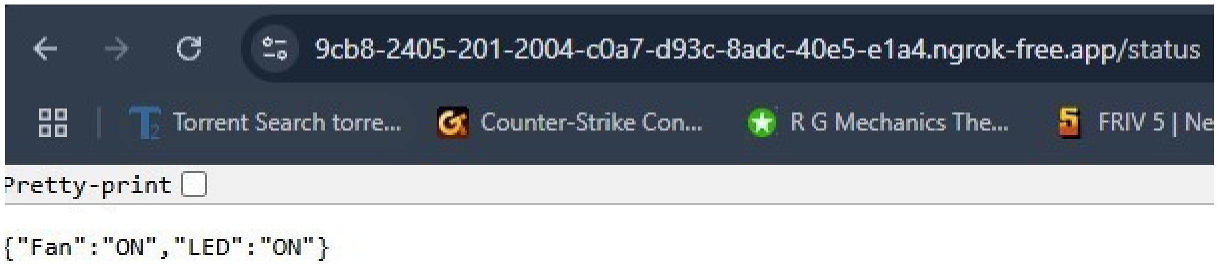
Use /control?device=FAN&state=ON to control the device.



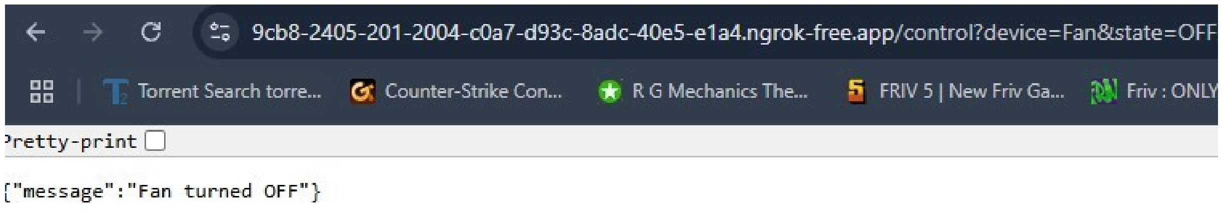
```
{"message":"Fan turned ON"}
```



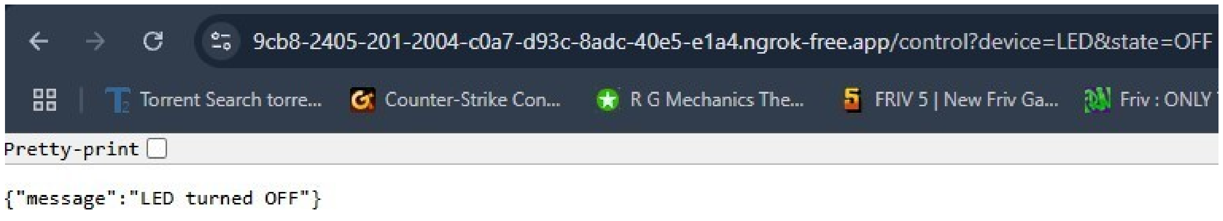
```
{"message":"LED turned ON"}
```



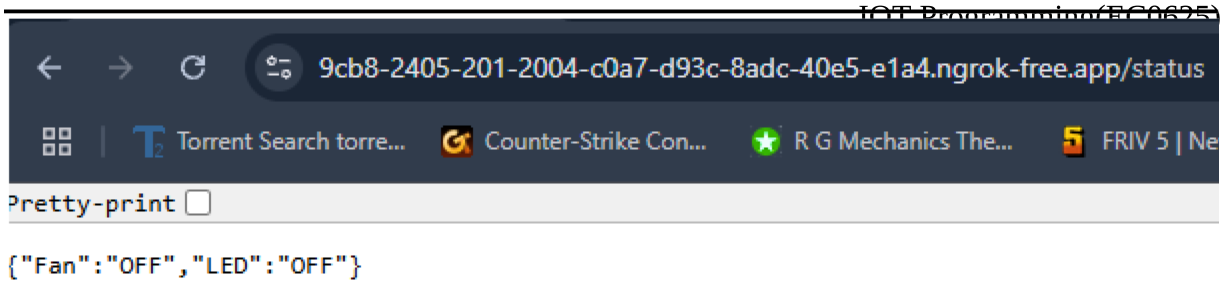
```
{"Fan":"ON","LED":"ON"}
```



```
{"message":"Fan turned OFF"}
```



```
{"message":"LED turned OFF"}
```



```
{"Fan":"OFF","LED":"OFF"}
```

Conclusion:

This experiment successfully demonstrates remote control of an IoT device using Flask and ngrok. Flask provides a lightweight, easy-to-use API for controlling the LED and Fan.ngrok allows secure remote access without configuring firewalls.This approach can be extended to control real IoT hardware (Raspberry Pi, Arduino, ESP32, etc.).