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FASTAPI BEYOND CRUD

(Build powerful,Scalable Apps with Python)

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About Me

- I am a software engineer
- Teacher

Works

- FastAPI Beyond CRUD Course

Links

- github.com/jod35
- x.com/jod35_
- linkedin.com/in/jod35
- dev.to/jod35

- Created in 2018 by Sebastian Ramirez
- Most popular Python Backend Framework

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I have some Assumptions

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- You know the Python programming language
- You know the basics of API Development
- You can build a server-side app with FastAPI, Flask or Django
- You can build a CRUD API with FastAPI
- You have an idea of an ORM like SQLAlchemy
- You have an idea of Pydantic

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Please Read the Docs (fastapi.tiangolo.com)

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The App for this Talk

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“You can build your FastAPI Backend in one file”

Here is a single-file simple CRUD APP Built with FastAPI and SQLModel

Requirements

```
fastapi[all]==0.116.1
pydantic-settings==2.10.1
ruff==0.12.4
sqlmodel==0.0.24
```

Define a database model

```
# app.py
from sqlmodel import SQLModel , Field
from datetime import datetime


class Comment(SQLModel, table=True):
    id: Optional[int] = Field(default=None, primary_key=True)
    user_ip: str = Field(max_length=45, nullable=False)  # Supports IPv4 and IPv6
    comment_text: str = Field(nullable=False)
    created_at: datetime = Field(default_factory=datetime.now(tz=timezone.utc))
    updated_at: datetime = Field(default_factory=datetime.now(tz=timezone.utc),
     sa_column_kwargs={"onupdate": datetime.now(tz=timezone.utc)})
    __table_args__ = (
        Index("idx_talk_id", "talk_id"),
        Index("idx_user_ip", "user_ip"),
    )
```

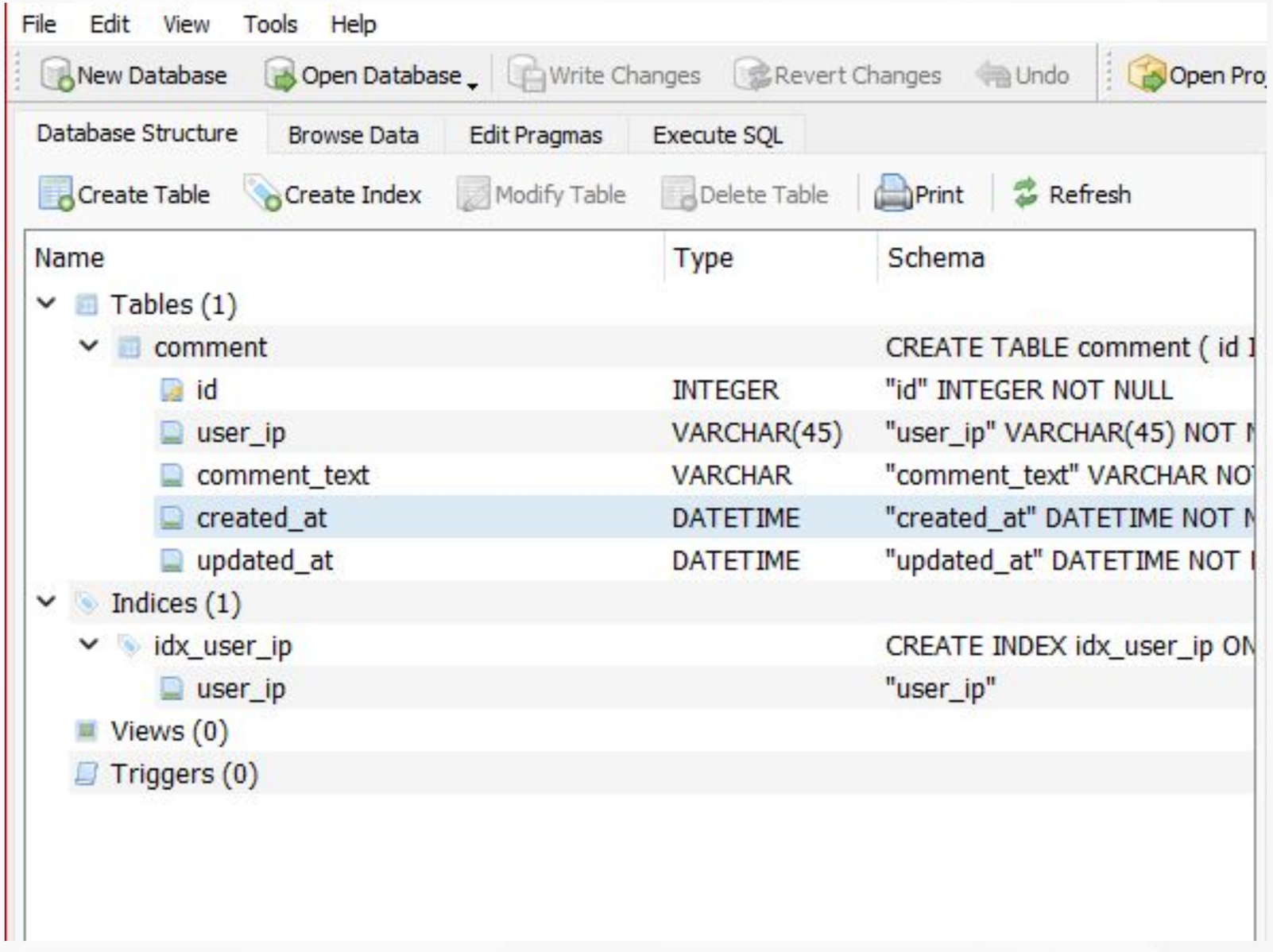
Create the database from the model

```
# app.py
from sqlmodel import create_engine


# ... the model
engine = create_engine("sqlite:///comments.db")


if __name__ == "__main__":
    SQLModel.metadata.create_all(engine)
```

Run the file

```
$ python3 app.py
```

Created Database



Create the session for CRUD

```
from sqlmodel import Session

engine = create_engine("sqlite:///comments.db")

def get_session():
    with Session(engine) as session:
        yield session
```

We need serializers and request/ response validation

```
from sqlmodel import SQLModel, fields
# ... more imports here


# .. more code here

class Comment(SQLModel, table=True):
    id: Optional[int] = Field(default=None, primary_key=True)
    # ... the rest of the fields
    # we shall use this as a read schema (sqlmodel)

class CommentCreateSchema(BaseModel):
    user_ip : str = Field(max_length=45)
    comment_text: str

class CommentUpdateSchema(BaseModel):
    comment_text: str
```

Then the CRUD Routes (Create the FastAPI instance)

```
from fastapi import FastAPI


app = FastAPI(
    title="LiveTalk API v1",
    description="A simple REST API built for a talk at Pycon Uganda"
)
```

Then the CRUD Routes (Create / Read Endpoints)

```python
# ... rest of the code in app.py

@app.post("/comments/", response_model=CommentResponse)
def create_comment(
    comment: CommentCreateSchema, session: Session = Depends(get_session)
):
    """Create a new comment."""
    db_comment = Comment(**comment.model_config())
    session.add(db_comment)
    session.commit()
    session.refresh(db_comment)
    return db_comment


@app.get("/comments/{comment_id}", response_model=CommentResponse)
def read_comment(comment_id: int, session: Session = Depends(get_session)):
    """Read a comment by ID."""
    comment = session.get(Comment, comment_id)
    if not comment:
        raise HTTPException(status_code=404, detail="Comment not found")
    return comment

# .. more code here
```

Then the CRUD Routes (Update / Delete Endpoints)

```python
# ... the rest of the code

@app.put("/comments/{comment_id}", response_model=CommentResponse)
def update_comment(
    comment_id: int,
    comment_update: CommentUpdateSchema,
    session: Session = Depends(get_session),
):
    """Update a comment's text, talk_id, or user_ip."""
    comment = session.get(Comment, comment_id)
    if not comment:
        raise HTTPException(status_code=404, detail="Comment not found")
    # Verify talk exists
    comment.comment_text = comment_update.comment_text
    session.add(comment)
    session.commit()
    session.refresh(comment)
    return comment


@app.delete("/comments/{comment_id}")
def delete_comment(comment_id: int, session: Session = Depends(get_session)):
    """Delete a comment."""
    comment = session.get(Comment, comment_id)
    if not comment:
        raise HTTPException(status_code=404, detail="Comment not found")
    session.delete(comment)
    session.commit()
    return {"message": "Comment deleted"}
```

Running The App

```
$ fastapi dev #run web server in dev mode
```

The FastAPI command can automatically read names such as app.py, main.py and api.py

Automatic Swagger Docs

LiveTalk API V1 0.1.0 OAS 3.1

/openapi.json

A simple REST API built for a talk at Pycon Uganda 2025

comments

- GET /comments/ Get All Comments
- POST /comments/ Create Comment
- GET /comments/{comment_id} Read Comment
- PUT /comments/{comment_id} Update Comment
- DELETE /comments/{comment_id} Delete Comment
- GET /comments/ip/{user_ip} Read Comments By Ip

Schemas

- CommentCreateSchema › Expand all object
- CommentResponse › Expand all object
- CommentUpdateSchema › Expand all object

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“What’s beyond CRUD?”

A better project structure

Current folder structure

```
├── app.py # single-file app
└── comments.db # created database file
```

A better folder structure

```
└── src
    ├── api # api specific stuff
    │   ├── auth # auth module
    │   └── comments # comments module
    ├── db # database connection stuff
    ├── templates # html templates
    └── tests # tests
        ├── auth
        └── comments
```

A structure for an individual module in the api folder

```
src/api/
#  ... auth folder
├── comments
│   ├── constants.py # module constants
│   ├── dependencies.py # module specific dependencies
│   ├── exceptions.py # module level exceptions
│   ├── __init__.py
│   ├── models.py # module level database models
│   ├── routes.py # routes specific to the comments
│   ├── schemas.py # pydantic models
│   ├── services.py # business logic
│   └── utils.py # utilities specific to the module
└── __init__.py
```

Routers help related endpoints together under a prefix

```python
# src/api/comments/routes.py

from fastapi import APIRouter

comments_router = APIRouter(
    prefix="/comments",
    tags=['comments']
)

@comment_router.get("/", response_model=List[CommentResponse])
def read_comments_by_talk(session: Session = Depends(get_session)):
    """Read all comments for a talk."""
    ...
@comment_router.post("/", response_model=CommentResponse)
def create_comment(
    comment: CommentCreateSchema, session: Session = Depends(get_session)
):
    """Create a new comment."""
    ...
```

Register Routers

```python
# src/__init__.py
from api.comments.routes import comment_router
from api.auth.routes import auth_router

app = FastAPI(
    title="LiveTalk API V1",
    description="A simple REST API built for a talk at Pycon Uganda 2025"
)


app.include_router(router=comment_router)
app.include_router(router=auth_router)
```

Separate Pydantic models

```python
# inside api/comments/schemas.py

from pydantic import BaseModel, Field

class CommentCreateSchema(BaseModel):
    user_ip: str = Field(max_length=45)
    comment_text: str


class CommentUpdateSchema(BaseModel):
    comment_text: str
```

Separate business logic from your routes

```python
# src/api/comments/service.py

from sqlmodel import Session, select

async def read_all_comments(session:Session):
    """Read all comments for a talk."""
    statement = select(Comment).where(Comment.talk_id == talk_id)
    result = session.exec(statement).all()
    return result

async def create_comment(session:Session):
    # .... the rest of the code
```

Separate models into specific folders

```
# src/api/comments/models.py

from sqlmodel import SQLModel, Field, Index
from typing import Optional
from datetime import datetime, timezone

class Comment(SQLModel, table=True):
    id: Optional[int] = Field(default=None, primary_key=True)
    user_ip: str = Field(max_length=45, nullable=False)  # Supports IPv4 and
IPv6

# ... other code here
```

Decouple settings with Pydantic Settings

```python
# src/config.py

from pydantic_settings import BaseSettings, SettingsConfigDict

class Settings(BaseSettings):
    DATABASE_URL : str = "sqlite:///comments.db"

    model_config = SettingsConfigDict(
        env_file='.env',
        env_file_encoding='utf-8'
    )

CONFIG = Settings()
```

Decouple settings with Pydantic Settings

```python
#src/db/main.py

from sqlmodel import create_engine, SQLModel
from src.config import CONFIG

DATABASE_URL = CONFIG.DATABASE_URL

engine = create_engine(DATABASE_URL)


def init_db():
    SQLModel.metadata.create_all(engine)
```

Dependency Injection (DI)

Dependency injection is a technique where an object gets its dependencies from external code, making programs loosely coupled and easier to manage.

Dependency Injection (DI)

- **Use Case**: Manage users with a database connection and token-based authentication
- **Benefits**:
  - Decouples logic from resources
  - Ensures cleanup with generators
  - Reusable and testable
- **Example**: Inject database session

Dependency Injection (DI)

```python
#src/db/session.py

from sqlmodel import Session
from .main import engine

def get_session(): # session dependency
    with Session(engine) as session:
      yield session
```

Dependency Injection (DI)

```
#src/db/session.py
from sqlmodel import Session
from fastapi import Depends, APIRouter
# .. more imports
from src.db.session import get_session


# … more code here


@comment_router.get('/',response_model=List[CommentResponse])
def get_all_comments(session: Session = Depends(get_session)): # inject the
session
    return get_all_comments_service(session)
```

Dependency Injection (DI)

```
#src/db/session.py
from sqlmodel import Session
from fastapi import Depends, APIRouter
# .. more imports
from src.db.session import get_session


# … more code here


@comment_router.get('/',response_model=List[CommentResponse])
def get_all_comments(session: Session = Depends(get_session)): # inject the
session
    return get_all_comments_service(session)
```

Dependency Injection (Class Based Dependencies)

```
class RateLimiter:
    def __init__(self, request: Request = Depends()):
        self.request = request
        self.requests = defaultdict(list)
        self.limit = 5  # 5 requests
        self.window = 60  # per 60 seconds

    def check_limit(self, client_id: str):
        now = time()
        self.requests[client_id] = [
            t for t in self.requests[client_id] if now - t < self.window
        ]
        if len(self.requests[client_id]) >= self.limit:
            raise HTTPException(status_code=429, detail="Rate limit
exceeded")
        self.requests[client_id].append(now)
```

Dependency Injection (Nested Dependencies)

```python
def get_session(): # session dependency
    with Session(engine) as session:
        yield session


# another dependency depends on get_db
def get_current_user(
    session: Session = Depends(get_session), token: str = Depends(lambda: "test-token")
):
    user = session.exec(select(User).where(User.token == token)).first()
    if not user:
        raise HTTPException(status_code=401, detail="Invalid token")
    return {"id": user.id, "name": user.name}
```

Authentication

Checking who someone is by verifying their credentials (e.g., a token or password)

Authentication (example with HTTPBearer)

Classes in **fastapi.security** for handling authentication

Common Classes (from fastapi.security):

- **OAuth2PasswordBearer**: Extracts bearer token for OAuth2 password flow
- **OAuth2PasswordRequestForm**: Parses username/password for token endpoints
- **HTTPBasic**: Handles username/password via HTTP Basic Auth
- **APIKeyHeader**: Retrieves API key from a header (e.g., X-API-Key)
- **HTTPBearer**: Extracts bearer token from Authorization: Bearer <token> header

Authentication (example with HTTPBearer)

```python
from typing import Any, List

from fastapi import Depends, Request, status
from fastapi.exceptions import HTTPException
from fastapi.security import HTTPBearer
from fastapi.security.http import HTTPAuthorizationCredentials


class TokenBearer(HTTPBearer): # subclass HTTPBearer
    def __init__(self, auto_error=True):
        super().__init__(auto_error=auto_error)

    async def __call__(self, request: Request) -> HTTPAuthorizationCredentials | None:
        creds = await super().__call__(request)
        # ... do all your token validations here

        return creds

    def token_valid(self, token: str) -> bool:
        ...
    def verify_token_data(self, token_data):
        ...
```

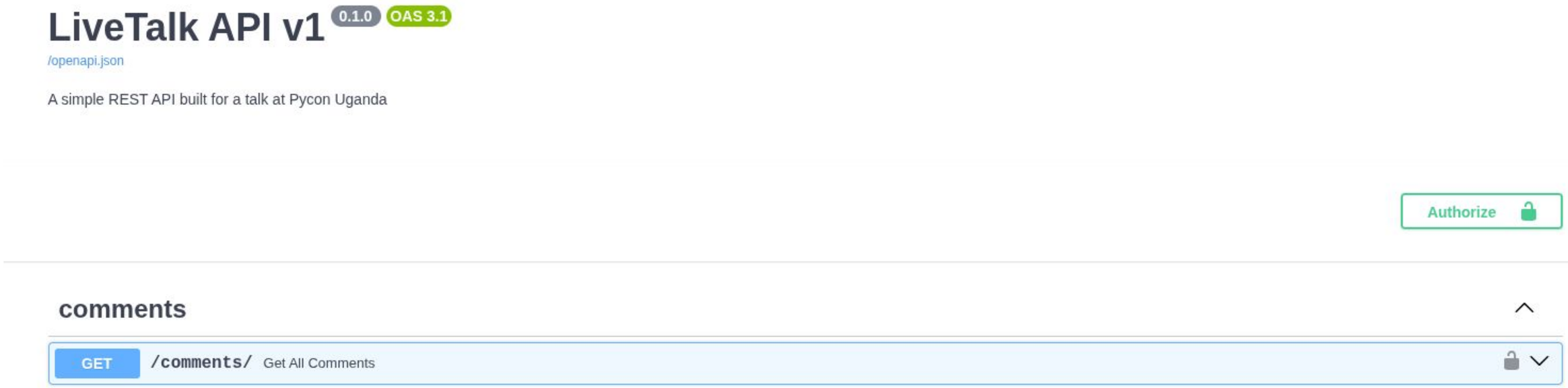
Authentication (example with HTTPBearer)

```
acccess_token_bearer = TokenBearer()

# this will make the endpoint protected

@comment_router.get('/',response_model=List[CommentResponse])
def get_all_comments(
        session: Session = Depends(get_session),
        user_data: Depends(acccess_token_bearer)
    ):
    return get_all_comments_service(session)
```

Authentication (example with HTTPBearer)



Async Routes

FastAPI is built for async I/O, enabling high performance.

Async Routes (An example)

```python
import asyncio

@app.get("/terrible-ping")
async def terrible_ping():
    time.sleep(10) # this is blocking
    return {"pong": True}

@app.get("/good-ping")
def good_ping():
    time.sleep(10) # this is also blocking
    return {"pong": True}

@app.get("/perfect-ping")
async def perfect_ping():
    await asyncio.sleep(10) # this is non blocking
    return {"pong": True}
```

Middleware

Code that runs before/after every request to handle cross-cutting concerns

Middleware

```
# a custom middleware for logging

@app.middleware("http")
async def custom_logging(request: Request, call_next):
    start_time = time.time()
    response = await call_next(request)
    processing_time = time.time() - start_time
    message = f"{request.client.host}:{request.client.port} - {request.method} - {request.url.path}
- {response.status_code} completed after {processing_time}s"
    logger.info(message)
    return response
```

Middleware (in-built)

```
# some in-built middleware

from fastapi.middleware.cors import CORSMiddleware
from fastapi.middleware.trustedhost import TrustedHostMiddleware

app.add_middleware(
    CORSMiddleware,
    allow_origins=["*"],
    allow_methods=["*"],
    allow_headers=["*"],
    allow_credentials=True,
)

app.add_middleware(
    TrustedHostMiddleware,
    allowed_hosts=["localhost", "127.0.0.1" ,"yourapp.com","0.0.0.0"],
)
```

Middleware (in-built)

```
# some in-built middleware

from fastapi.middleware.cors import CORSMiddleware
from fastapi.middleware.trustedhost import TrustedHostMiddleware

app.add_middleware(
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    allow_headers=["*"],
    allow_credentials=True,
)

app.add_middleware(
    TrustedHostMiddleware,
    allowed_hosts=["localhost", "127.0.0.1" ,"yourapp.com","0.0.0.0"],
)
```

Background Tasks

Run tasks asynchronously after responding to a request (e.g., sending emails, processing data).

- Improves performance by offloading heavy tasks, keeping API responses fast.

- ***BackgroundTasks*** class integrates with endpoints and dependencies.

- Send a notification email after a user posts a comment, leveraging your existing authentication setup.

Background Tasks

Run tasks asynchronously after responding to a request (e.g., sending emails, processing data).

- Improves performance by offloading heavy tasks, keeping API responses fast.
- ***BackgroundTasks*** class integrates with endpoints and dependencies.
- Send a notification email after a user posts a comment, leveraging your existing authentication setup.

Background Tasks

```python
from fastapi import FastAPI, BackgroundTasks
from time import sleep

# ... some code here

def process_large_dataset(data: str):
    sleep(10)  # Simulate 10-second processing
    with open("processed_data.txt", "a") as f:
        f.write(f"Processed: {data}\n")

@app.post("/process")
async def start_processing(data: str, background_tasks: BackgroundTasks):
    background_tasks.add_task(process_large_dataset, data) #send to background
    return {"message": "Processing started"}
```

Background Tasks

- For CPU intensive tasks, you can use a tool such as **Celery**.
- It is a distributed task queue.
- Works with a broker such as Redis or RabbitMQ
- Supports monitoring of tasks with Flower

Background Tasks (Celery example)

```python
from celery import Celery

@celery_app.task
def process_dataset(data: str):
    import time
    time.sleep(10)  # Simulate 10-second processing
    with open("processed_data.txt", "a") as f:
        f.write(f"Processed: {data}\n")

@app.post("/process")
async def start_processing(data: str):
    process_dataset.delay(data)
    return {"message": "Processing queued"}
```

WebSockets

- Enable real-time, two-way communication between client and server
- Very useful for implementing real-time features like real-time chat, notifications, e.t.c.
- Leverages FastAPI’s async capabilities for speed

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WebSockets

```python
from fastapi import FastAPI, WebSocket


@app.websocket("/chat")
async def chat_websocket(websocket: WebSocket):
    await websocket.accept() # accept connections
    try:
        while True:
            message = await websocket.receive_text()
            await websocket.send_text(f"Echo: {message}") # echo any messages sent
    except Exception:
     await websocket.close() # close the connection
```

Testing

Unit Testing: Test individual endpoints and functions using pytest and FastAPI's ***TestClient***.

TestClient: Simulates HTTP requests to your FastAPI app.

Key Tools:

- **pytest**: For writing and running tests.
- **httpx**: For async HTTP requests using ***httpx.AsyncClient*** (alternative to TestClient).
- **pytest-asyncio**: For testing async endpoints.

Testing

```
# inside your tests module
from fastapi.testclient import TestClient

client = TestClient(app)

def test readroot():
    response = client.get(”/”)
    assert response.statuscode ==200
    assert response.json() == {”message” : ”Hello, World!”}
```

Finally run the tests with ***pytest***

Testing (Async Tests)

```python
from fastapi import FastAPI, Depends
from fastapi.testclient import TestClient
import httpx
import pytest

# ... more code here

# Override the dependency
app.dependency_overrides[get_session] = mock_get_session

# Asynchronous test using httpx.AsyncClient
@pytest.mark.asyncio
async def test_read_root():
    async with httpx.AsyncClient() as client:
        response = await client.get("/")
        assert response.status_code == 200
        assert response.json() == {"message": "Hello, World!"}
```

Deploying FastAPI Apps

Run FastAPI with production mode using the FastAPI CLI

```
fastapi run src/ --workers 4
```

Deploying FastAPI Apps (Docker)

- You can also run your apps in **Docker** containers
- Use **Docker Compose** to run single instances of your app
- Use container management services like **Kubernetes** to run multiple instances of your app

Deploying FastAPI Apps (Docker)

- Utilize tools like **Traefik** to handle automatic handling of HTTPS

Find out more

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And so much More

Thank you so much