Lecture 16-18: APIs & App Frontend

Advanced Practical Data Science, MLOps

AC215

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Institute for Applied Computational Science, Harvard

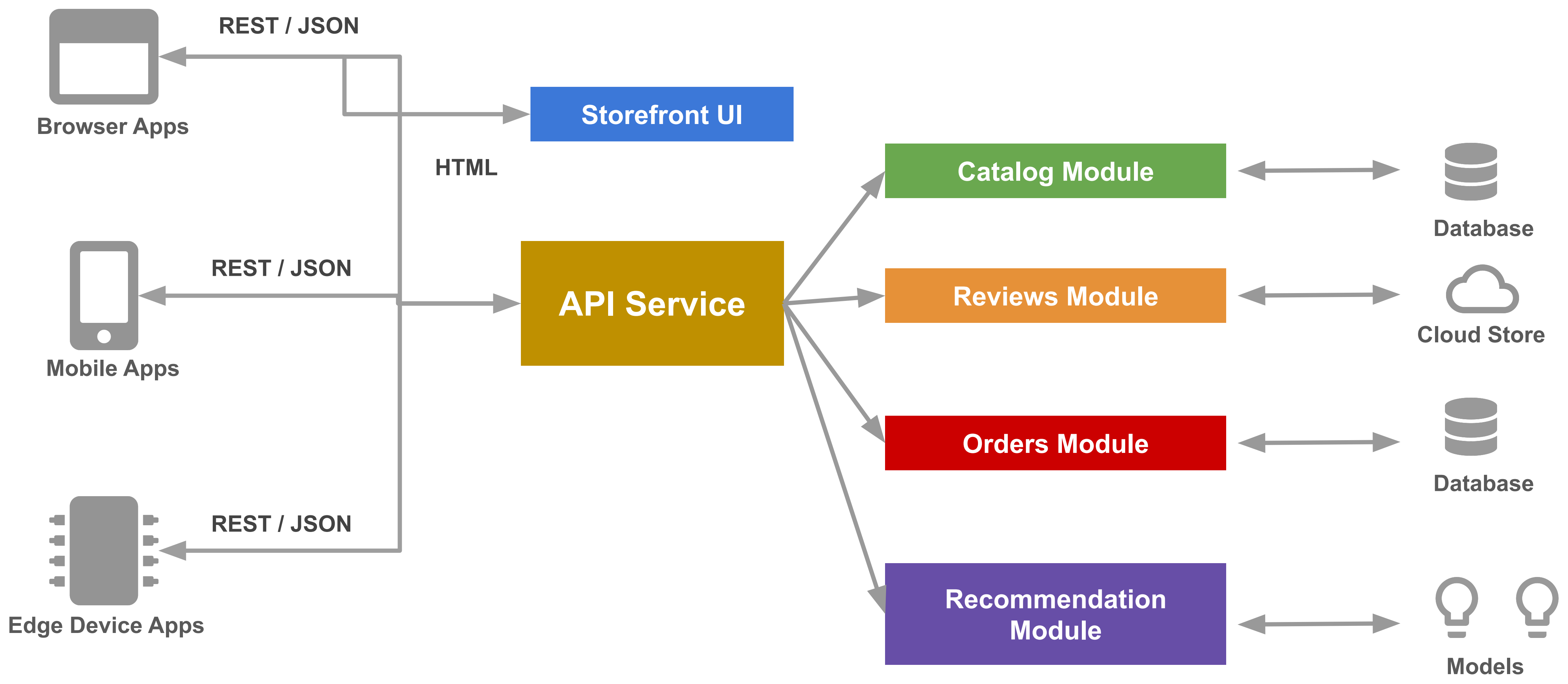
Outline

1. Recap
2. APIs
3. App Frontend (Simple)
4. Model Serving
5. Frontend Frameworks

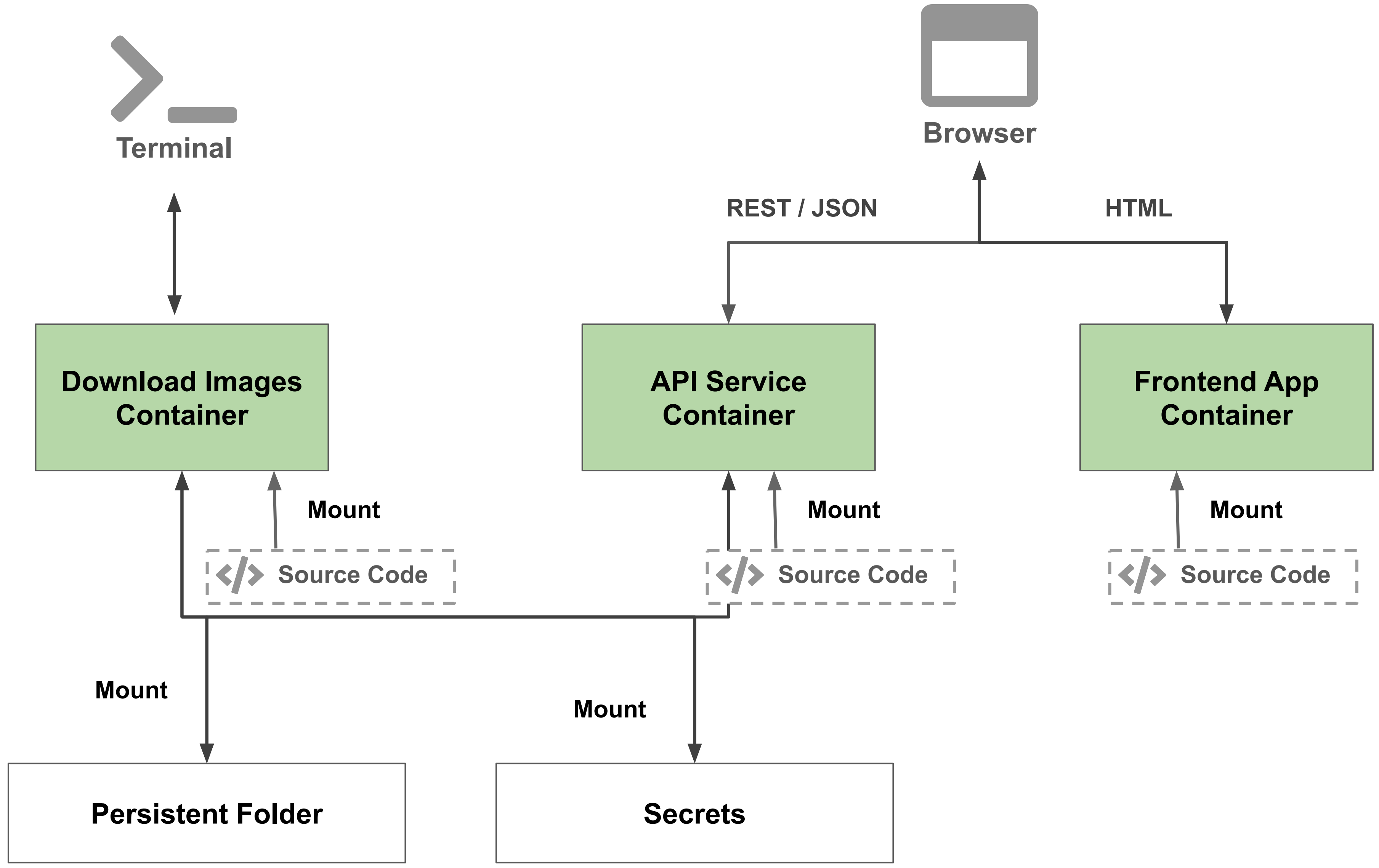
Outline

1. **Recap**
2. APIs
3. App Frontend (Simple)
4. Model Serving
5. Frontend Frameworks

Microservice Architecture



What we built so far



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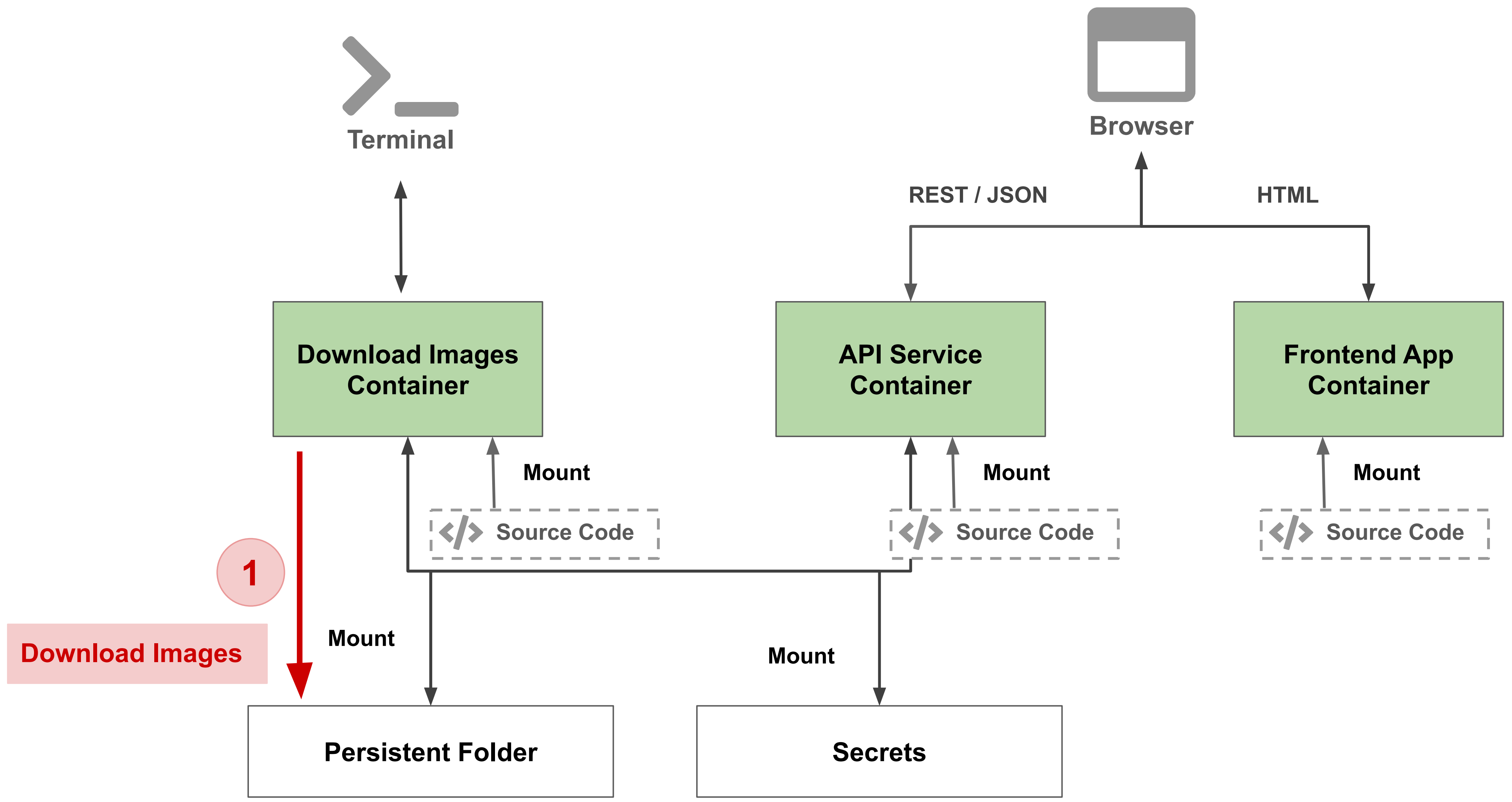

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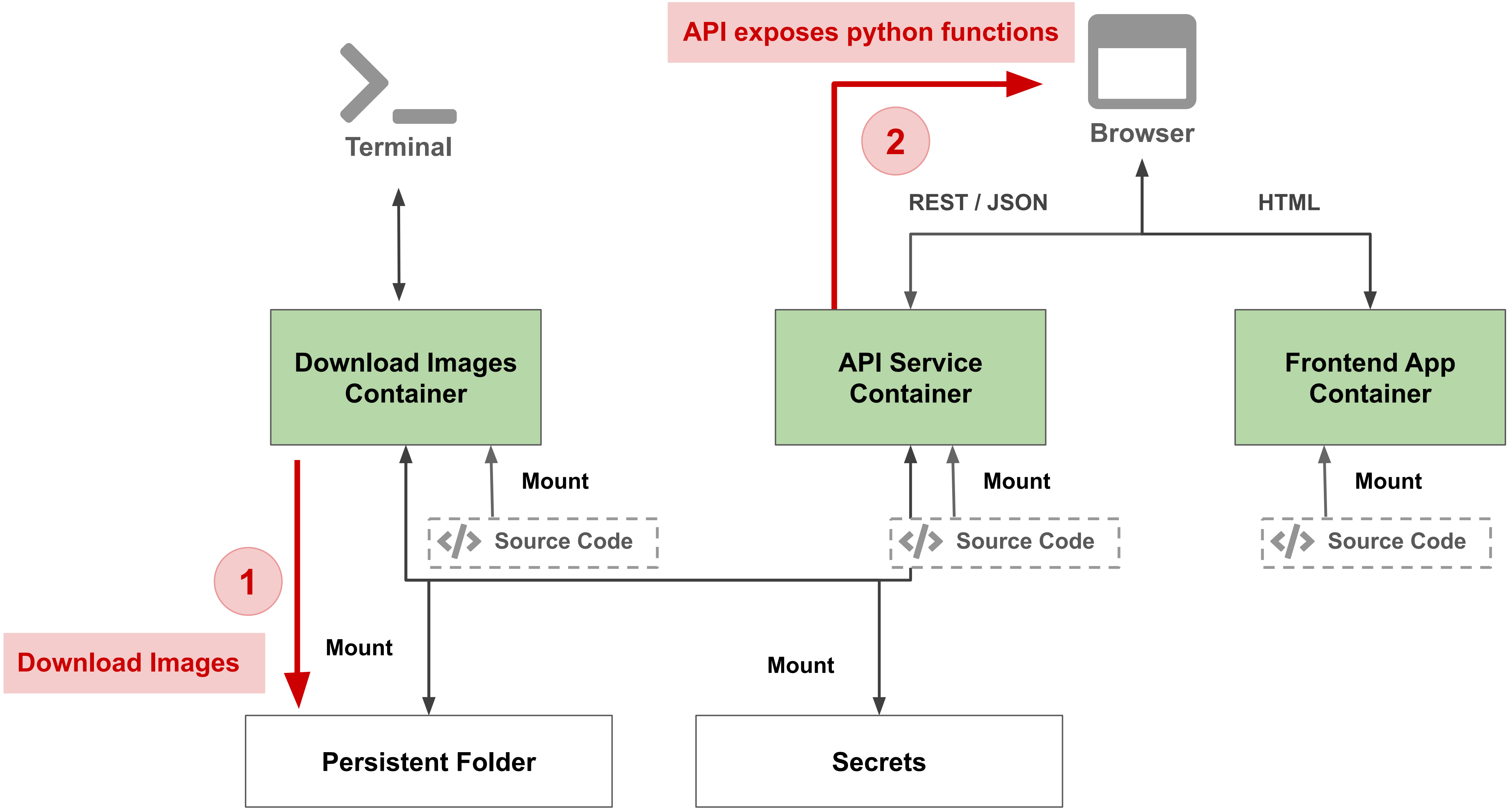


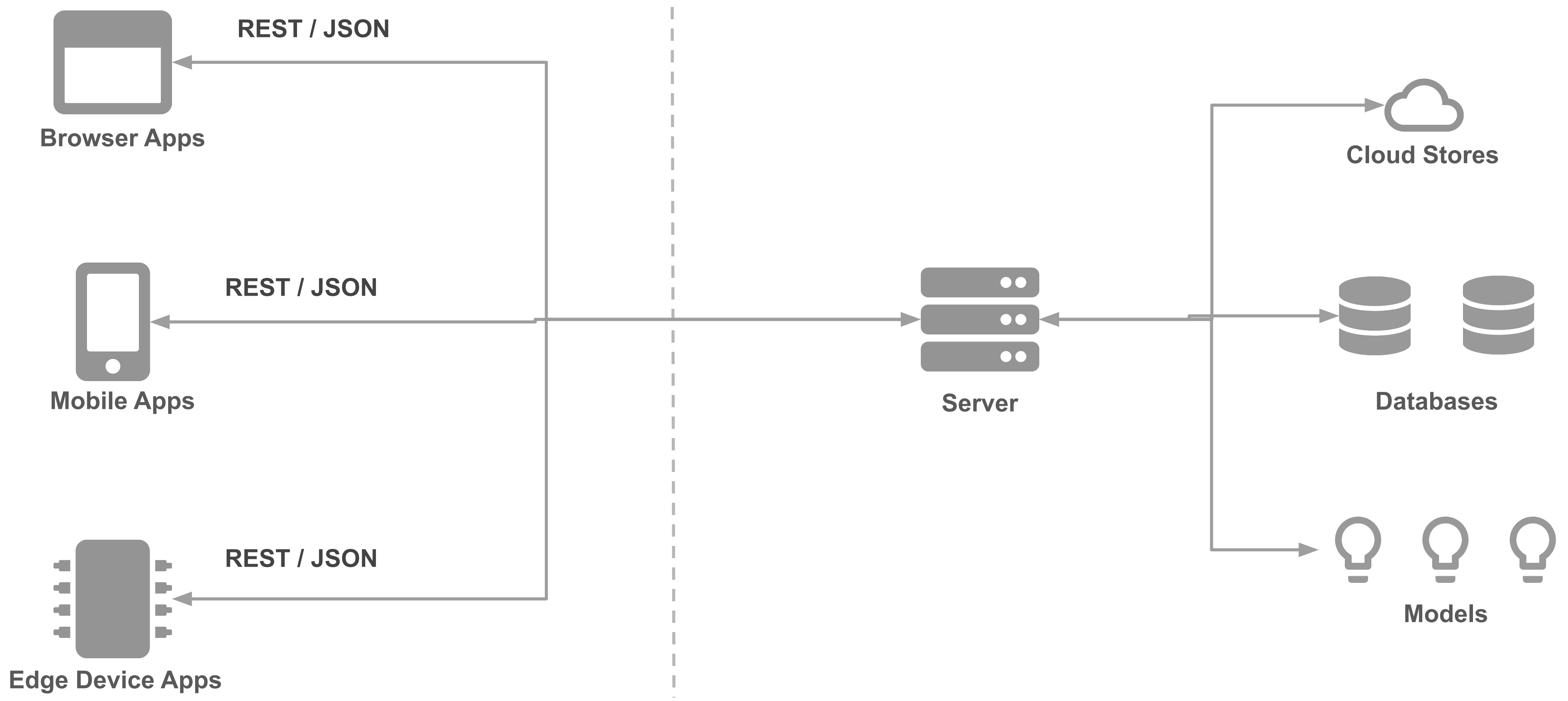
Outline

What is an API

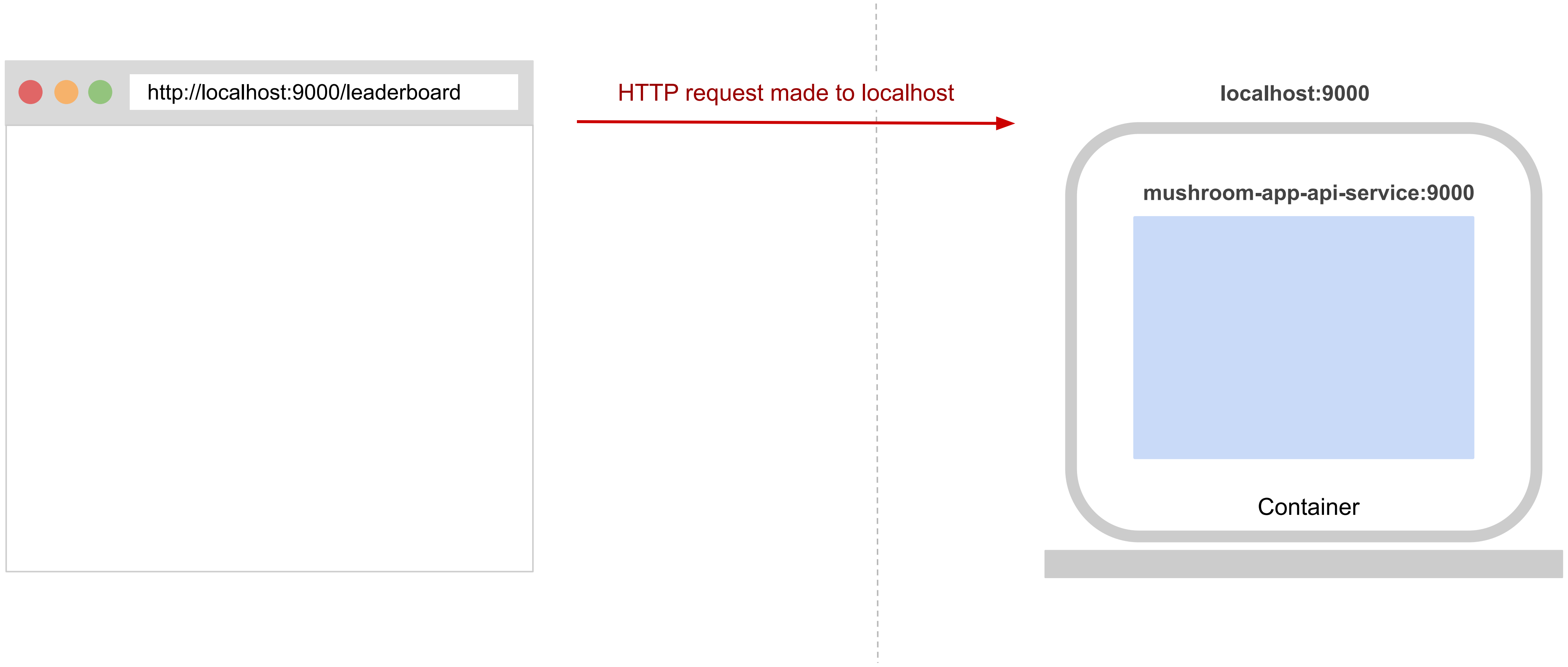
- API is **Application Programming Interface**
- **Web API** is one that can be access using HTTP/S
- A **REST API** is a Web API that follows the HTTP method constraints - get, post, put, delete
- We will use **FastAPI** a Python framework to build REST APIs

APIs

We will be using the term **API** to refer to REST API, which will be used to connect to various components



How does an API work

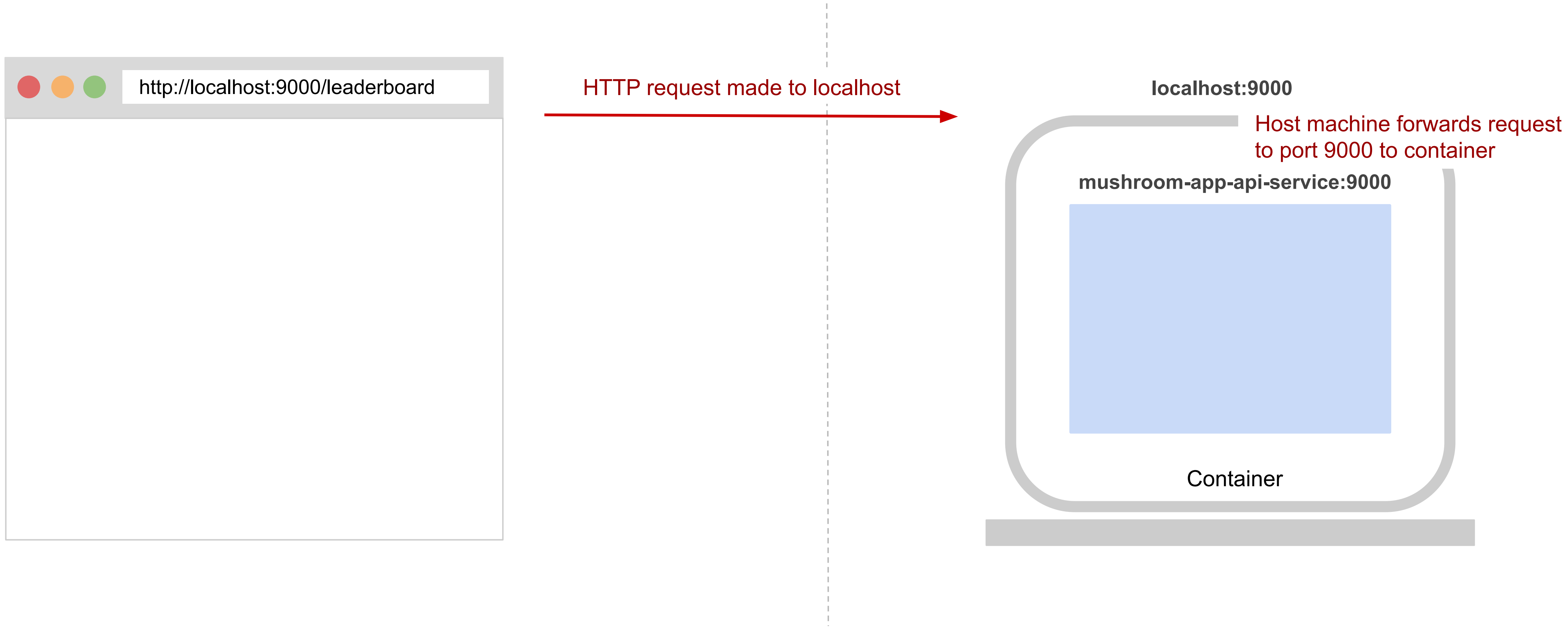


http://localhost:9000/leaderboard
HTTP request made to localhost
localhost:9000
mushroom-app-api-service:9000
Container

Browser

Local computer / Server

How does an API work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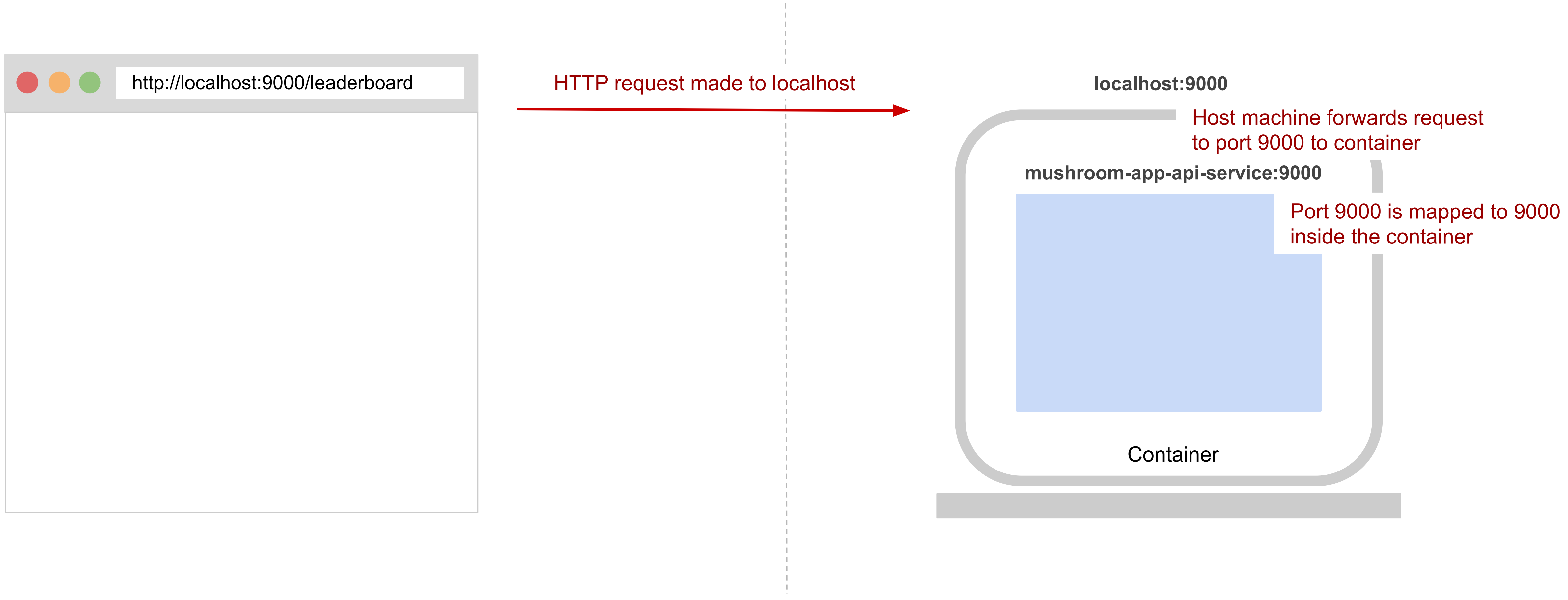
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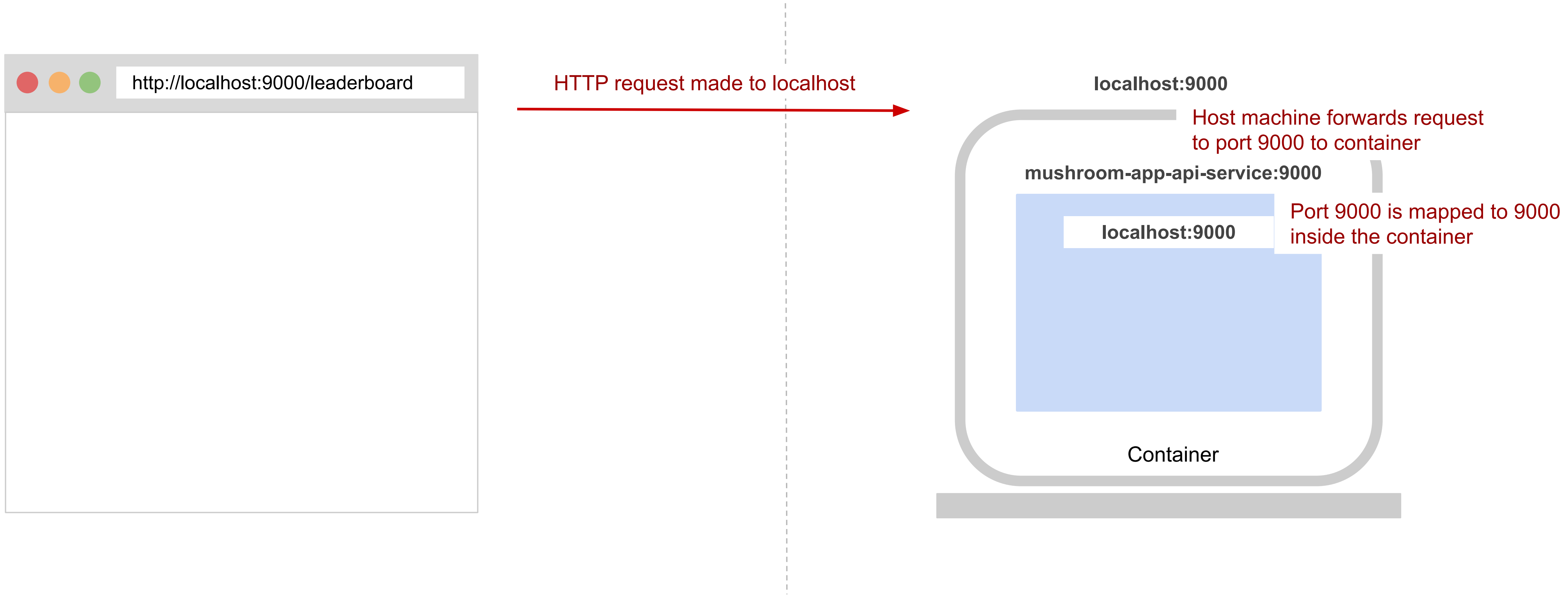
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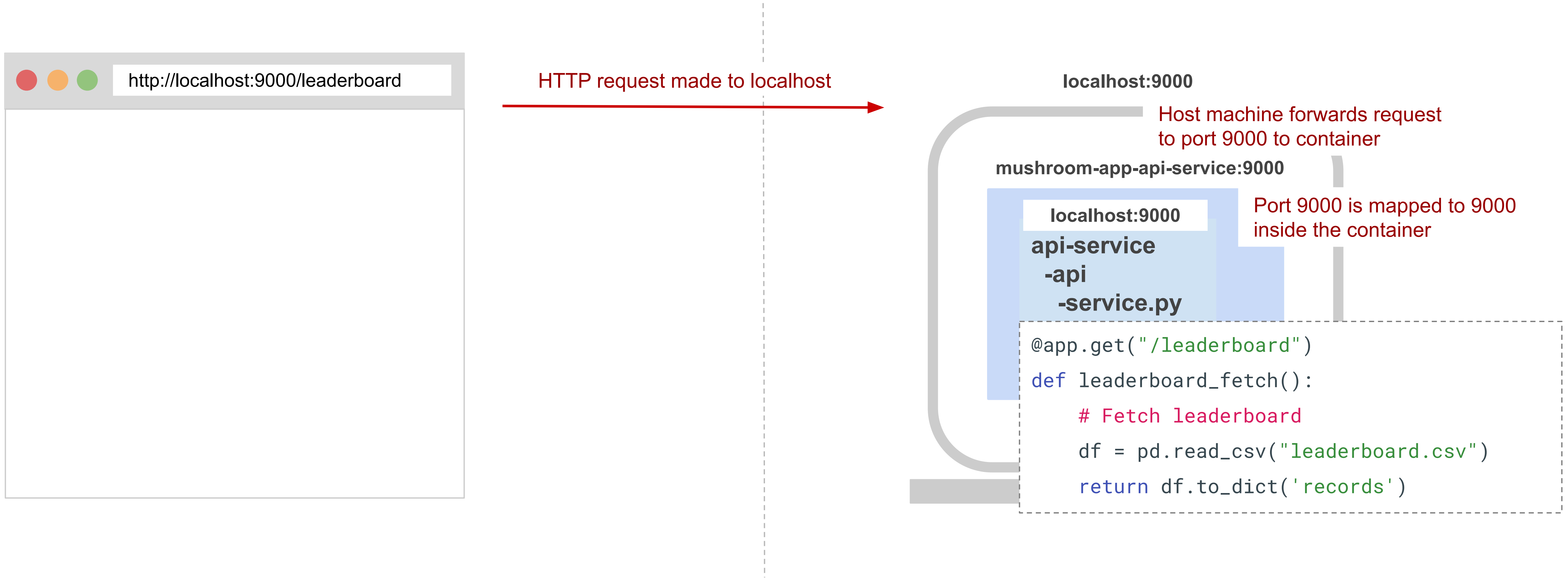
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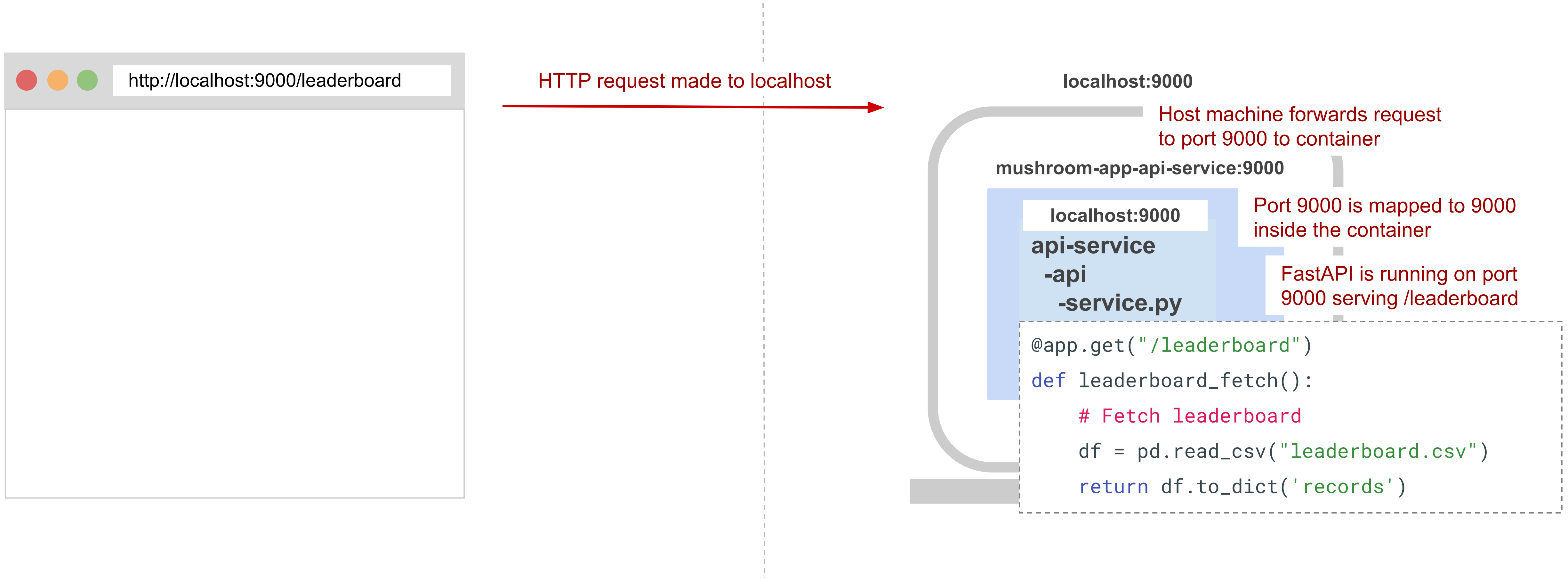
mushroom-app-api-service:9000
localhost:9000
Port 9000 is mapped to 9000 inside the container
api-service
-api
-service.py

```
@app.get("/leaderboard")
def leaderboard_fetch():
    # Fetch leaderboard
    df = pd.read_csv("leaderboard.csv")
    return df.to_dict('records')
```

Browser

Local computer / Server

How does an API work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mushroom-app-api-service:9000
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Port 9000 is mapped to 9000 inside the container
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FastAPI is running on port 9000 serving /leaderboard

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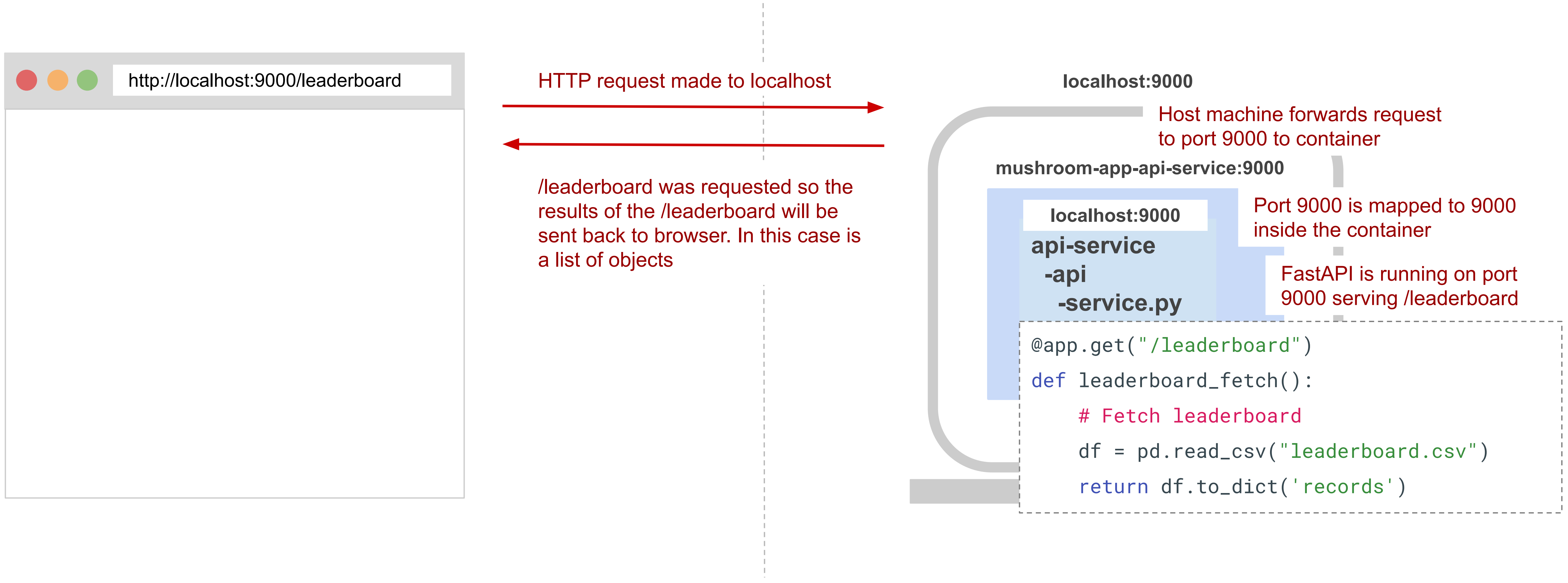
Browser

Local computer / Server

How does an API work


http://localhost:9000/leaderboard
HTTP request made to localhost
/leaderboard was requested so the results of the /leaderboard will be sent back to browser. In this case is a list of objects
localhost:9000
Host machine forwards request to port 9000 to container
mushroom-app-api-service:9000
localhost:9000
Port 9000 is mapped to 9000 inside the container
api-service
-api
-service.py
FastAPI is running on port 9000 serving /leaderboard

```python
@app.get("/leaderboard")
def leaderboard_fetch():
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```
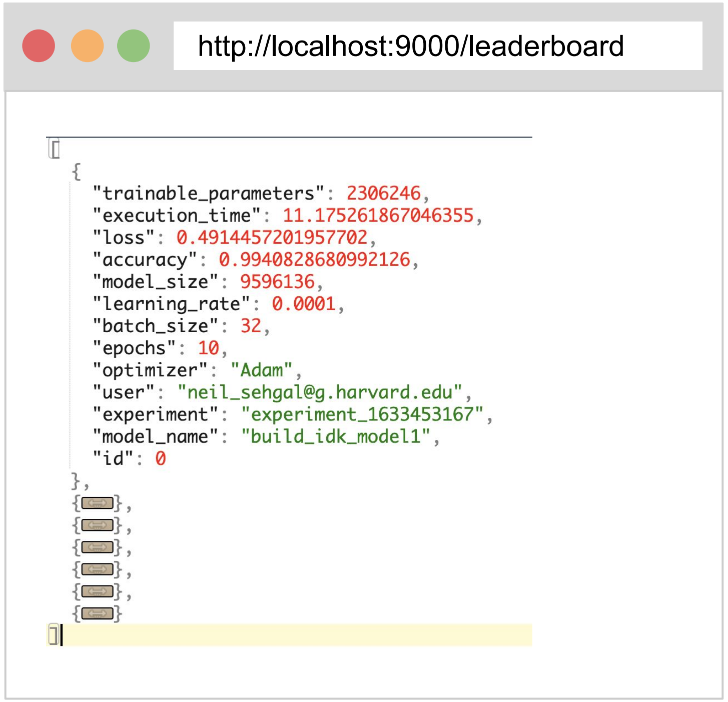

Browser

Local computer / Server

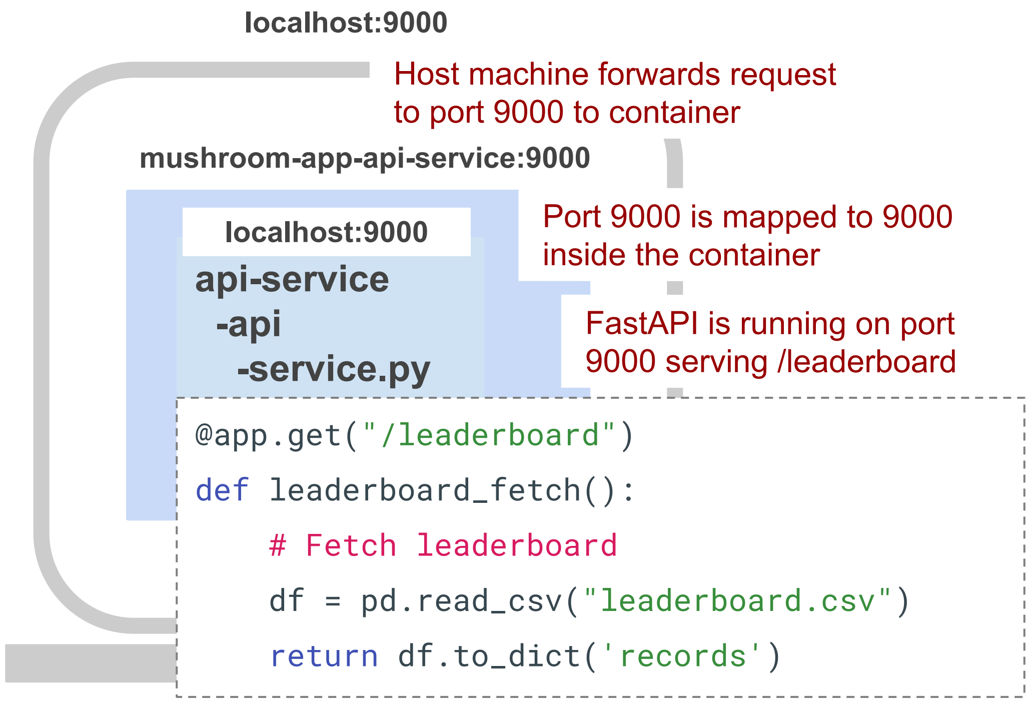
How does an API work



```
[
  {
    "trainable_parameters": 2306246,
    "execution_time": 11.175261867046355,
    "loss": 0.4914457201957702,
    "accuracy": 0.9940828680992126,
    "model_size": 9596136,
    "learning_rate": 0.0001,
    "batch_size": 32,
    "epochs": 10,
    "optimizer": "Adam",
    "user": "neil_sehgal@g.harvard.edu",
    "experiment": "experiment_1633453167",
    "model_name": "build_idk_model1",
    "id": 0
  },
  {↔},
  {↔},
  {↔},
  {↔},
  {↔},
  {↔}
]
```

HTTP request made to localhost

/leaderboard was requested so the results of the /leaderboard will be sent back to browser. In this case is a list of objects

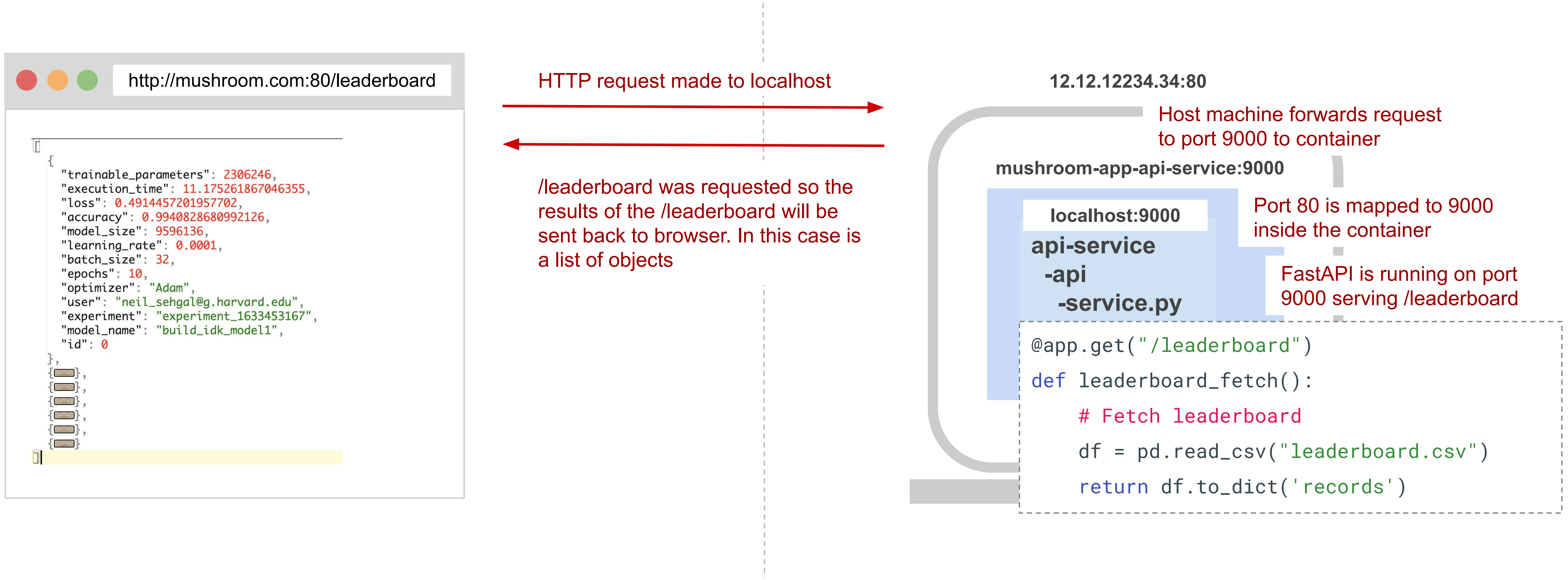

localhost:9000
Host machine forwards request to port 9000 to container
mushroom-app-api-service:9000
localhost:9000
Port 9000 is mapped to 9000 inside the container
api-service
-api
-service.py
FastAPI is running on port 9000 serving /leaderboard

```python
@app.get("/leaderboard")
def leaderboard_fetch():
    # Fetch leaderboard
    df = pd.read_csv("leaderboard.csv")
    return df.to_dict('records')
```

Browser

Local computer / Server

How does an API work (In Production)



http://mushroom.com:80/leaderboard

```
[
  {
    "trainable_parameters": 2306246,
    "execution_time": 11.175261867046355,
    "loss": 0.4914457201957702,
    "accuracy": 0.9940828680992126,
    "model_size": 9596136,
    "learning_rate": 0.0001,
    "batch_size": 32,
    "epochs": 10,
    "optimizer": "Adam",
    "user": "neil_sehgal@g.harvard.edu",
    "experiment": "experiment_1633453167",
    "model_name": "build_idk_model1",
    "id": 0
  },
  {…},
  {…},
  {…},
  {…},
  {…},
  {…}
]
```

HTTP request made to localhost

/leaderboard was requested so the results of the /leaderboard will be sent back to browser. In this case is a list of objects

12.12.12234.34:80

Host machine forwards request to port 9000 to container

mushroom-app-api-service:9000

localhost:9000

api-service
-api
-service.py

Port 80 is mapped to 9000 inside the container

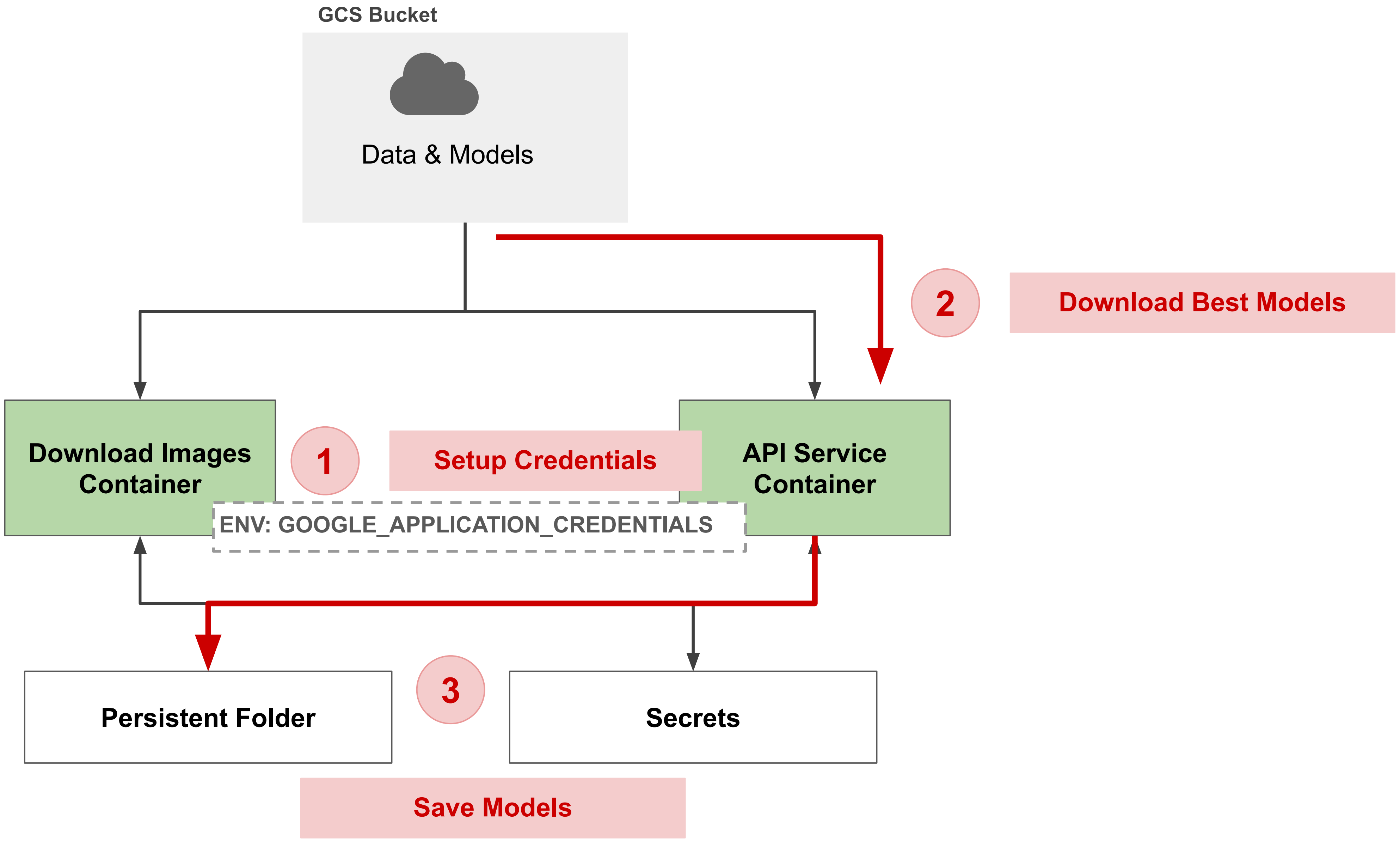
FastAPI is running on port 9000 serving /leaderboard

```python
@app.get("/leaderboard")
def leaderboard_fetch():
    # Fetch leaderboard
    df = pd.read_csv("leaderboard.csv")
    return df.to_dict('records')
```

Browser

GCP Server

Tutorial: Setup GCP Credentials/ Download Best Models

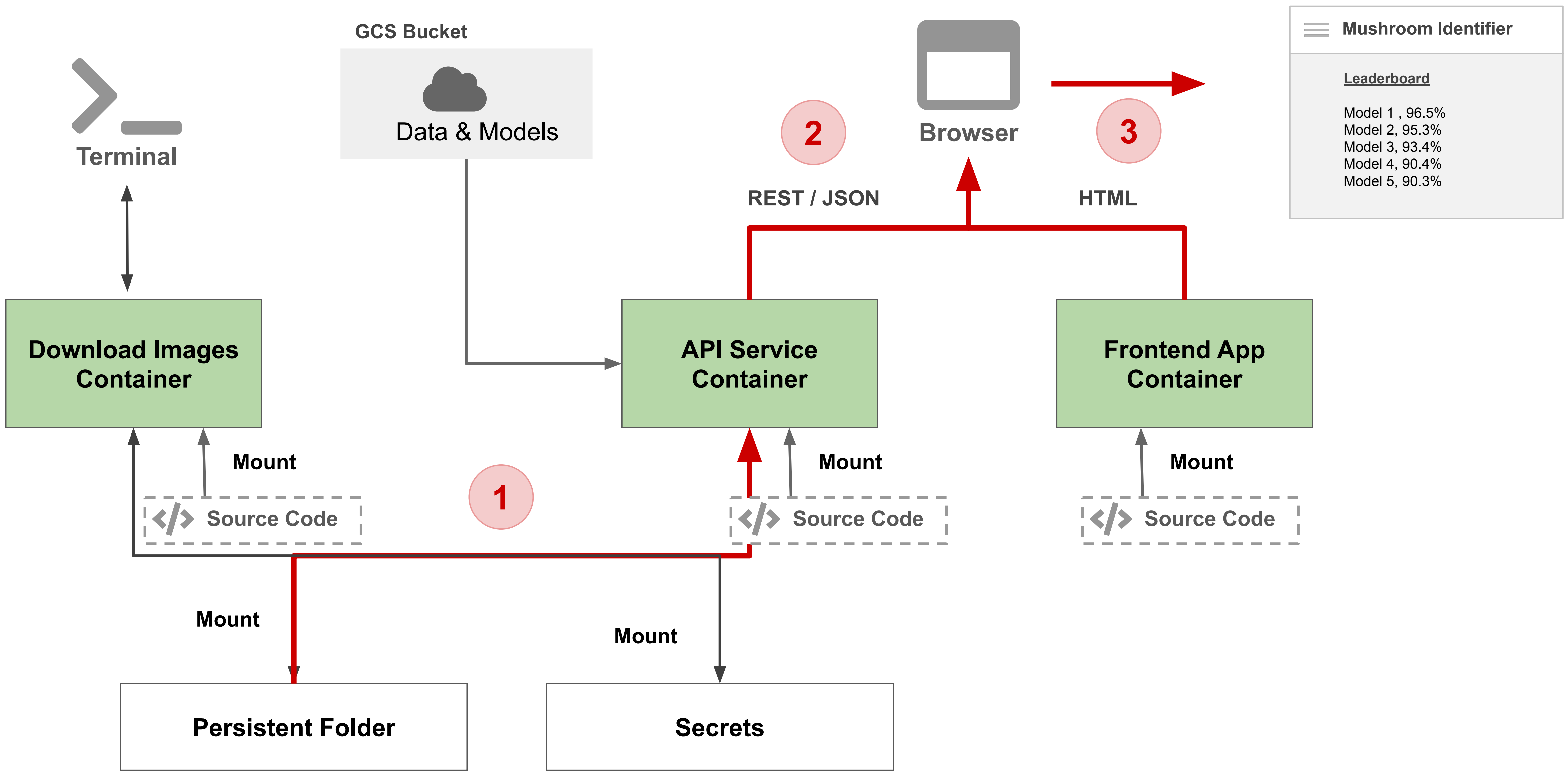


Tutorial: Setup GCP Credentials/ Download Best Models

Mushroom App - Setup GCP Credentials

Mushroom App - Download Best Models

Tutorial: APIs & Frontend App



Tutorial: APIs & Frontend App

Mushroom App - APIs & Frontend App

Outline

App Frontend

HTML

- Is Hyper Text Markup Language (Remember Markdowns)
- Browsers use HTML to display web pages

CSS

- Cascading style sheets
- Used to format & style web pages

Javascript

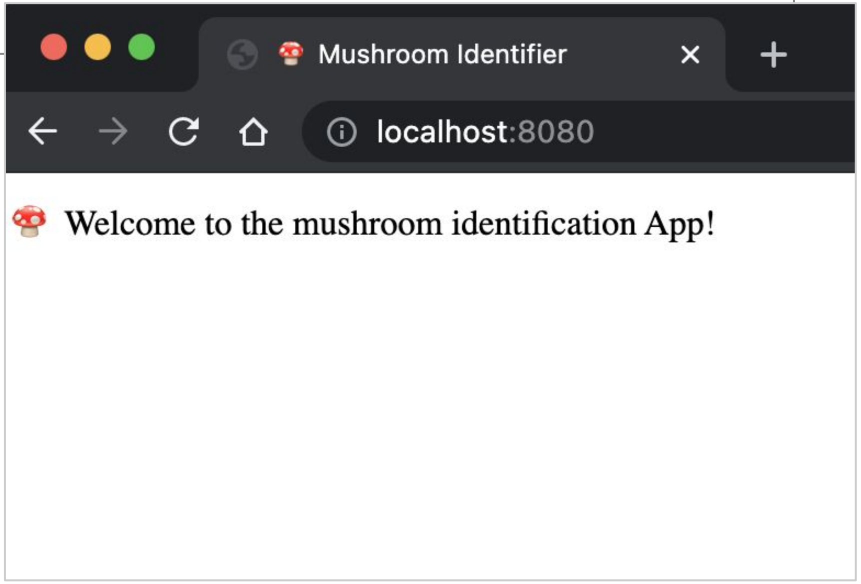
- Programming language understood by browser

App Frontend

```
<!DOCTYPE html>
<html>
<head>
    <title>🍄 Mushroom Identifier</title>
</head>
<body>
    🍄 Welcome to the mushroom identification App!
</body>
</html>
```

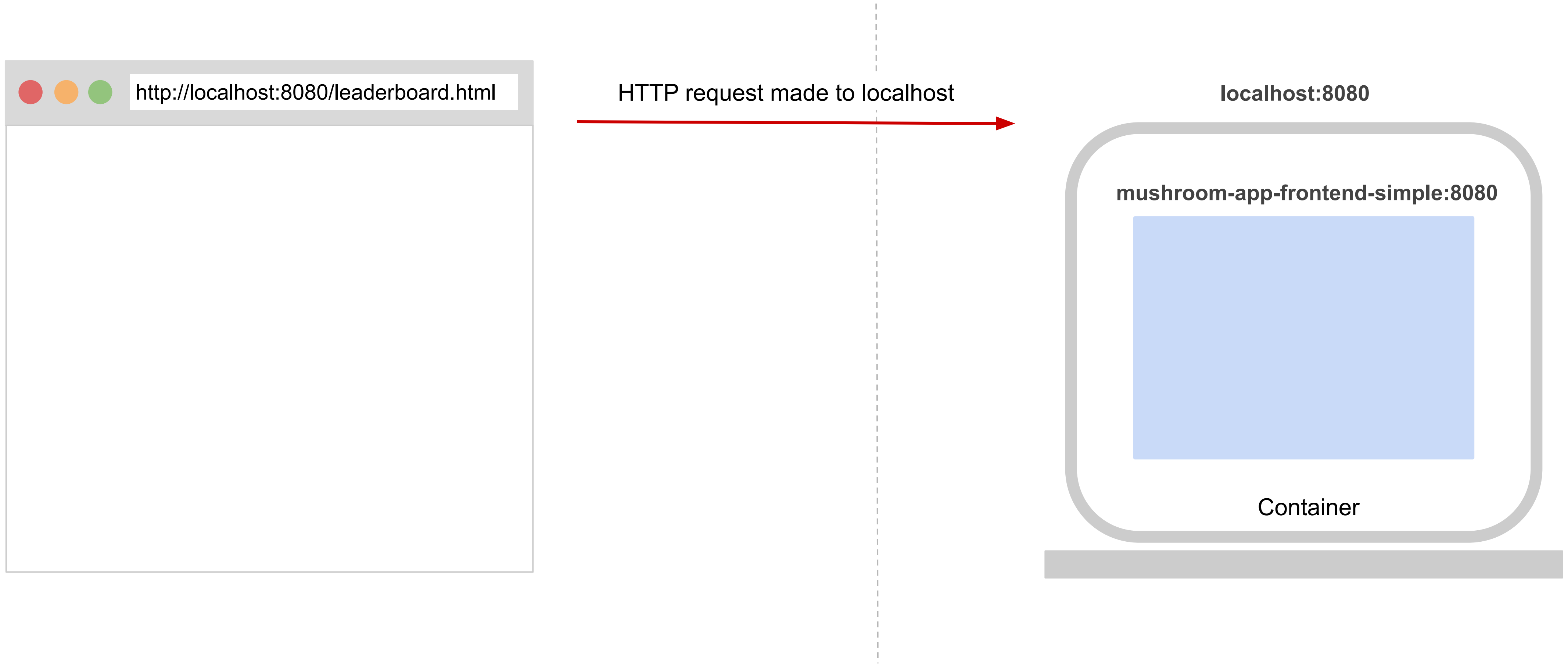
Browser Title

Web page details



🍄 Welcome to the mushroom identification App!

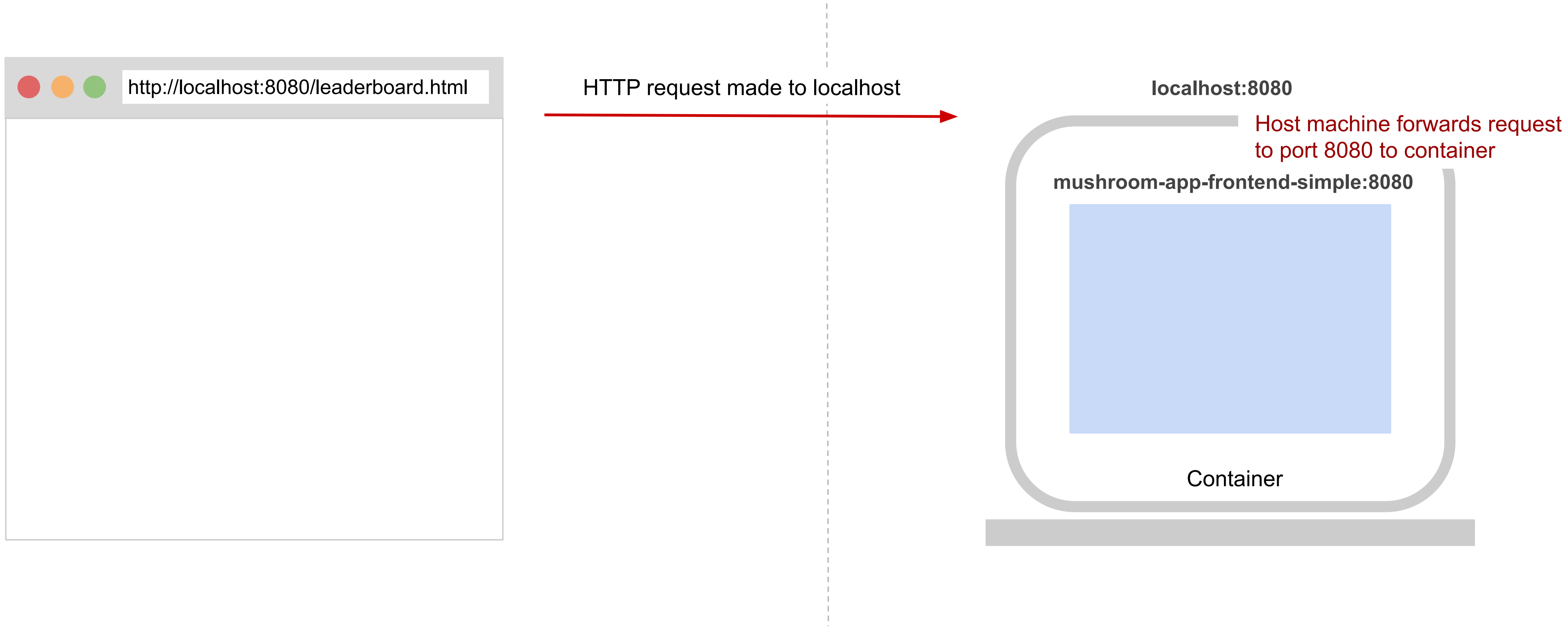
How does the App work


http://localhost:8080/leaderboard.html
HTTP request made to localhost
localhost:8080
mushroom-app-frontend-simple:8080
Container

Browser

Local computer / Server

How does the App work


http://localhost:8080/leaderboard.html
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Host machine forwards request to port 8080 to container
mushroom-app-frontend-simple:8080
Container

Browser

Local computer / Server

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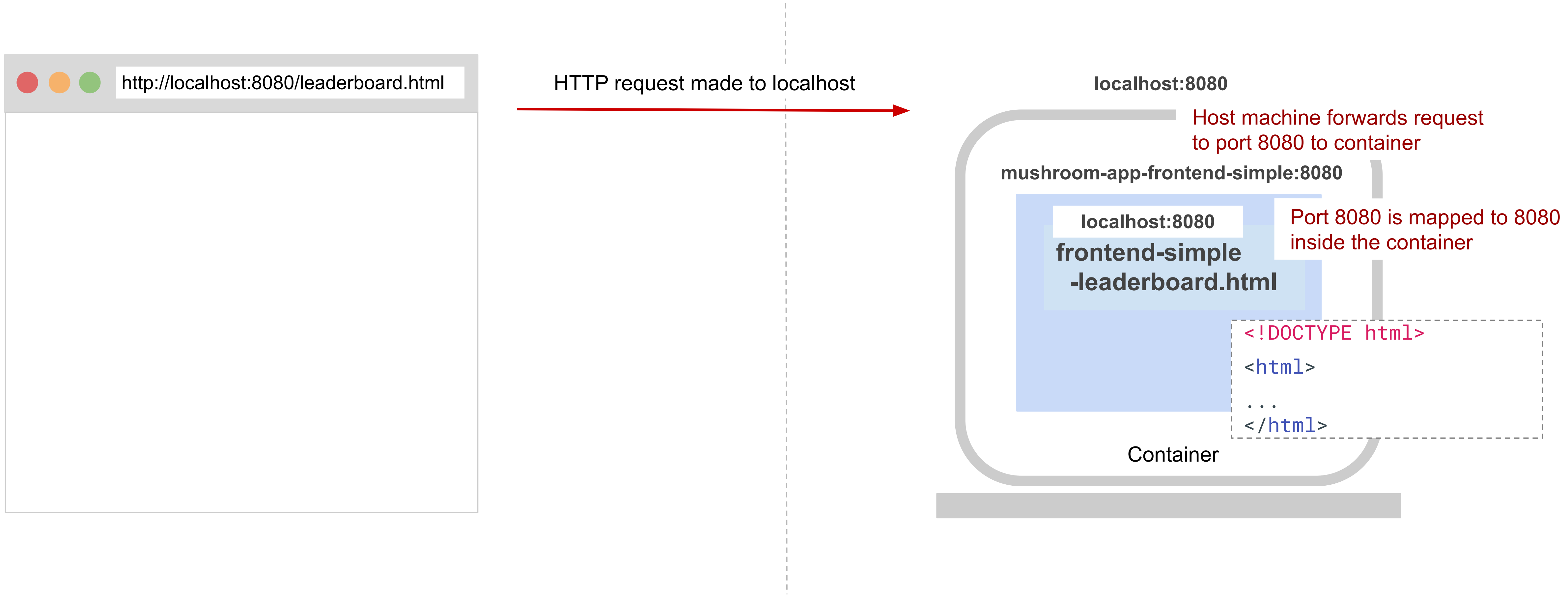
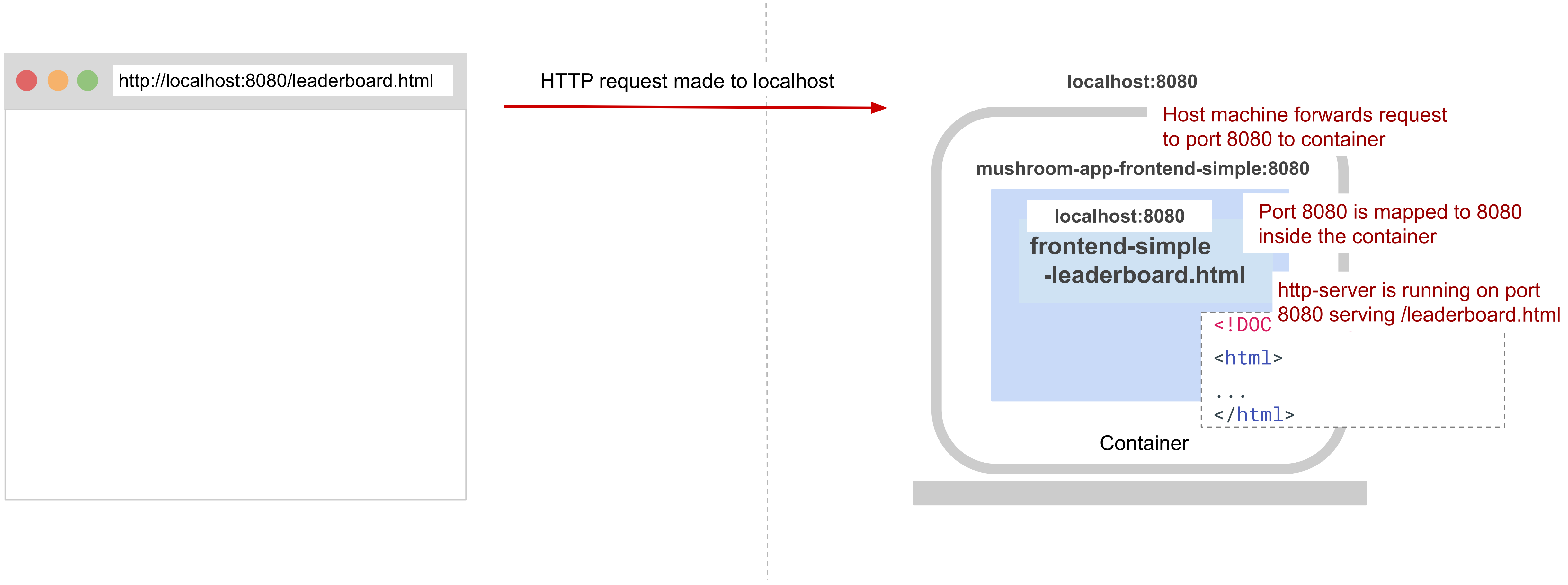

http://localhost:8080/leaderboard.html
HTTP request made to localhost
localhost:8080
Host machine forwards request to port 8080 to container
mushroom-app-frontend-simple:8080
localhost:8080
frontend-simple -leaderboard.html
Port 8080 is mapped to 8080 inside the container
Container

```
<!DOCTYPE html>
<html>
...
</html>
```

Browser

Local computer / Server

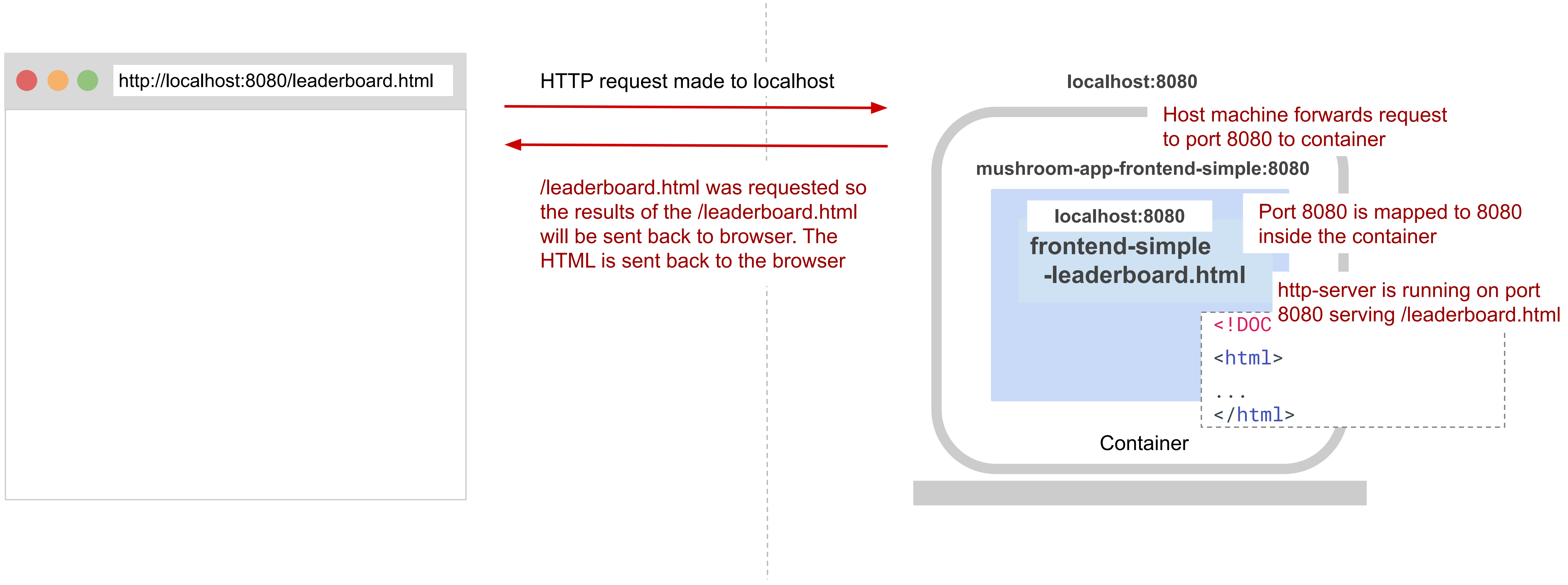
How does the App work


http://localhost:8080/leaderboard.html
HTTP request made to localhost
localhost:8080
Host machine forwards request to port 8080 to container
mushroom-app-frontend-simple:8080
localhost:8080
frontend-simple -leaderboard.html
Port 8080 is mapped to 8080 inside the container
http-server is running on port 8080 serving /leaderboard.html
<!DOC
<html>
...
</html>
Container

Browser

Local computer / Server

How does the App work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HTTP request made to localhost
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Browser

Local computer / Server

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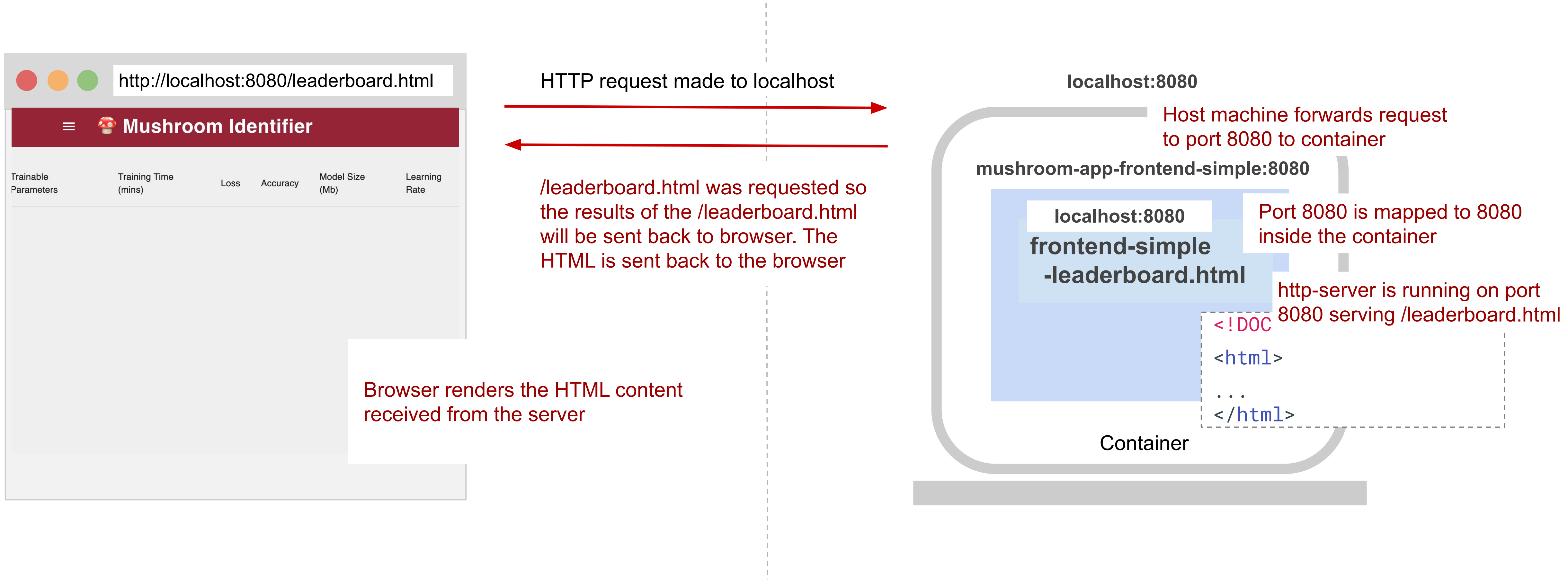

http://localhost:8080/leaderboard.html
Mushroom Identifier
Trainable Parameters
Training Time (mins)
Loss
Accuracy
Model Size (Mb)
Learning Rate
HTTP request made to localhost
/leaderboard.html was requested so the results of the /leaderboard.html will be sent back to browser. The HTML is sent back to the browser
Browser renders the HTML content received from the server
localhost:8080
Host machine forwards request to port 8080 to container
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Browser

Local computer / Server

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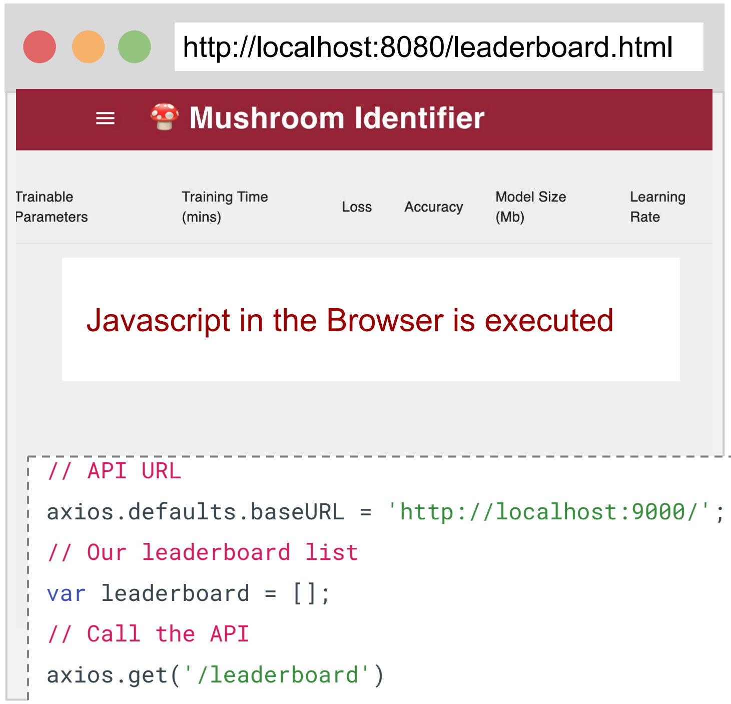
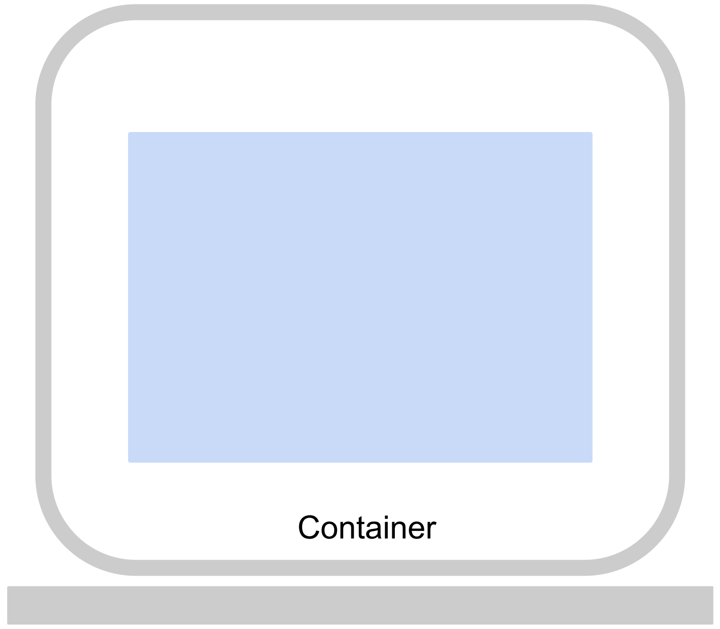


Javascript in the Browser is executed

```
// API URL
axios.defaults.baseURL = 'http://localhost:9000/';
// Our leaderboard list
var leaderboard = [];
// Call the API
axios.get('/leaderboard')
    .then((response) => {
        leaderboard = response.data;
        // Build the table
        buildLeaderboardTable(leaderboard);
    });
```

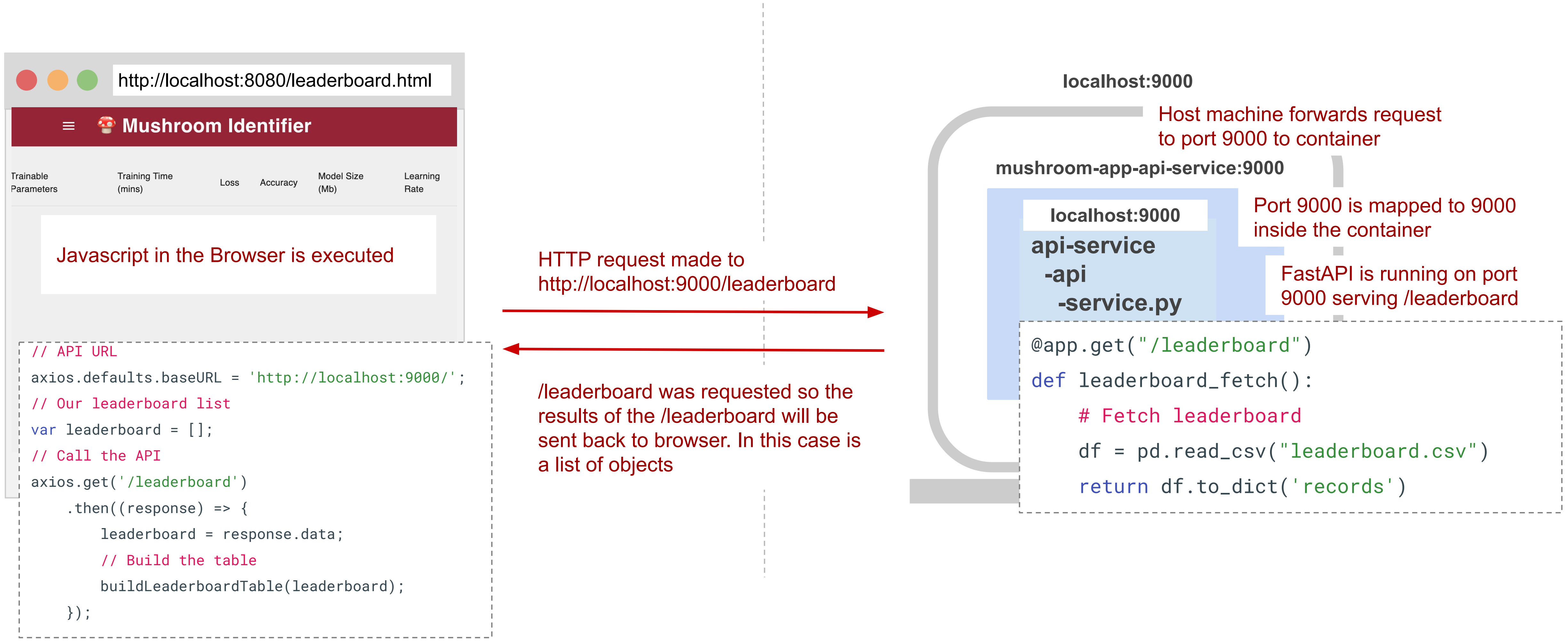
HTTP request made to http://localhost:9000/leaderboard



Browser

Local computer / Server

How does the App work



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HTTP request made to http://localhost:9000/leaderboard

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Host machine forwards request to port 9000 to container

Port 9000 is mapped to 9000 inside the container

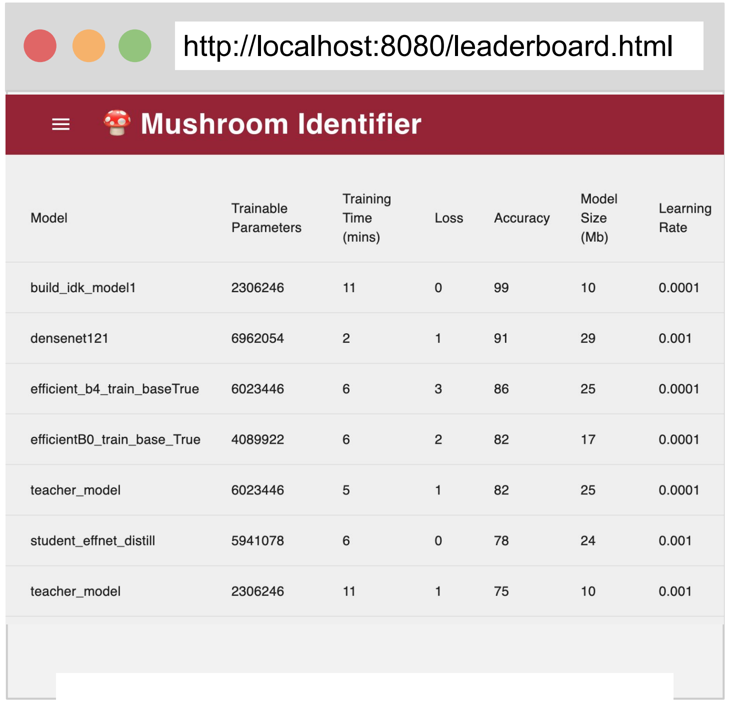
FastAPI is running on port 9000 serving /leaderboard

```
@app.get("/leaderboard")
def leaderboard_fetch():
    # Fetch leaderboard
    df = pd.read_csv("leaderboard.csv")
    return df.to_dict('records')
```

Browser

Local computer / Server

How does the App work



http://localhost:8080/leaderboard.html

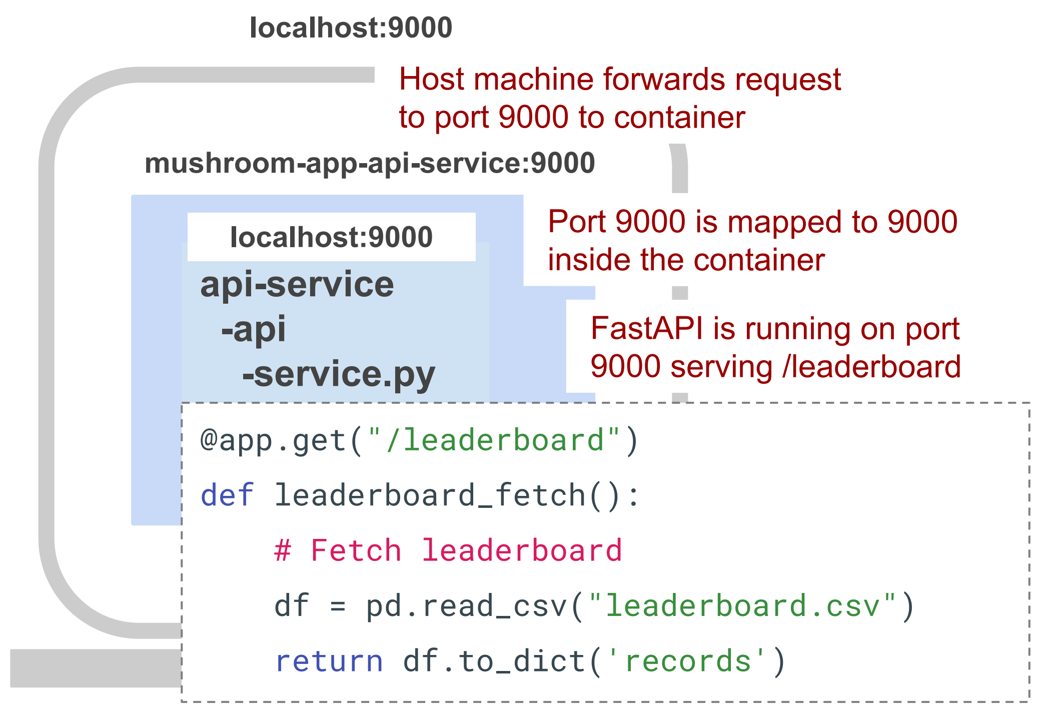
Mushroom Identifier

Model	Trainable Parameters	Training Time (mins)	Loss	Accuracy	Model Size (Mb)	Learning Rate
build_idk_model1	2306246	11	0	99	10	0.0001
densenet121	6962054	2	1	91	29	0.001
efficient_b4_train_baseTrue	6023446	6	3	86	25	0.0001
efficientB0_train_base_True	4089922	6	2	82	17	0.0001
teacher_model	6023446	5	1	82	25	0.0001
student_effnet_distill	5941078	6	0	78	24	0.001
teacher_model	2306246	11	1	75	10	0.001

Javascript displays the leaderboard data in the html page.

HTTP request made to http://localhost:9000/leaderboard

/leaderboard was requested so the results of the /leaderboard will be sent back to browser. In this case is a list of objects


localhost:9000
Host machine forwards request to port 9000 to container
mushroom-app-api-service:9000
Port 9000 is mapped to 9000 inside the container
localhost:9000
api-service -api -service.py
FastAPI is running on port 9000 serving /leaderboard

```
@app.get("/leaderboard")
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Browser

Local computer / Server

Outline

1. Recap
2. APIs
3. App Frontend (Simple)
4. **Model Serving**
5. Frontend Frameworks

Tutorial: Model Serving API

Mushroom App - Model Serving API

Outline

1. Recap
2. APIs
3. App Frontend (Simple)
4. Model Serving
5. **Frontend Frameworks**

Frontend

When we build our frontend we had a page for each component:

- index.html
- leaderboard.html
- predict.html

Frontend

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- index.html
- leaderboard.html
- predict.html

Problems:

- Each of these had its own HTML, Javascript, CSS
- How do we share/reuse code across pages
- Each page is loaded separately in browser (Slow)

Frontend

Problems:

- Each of these had its own HTML, Javascript, CSS
- How do we share/reuse code across pages
- Each page is loaded separately in browser (Slow)

Solution:

- Create a single page app that manages HTML, Javascript, CSS as components
- Frontend App Frameworks to the rescue

Frontend Frameworks

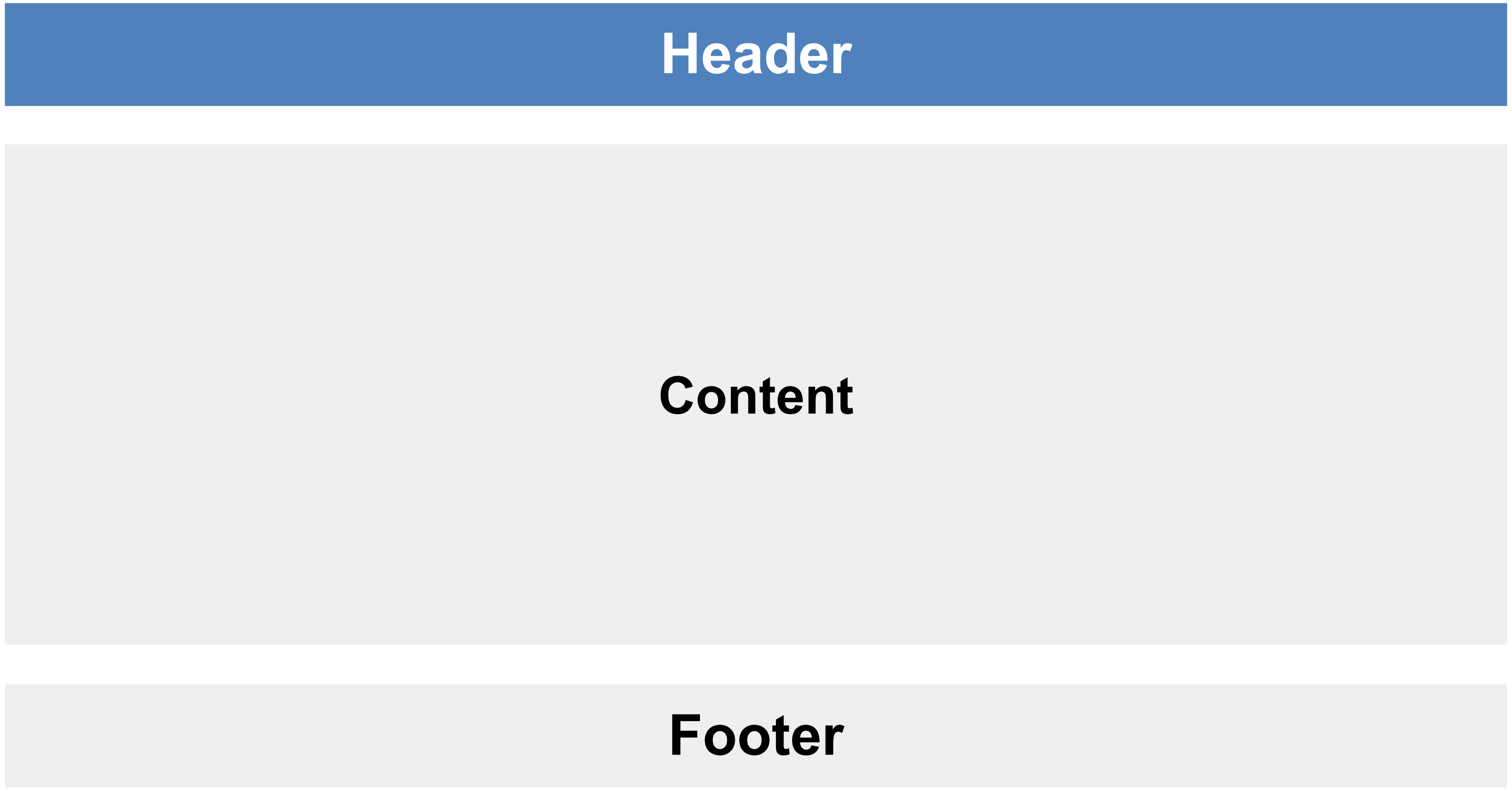
There major frontend app frameworks are:

- Angular (Google)
- React (Facebook)
- Vue

React

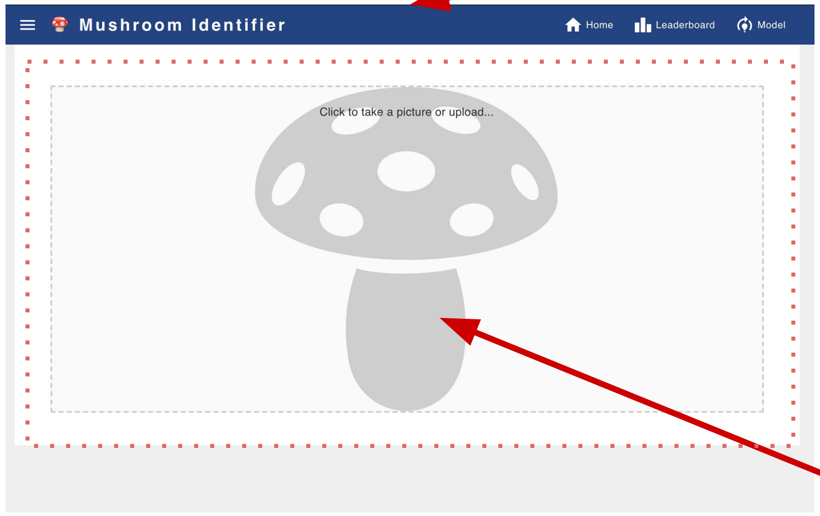
- Everything is a Component
- Uses JSX instead of Javascript
- JSX is an extension to JavaScript
- JSX is like a template language, but it comes with the full power of JavaScript

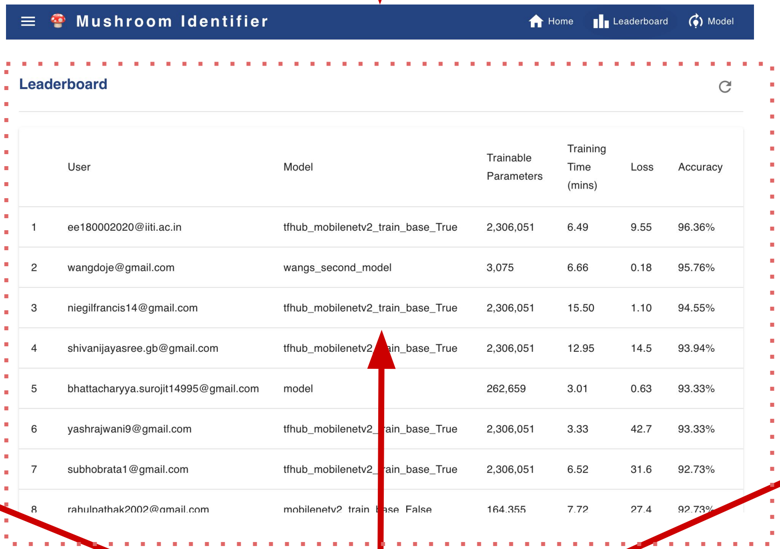
React App



React App

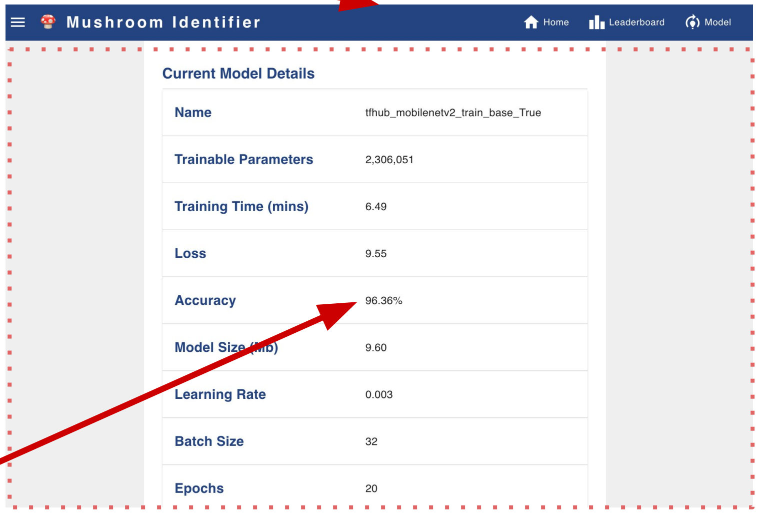
Header defined only once





Leaderboard

	User	Model	Trainable Parameters	Training Time (mins)	Loss	Accuracy
1	ee180002020@iiti.ac.in	tfhub_mobilenetv2_train_base_True	2,306,051	6.49	9.55	96.36%
2	wangdoje@gmail.com	wangs_second_model	3,075	6.66	0.18	95.76%
3	niegilfrancis14@gmail.com	tfhub_mobilenetv2_train_base_True	2,306,051	15.50	1.10	94.55%
4	shivanijayasree.gb@gmail.com	tfhub_mobilenetv2_train_base_True	2,306,051	12.95	14.5	93.94%
5	bhattacharyya.surojit14995@gmail.com	model	262,659	3.01	0.63	93.33%
6	yashrajwani9@gmail.com	tfhub_mobilenetv2_train_base_True	2,306,051	3.33	42.7	93.33%
7	subhobrata1@gmail.com	tfhub_mobilenetv2_train_base_True	2,306,051	6.52	31.6	92.73%
8	rahulpathak2002@gmail.com	mobilenetv2_train_base_False	164,355	7.72	27.4	92.73%



Current Model Details

Name	tfhub_mobilenetv2_train_base_True
Trainable Parameters	2,306,051
Training Time (mins)	6.49
Loss	9.55
Accuracy	96.36%
Model Size (Mb)	9.60
Learning Rate	0.003
Batch Size	32
Epochs	20

Content block switched for each page

THANK YOU