Web Programming

Server-side programming III.

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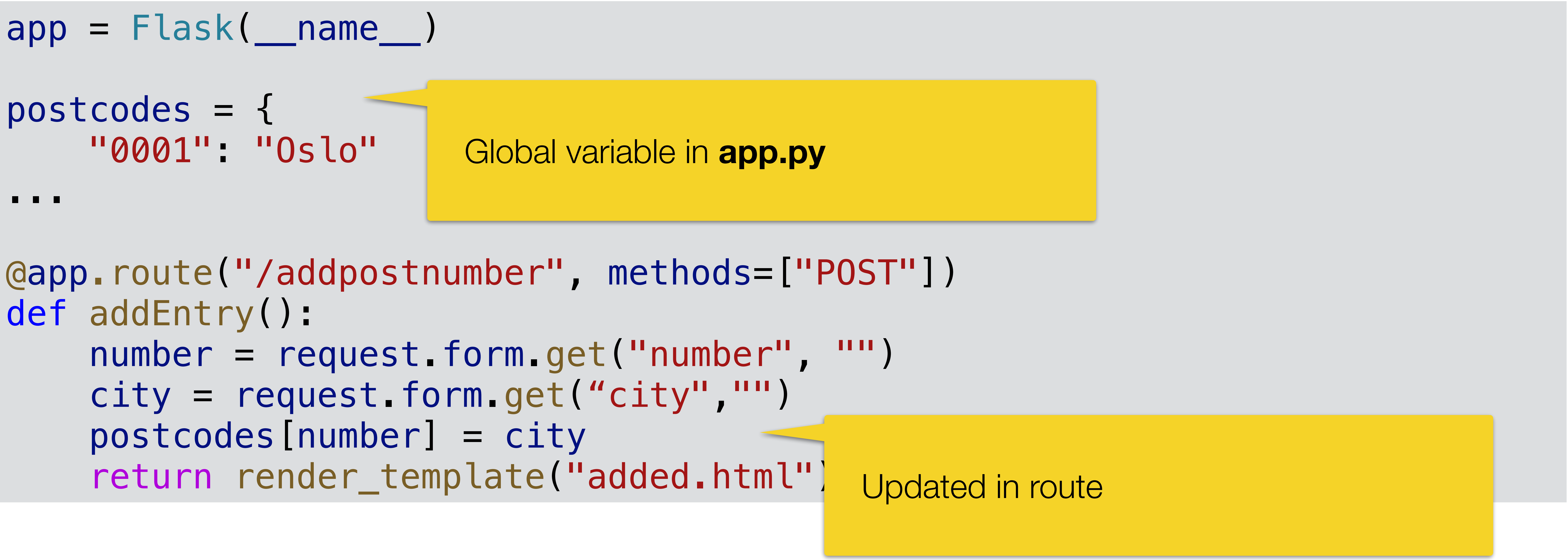
Server-side programming

- Part I. handling requests
- Part II. templating
- Part III. Storing data
- Part IV. cookies and sessions

State 1: global variables

Example

- A global variable is read and written to



```
app = Flask(__name__)

postcodes = {
    "0001": "Oslo"
...

@app.route("/addpostnumber", methods=["POST"])
def addEntry():
    number = request.form.get("number", "")
    city = request.form.get(“city","")
    postcodes[number] = city
    return render_template("added.html")
```

Global variable in **app.py**

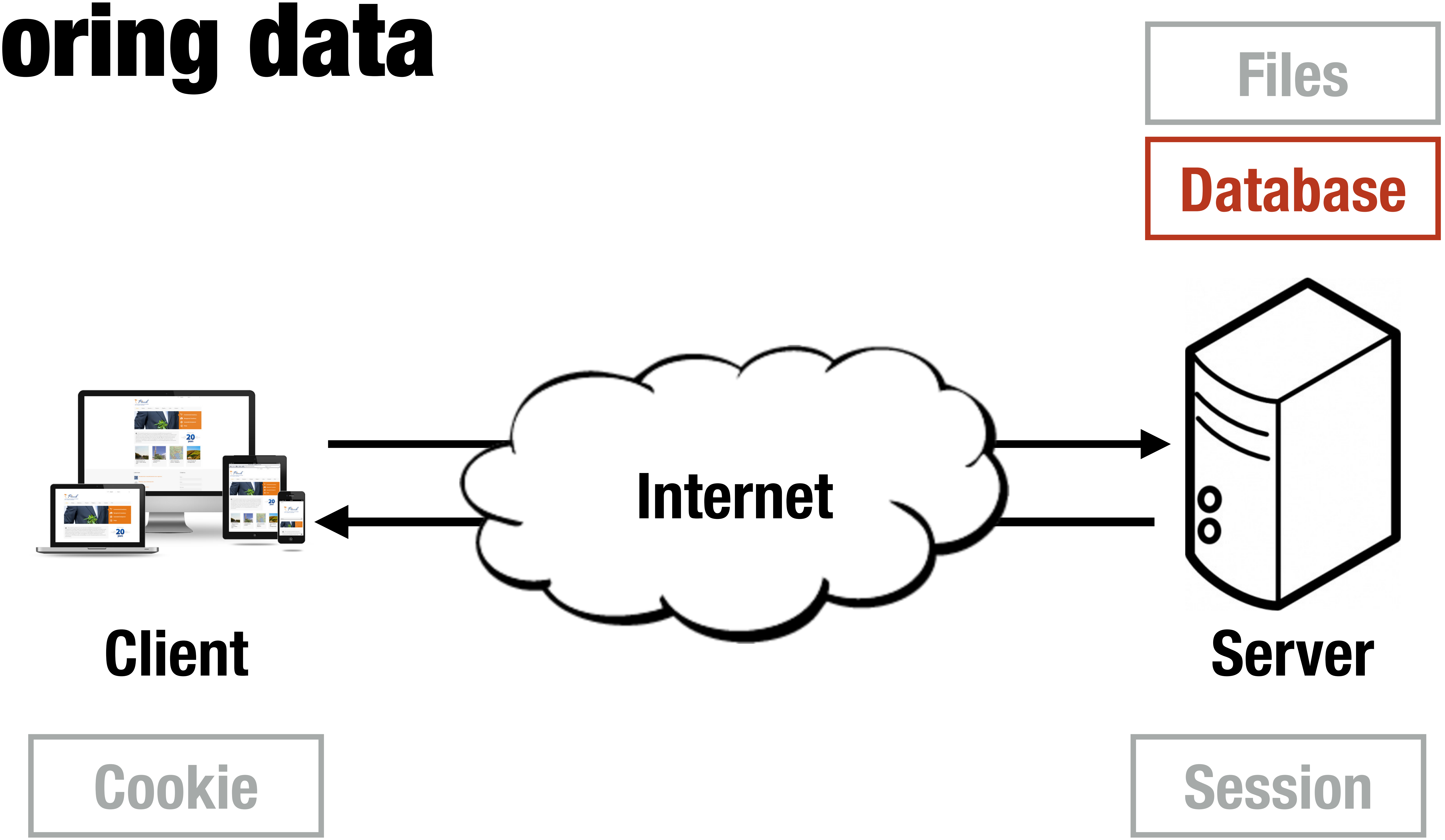
Updated in route

State in global variable

- State is not persisted when program stops
- Not thread safe:
    - When multiple clients are connected, this may give:
        - Incorrect values
        - Program crashes

Not good in production. Use Lock.
Ok for testing.

Storing data



Files

Database

Internet

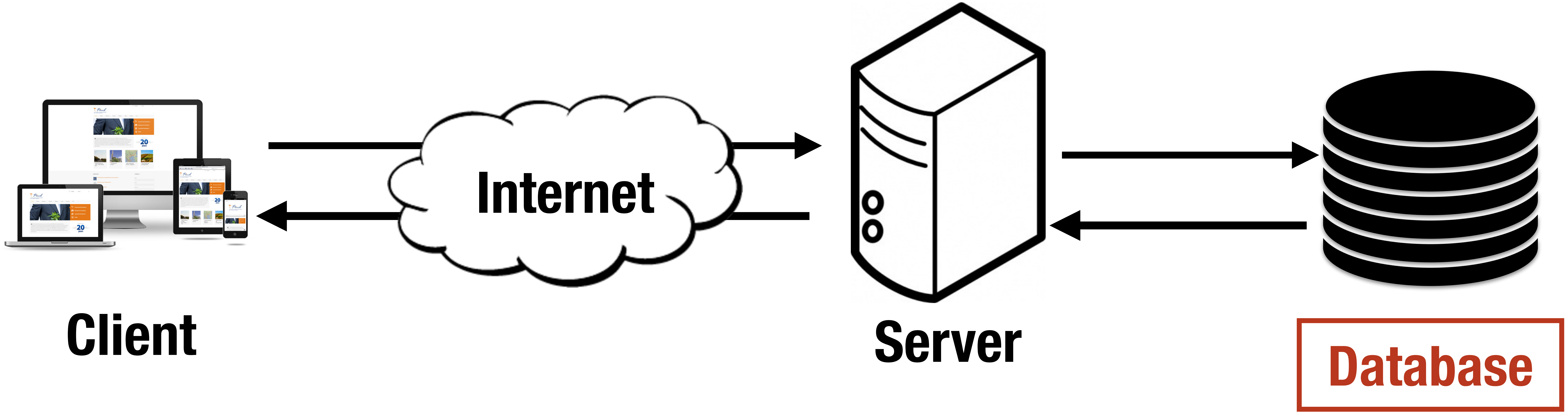
Client

Server

Cookie

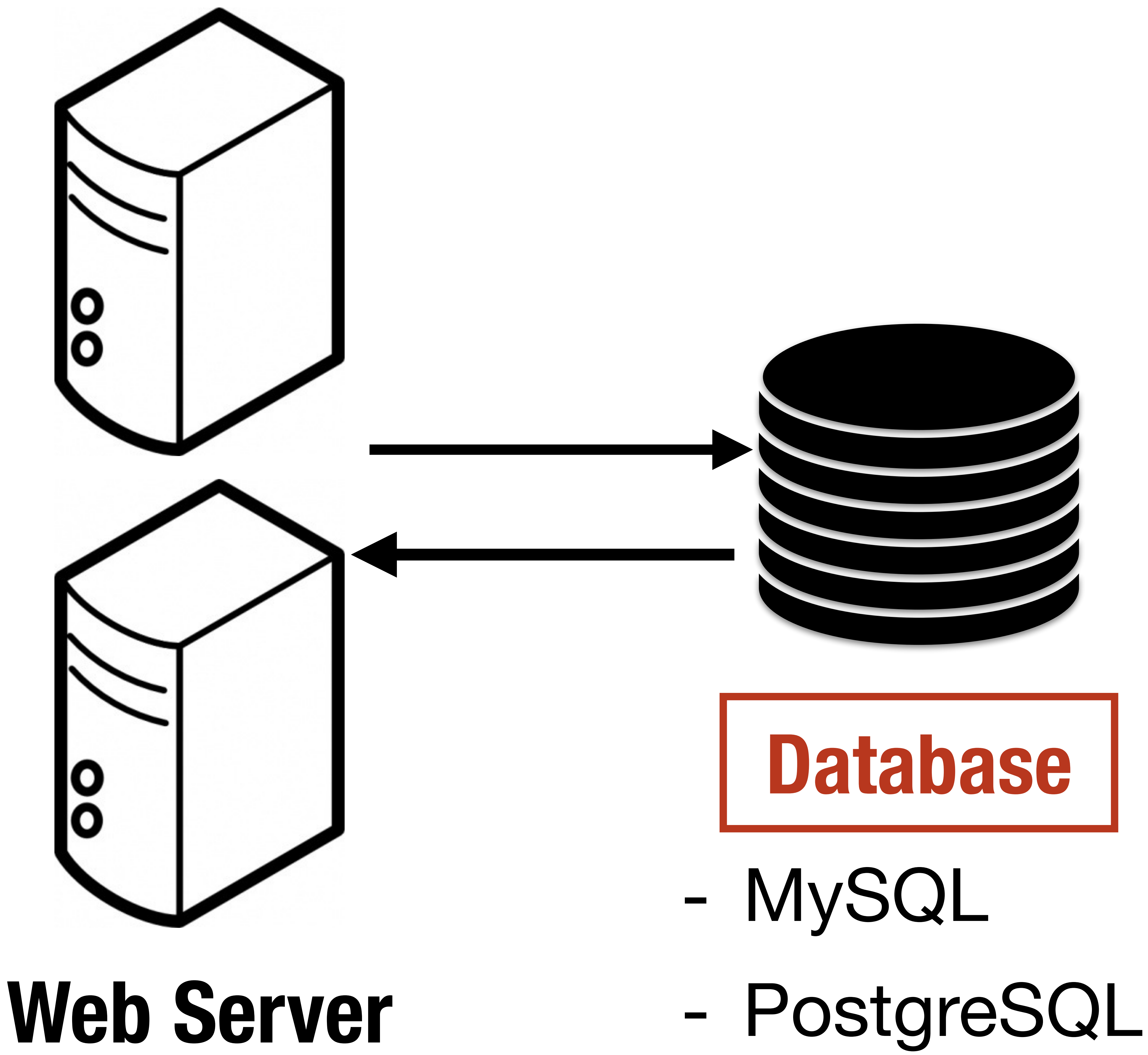
Session

Architecture



Architecture

- Database server:
  - maintains state
  - stays consistent
- Web servers:
  - process client request
  - access state from database servers
  - may cache state but otherwise stateless



- MySQL
- PostgreSQL
- SQL Server

SQLite

- Lightweight database:
    - Store database in a file
    - Good for prototyping and examples
    - Only for single webserver
    - Tutorial: https://www.sqlitetutorial.net/
    - Try it editor: https://www.sqlitetutorial.net/tryit/

Databases store data in Tables:

- Defined column names
- Same columns on every row

Can add information and constraints to column, e.g. type, length, non-empty

Postcodes

number	city
"0001"	"Oslo"
“4036"	“Stavanger”
"4041"	“Hafrsfjord"
"7491"	"Trondheim"
"9019"	"Tromsø"

CREATE TABLE

- Create a table with row names:

```
CREATE TABLE postcode (number, city);
```

```
CREATE TABLE <tablename>
(<rowname>,<rowname>, ...);
```

Postcodes

number	city
"0001"	"Oslo"
“4036"	“Stavanger”
"4041"	“Hafrsfjord"
"7491"	"Trondheim"
"9019"	"Tromsø"

INSERT

- Insert a row into a table

```
INSERT INTO postcode (number, city) VALUES ('0001', 'Oslo');
```

```
INSERT INTO <tablename> (<rowname>,<rowname>) VALUES (value, value);
```

- Insert multiple values at once

```
INSERT INTO postcode (number, city) VALUES ('4036', 'Stavanger'), ('4024', ‘Stavanger');
```

SELECT

- Select named columns

```
SELECT number, city FROM postcode;
```

- Select all columns

```
SELECT * FROM postcode;
```

- Select rows with specific values

```
SELECT city FROM postcode WHERE number = '4036';
```

- Apply function to result, e.g. count rows:

```
SELECT COUNT(number) FROM postcode WHERE city = 'Stavanger';
```

DELETE & UPATE

- DELETE rows with specific values

```
DELETE FROM postcode WHERE city = 'Stavanger' AND number = '4024';
```

- UPDATE rows with specific values

```
UPDATE postcode SET city = 'Svg.' WHERE city = 'Stavanger';
```

Constraints

- Create a table with types and constraints

```
CREATE TABLE postcode
( number TEXT UNIQUE NOT NULL
              CHECK(length(number) == 4),
  city TEXT NOT NULL CHECK(length(number) > 0));
```

- Types:
  - TEXT, INTEGER, REAL

Sometimes: PRIMARY KEY is used instead of UNIQUE

Postcodes

number	city
"0001"	"Oslo"
“4036"	“Stavanger”
"4041"	“Hafrsfjord"
"7491"	"Trondheim"
"9019"	"Tromsø"

Rowid

- In SQLite, by default every row has a rowid

```
SELECT rowid, number, city FROM postcode;
```

  - rowid is useful as object identity

Postcodes

number	city
"0001"	"Oslo"
“4036"	“Stavanger”
"4041"	“Hafrsfjord"
"7491"	"Trondheim"
"9019"	"Tromsø"

FOREIGN KEY

- Contstraint connecting two tables
  - Make sure student exists.

```
CREATE TABLE grades (
  student INTEGER NOT NULL,
  grade TEXT NOT NULL,
  FOREIGN KEY (student)
    REFERENCES students (student_no);
```

Grades

grade	student
“A”	“123456”
“B”	“222222”

```
CREATE TABLE students (
  student_no INTEGER UNIQUE NOT NULL,
  name TEXT NOT NULL;
```

Student

student_no	name
“123456"	“Tom"
“222222”	“Alice”

Using SQLite from Python

Connectors

- Low level connectors vs. Object-relational mapping (ORM)
- Many packages for low level connection
  - Most of them are compliant with the Python Database API Specification (PEP 249) https://www.python.org/dev/peps/pep-0249/
- We will be using **PySQLite Connector/Python**
  - Included in the standard library
  - Similar inteface to database servers
  - Tutorial: https://www.sqlitetutorial.net/sqlite-python/

Python Database API Specification

- Two main objects
  - Connection
  - Cursor
- Connection methods
  - **`cursor()`** returns a new Cursor
  - **`close()`** closes connection to DB
  - **`commit()`** commits any pending transactions
  - **`rollback()`** rolls back to the start of any pending transaction (optional)

Connecting to a DB

```
import sqlite3


conn = sqlite3.connect(“database_file.db”)

# do some stuff

conn.close()
```

- The **`connect()`** constructor creates a connection to the SQLite database and returns a **`Connection`** object
- **`connect()`** takes the path to a database file (absolute or relative). If the file does not exist a new database is created.

Error Handling

examples/python/sqlite/sqlite1.py

```
from sqlite3 import Error


try:
    conn = sqlite3.connect(“database_file.db”)
except Error as err:
    print(err)
else:
    # do some stuff
   conn.close()
```

All database statements should be done inside `try: except:`

Python Database API Specification

- Cursor methods/attributes
  - **`execute()`** executes a database operation or query
  - **`rowcount`** read-only attribute, number of rows that the last execute command produced (SELECT) or affected (UPDATE, INSERT, DELETE)
  - **`close()`** closes the cursor
  - **`fetchone()`** fetches the next row of a query result set
  - **`fetchmany()`** fetches the next set of rows of a query result
  - **`fetchall()`** fetches all (remaining) rows of a query result
  - **`arraysize`** read/write attribute, specifying the number of rows to fetch at a time with **`fetchmany()`** (default is 1)

Creating a Table

examples/python/sqlite/sqlite1.py

```
cur = conn.cursor()
try:
    sql = ("CREATE TABLE postcodes ("
           "postcode TEXT, "
           "location TEXT)")
    cur.execute(sql)
except Error as err:
    print("Error: {}".format(err))
else:
    print("Table created.")
finally:
    cur.close()
```

Dropping a Table

examples/python/sqlite/sqlite1.py

```
cur = conn.cursor()
try:
    sql = "DROP TABLE postcodes"
    cur.execute(sql)
except Error as err:
    print("Error: {}".format(err))
else:
    print("Table dropped.")
finally:
    cur.close()
```

Inserting Data

examples/python/sqlite/sqlite1.py

```
sql = "INSERT INTO postcodes (postcode, location) VALUES (?, ?)”
try:
    cur.execute(sql, (k, v))  # data is provided as a tuple
    conn.commit()  # commit after each row
except Error as err:
    print("Error: {}".format(err))
```

- Add placeholder **?** to sql statement
- Data is provided as a tuple (list of values)
- DELETE and UPDATE work the same way
- You must **commit** the data after these statements

Inserting Data (2)

```
add_salary = ("INSERT INTO salaries "
              "(emp_no, salary, from_date, to_date) "
              "VALUES (%(emp_no)s, %(salary)s, %(from_date)s, %(to_date)s)")


# Insert salary information
data_salary = {
  'emp_no': emp_no,
  'salary': 50000,
  'from_date': tomorrow,
  'to_date': to_date,
}

cursor.execute(add_salary, data_salary)
```

- It is also possible to provide data in a dict

Querying Data

examples/python/sqlite/sqlite1.py

```
cur = conn.cursor()
try:
    sql = ("SELECT postcode, location FROM postcodes "
           "WHERE postcode BETWEEN ? AND ?”)
    cur.execute(sql, ("4000", "5000"))
    for (postcode, location) in cur:
        print("{}: {}".format(postcode, location))
except Error as err:
    print("Error: {}".format(err))
finally:
    cur.close()
```

- Use **cur.fetchall( )** to get list of row values

Object-Relational Mapping

- For Object-Relational Mapping (ORM), see SQLAlchemy
  - https://www.sqlalchemy.org/
  - Flask extension: http://flask.pocoo.org/docs/0.12/patterns/sqlalchemy/

```
users = Table('users', metadata,
    Column('user_id', Integer, primary_key=True),
    Column('name', String(40)),
    Column('age', Integer),
    Column('password', String),
)
users.create()

i = users.insert()
i.execute(name='Mary', age=30, password='secret')

s = users.select(users.c.age < 40)
rs = s.execute()
```

Using SQLite from Flask

Flask Contexts

- Flask provides two contexts
- `request` variable is associated with the current request

  ```
  from flask import request
  ```

- `g` is associated with the "global" application context

  ```
  from flask import g
  ```

  - typically used to cache resources that need to be created on a per-request case, e.g., DB connections
  - resource allocation: `get_X()` creates resource X if it does not exist yet, otherwise returns the same resource
  - resource deallocation: `teardown_X()` is a tear down handler

Example

examples/python/flask/5_sqlite/app.py

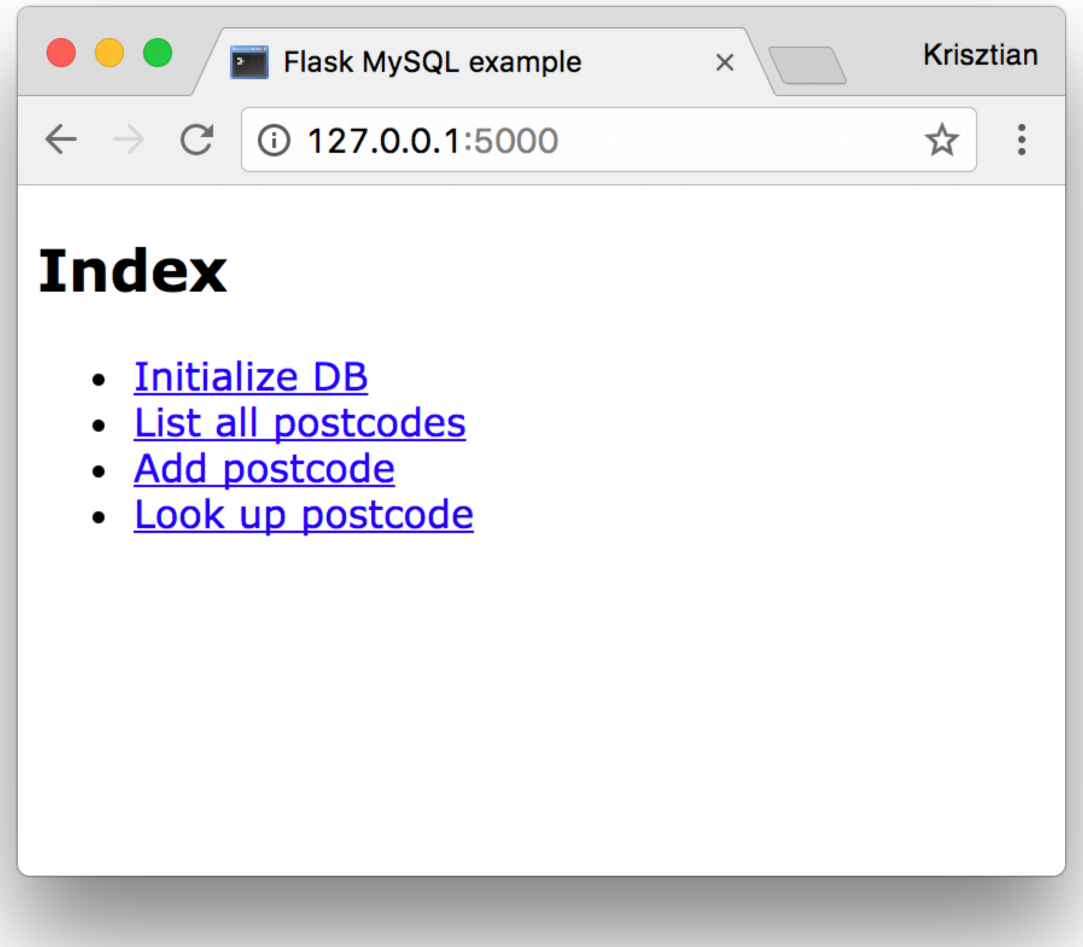
```python
def get_db():
    if not hasattr(g, "_database"):
        g._database = sqlite3.connect(“database.db")
   return g._database


@app.teardown_appcontext
def teardown_db(error):
    db = getattr(g, '_database', None)
    if db is not None:
        db.close()


@app.route("/listall")
def list_all():
    """List all postcodes."""
    db = get_db()
    cur = db.cursor()
```

The first time **`get_db()`** is called the connection will be established

Example

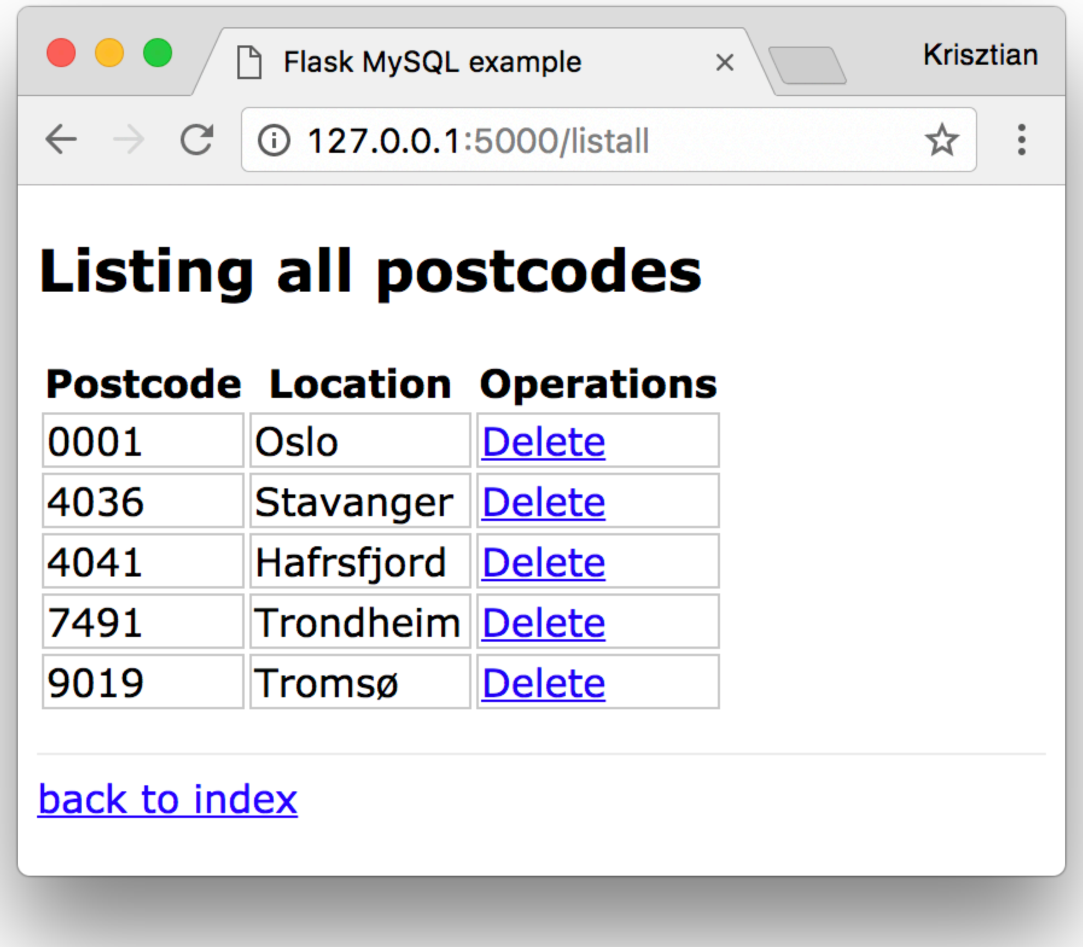
examples/python/flask/5_sqlite/app.py

- Contains examples of CREATE TABLE, INSERT, SELECT (single/multiple records), DELETE
- Uses flashing for success messages



Index

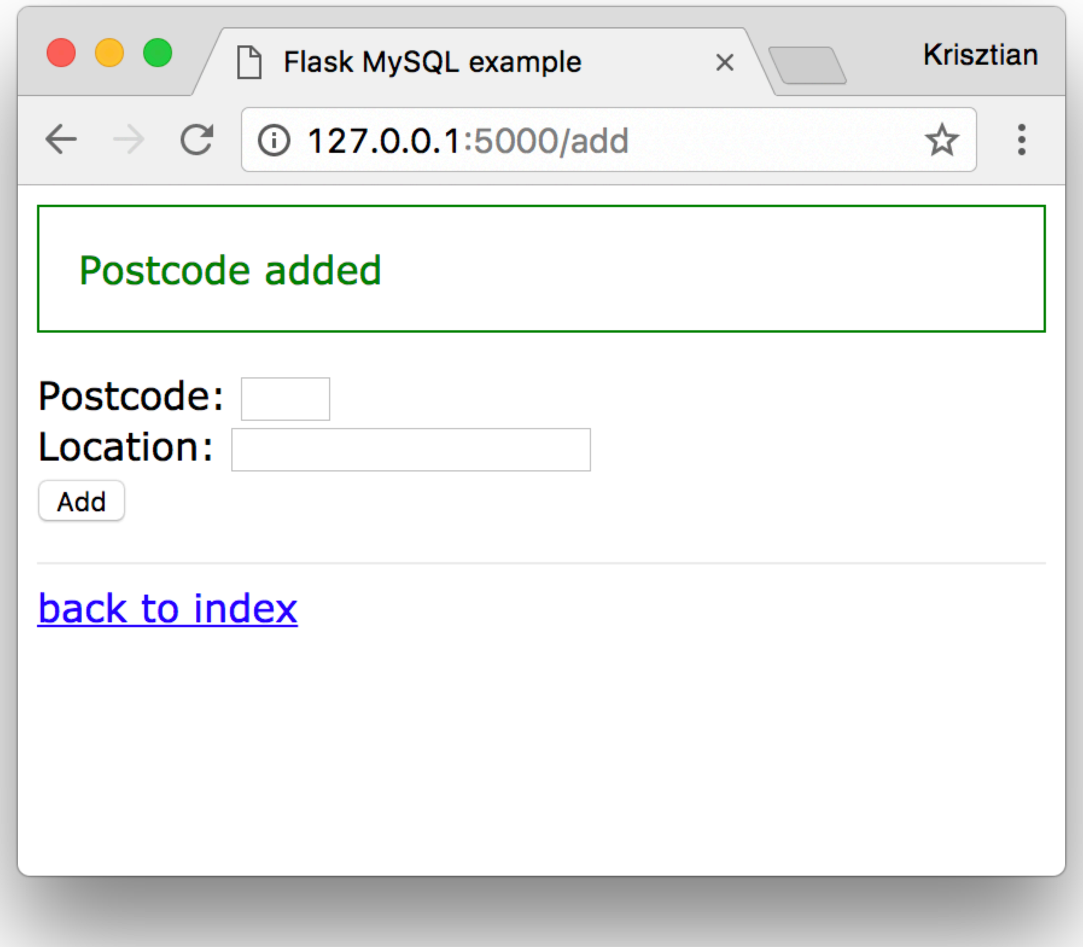
- Initialize DB
- List all postcodes
- Add postcode
- Look up postcode



Listing all postcodes

Postcode	Location	Operations
0001	Oslo	Delete
4036	Stavanger	Delete
4041	Hafrsfjord	Delete
7491	Trondheim	Delete
9019	Tromsø	Delete

back to index



Postcode added

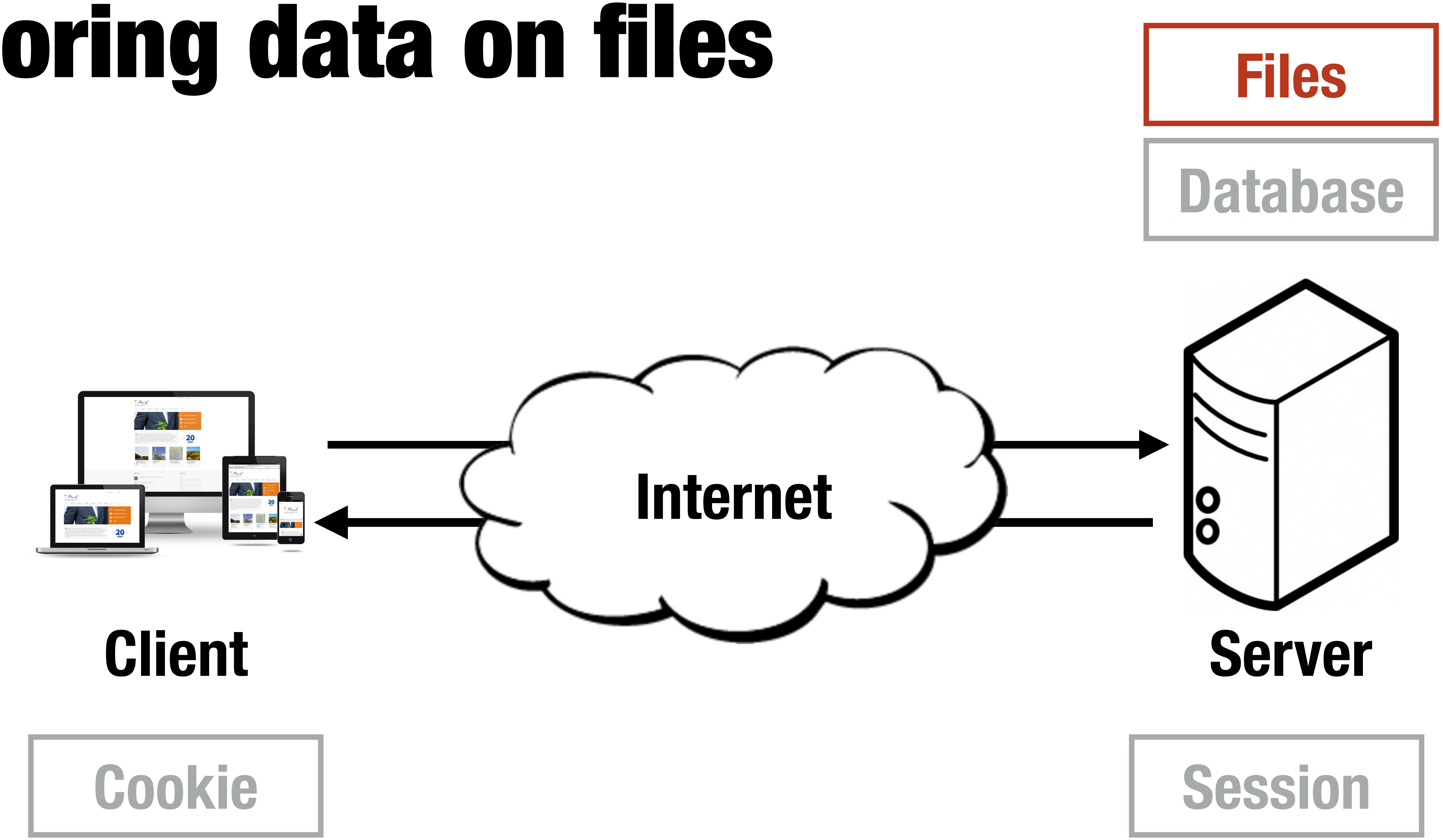
Postcode:
Location:

back to index

Exercises #1, #2

github.com/dat310-2025/info/tree/master/
exercises/python/flask3sql

Storing data on files



Files

Database

Internet

Client

Server

Cookie

Session

JSON

- JavaScript Object Notation
- Lightweight data-interchange format
- Language independent
- Two structures
  - Collection of name-value pairs (object)
    - a.k.a. record, struct, dictionary, hash table, associative array
  - Ordered list of values (array)
    - a.k.a. vector, list

JSON

- Values can be
  - string (in between "…")
  - number
  - object
  - array
  - boolean (true/false)
  - null

Example JSON

```
{
 "name":"John Smith",
 "age":32,
 "married":true,
 "interests":[1,2,3],
 "other":{
         "city":"Stavanger",
         "postcode":4041
         }
}
```

JSON with Python

examples/ajax/json/json_python.py

- **`json`** is a standard module
- **`json.dumps(data)`**
  - returns JSON representation of the data
- **`json.loads(json_value)`**
  - decodes a JSON value
- **`json.dumps()`** and **`json.loads()`** work with strings
- **`json.dump()`** and **`json.load()`** work with file streams

Example

examples/python/flask/5_json

fileaccess_json.py

```
FILENAME = "postcodes.json"

def create_file(filename):
   open(filename, 'x')

def readJSON(filename):
   ...

def writeJSON(filename, data):
    jsonstring = json.dumps(data)
    with open(filename, "w") as f:
        f.write(jsonstring)

if __name__ == "__main__":
    postcodes = {
        "0001": “Oslo",
    ...
    }
    create_file(FILENAME)
    writeJSON(FILENAME, postcodes)
```

- `readJSON` returns parsed json or empty dict.
- `writeJSON` writes new object to file.
- run `fileaccess_json.py` to create `postcodes.json` with init data.

Carefull, where the file is created.

Example

examples/python/flask/5_json

app.py

```
from fileaccess_json import readJSON,
writeJSON, FILENAME

app = Flask(__name__)
postcodes = readJSON(FILENAME)

@app.route("/addpostnumber",
methods=["POST"])
def addEntry():
    number = request.form.get("number",
"")
    city = request.form.get("city","")
    postcodes[number] = city
    writeJSON(FILENAME,postcodes)
```

- import `readJSON` and `writeJSON` from `fileaccess_json.py`
- call `readJSON` to init global variable
- call `writeJSON` to update file

State in JSON files

- State is persisted when program stops
- Not thread safe:
  - When multiple clients are connected, this may give:
    - Incorrect values
    - Program crashes
- Complex to update or read only parts
- No guarantees that data is correct

Not good in production. Use Lock.
Ok for testing.

Exercises #1

github.com/dat310-2025/info/tree/master/
exercises/python/flask3

Resources

- Python Database API Specification
  https://www.python.org/dev/peps/pep-0249/
- SQLite3 Connector/Python
  https://docs.python.org/3/library/sqlite3.html
- Flask SQLite
  https://flask.palletsprojects.com/en/1.1.x/patterns/sqlite3/
- SQLite CLI
  https://sqlite.org/cli.html