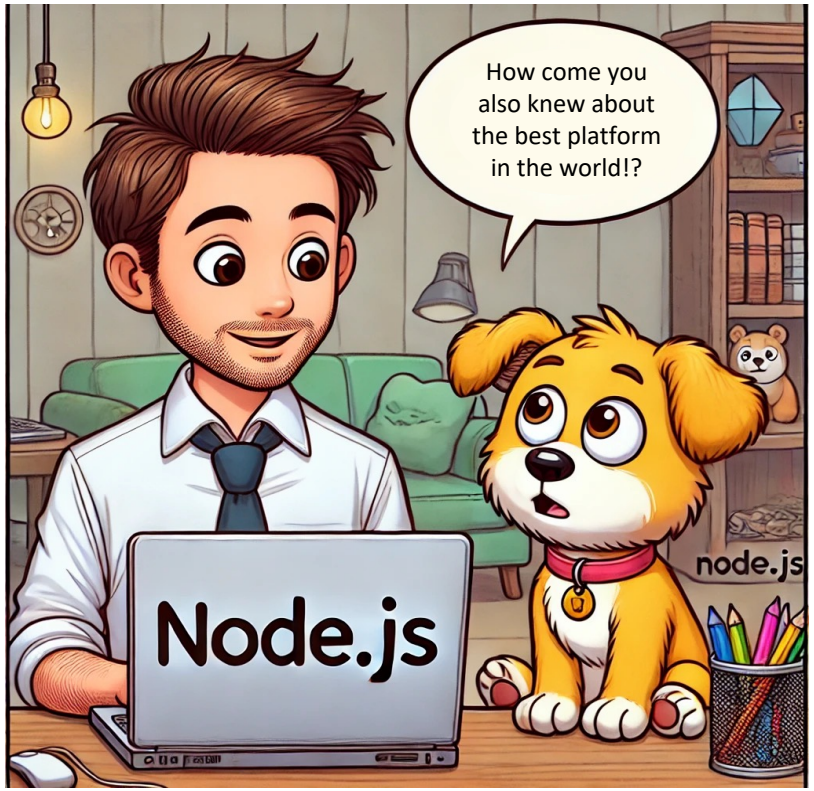

Node.js, Next.js, and APIs

CSC309

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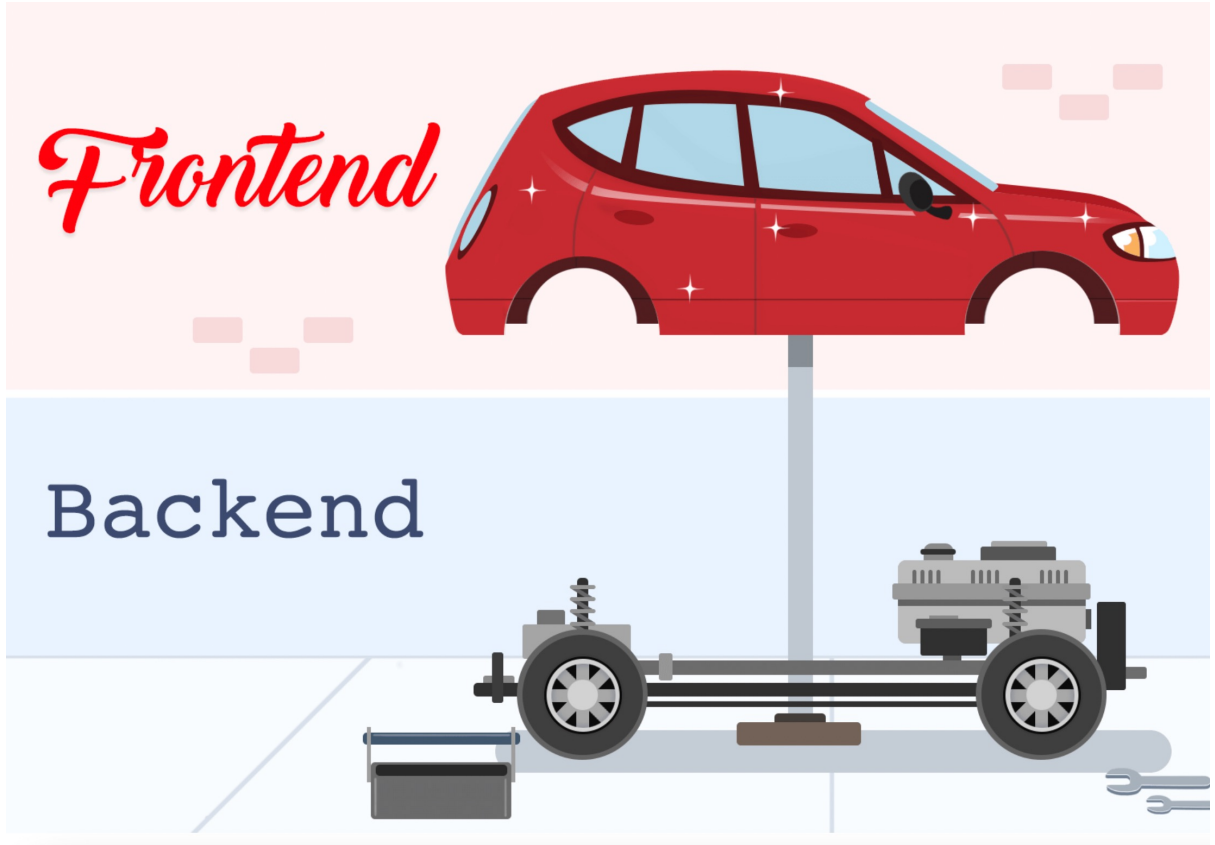
So far

- How web works
  - Client vs server
  - HTTP
- Static web pages
  - HTML and CSS
- JavaScript
  - Syntax, objects, scope, arrow functions
  - Dynamic web pages

This session

- Modern architecture of web apps
  - Frontend & backend
  - APIs
- Server-side JavaScript
  - JS projects with Node.js
- Intro to Next.js

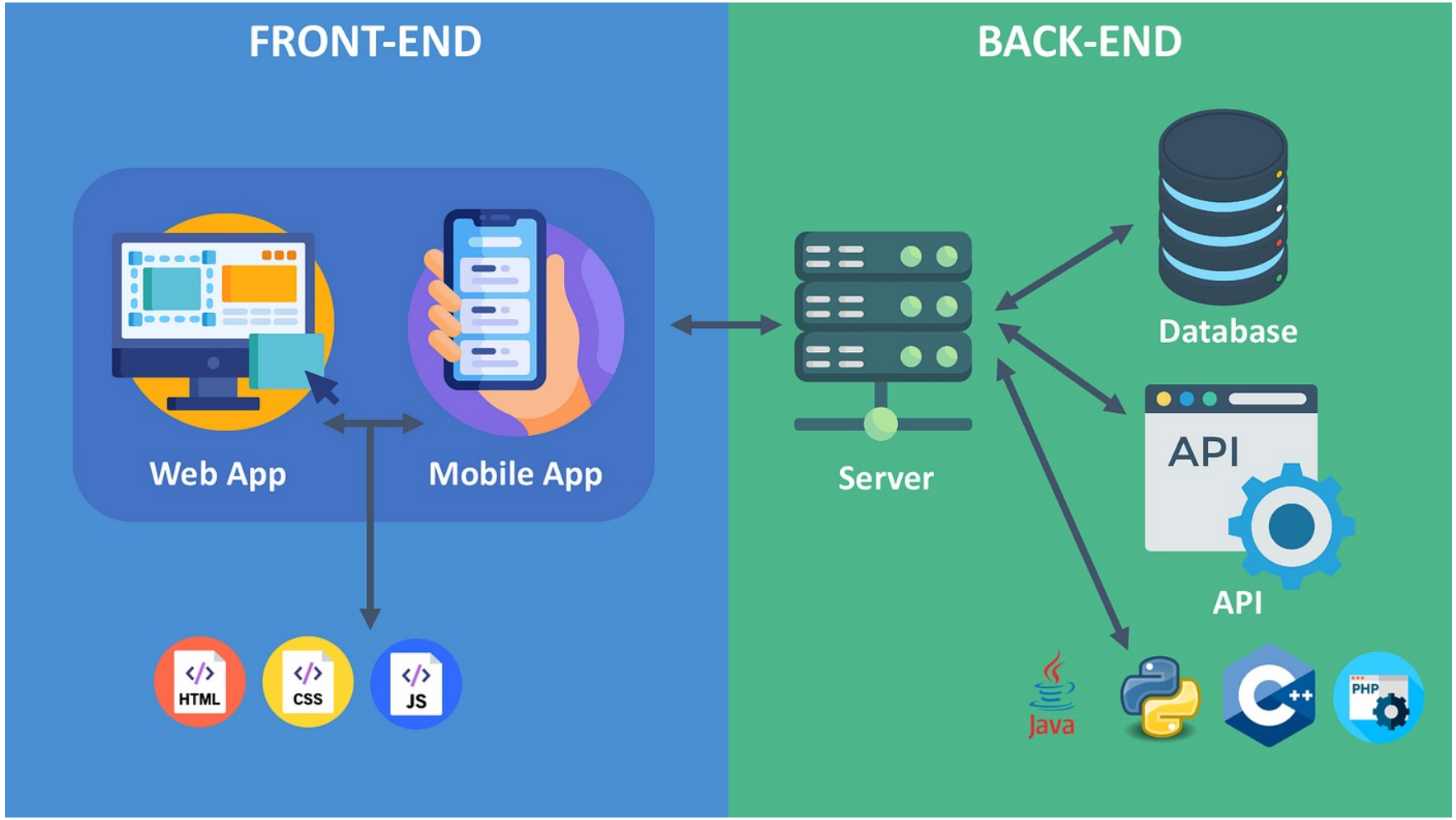
Web development



Source: blog.back4app.com

Source: https://www.reddit.com/r/ProgrammerHumor/comments/m187c4/backend_vs_frontend/

Web development



Source: https://mobilelive.medium.com/backend-for-frontend-basics-a-comprehensive-guide-37768062e55a

Front-end development

- What user can see
  - User interface (UI)
  - User experience (UX)

- What is run on the client-side
  - HTML/CSS rendering
  - Javascript codes running on browser

Back-end development

- What user can't see
  - What does it even mean?
- All logic and processes that happen behind the scene
- Including processing the requests, creating responses, data management, …
- At the server-side!

Web server

- Listens on specified port(s)
- Handles incoming connections
  - Generates a response
  - Fetches a file
  - Forwards them to corresponding applications
- Load balancing, security, file serving, etc
- Examples: Apache, Nginx

Backend frameworks

- Doing everything from scratch?
  - Listen on a port, process http requests (path, method, headers, body), retrieve data from storage, process data, create the response
- Not really a good idea!
- A lot of frameworks are out there!
  - A lot of things are pre-implemented

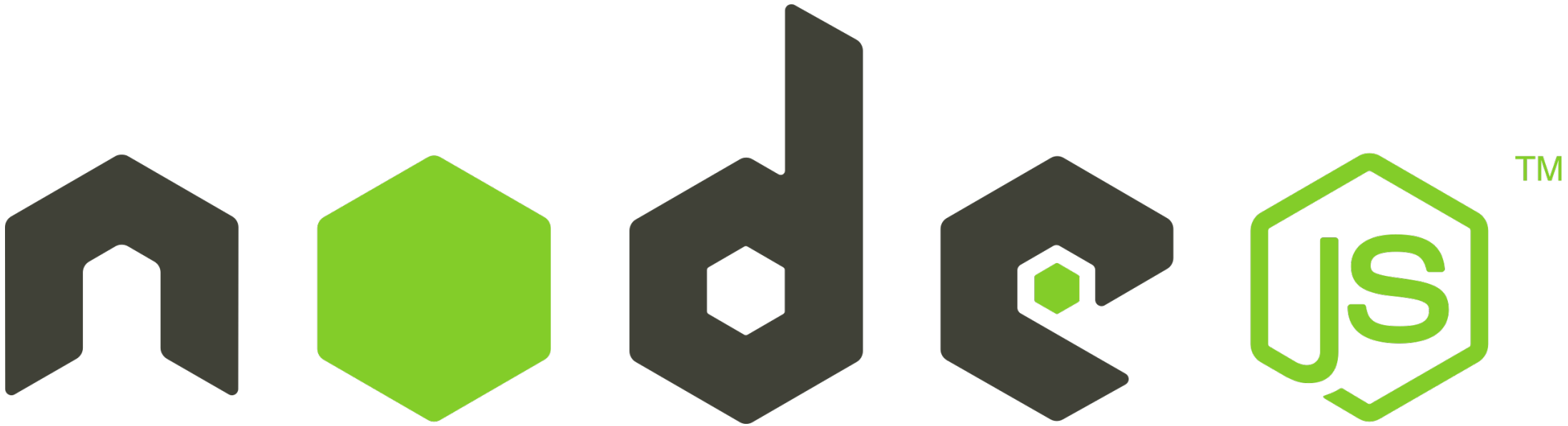
Backend frameworks

- PHP: Laravel, CodeIgniter
- Python: Django, Flask, FastAPI
- JavaScript: Express, Next.js
- Ruby: Ruby on Rails

Concept is more important than framework!

Unique power of JavaScript

- JavaScript is the only language that can be used in both front-end and back-end codes!
- Helpful for code consistency, unity, type sharing, library sharing, etc.
- Thanks to Node.js, we can have JavaScript projects
  - Could be backend, frontend, or even both!


TM
JS

Node.js

- JS does not have to be run on the browser!
- Node.js: a runtime environment to for running JS server-side
- Includes a package manager, console, build tools, etc.

Node console

- Opens with the `node` command
- You can execute inline JS code
- No window or DOM object
  - We are outside of the browser
- Files can be run as well

```
node <filename>
```

Installing libraries

- Node Package Manager (npm)
  - Similar to pip, maven, etc. in other languages
- Install packages via `npm install <package_name>`
  - Packages are stored in the `node_modules` directory
- Automatically generates and maintains a file named `package.json`

Import and export

- Variables, classes, or functions can be exported from a JS file (aka module)

```
const var1 = 3, var2 = (x) => x + 1
export { var1, var2 }
```

- Can be reduced to one statement:

```
export const var1 = 3, var2 = (x) => x + 1
```

- Other modules can import them

```
import { var1 } from './App'
```

Default export

- Each module can have one default export

```
export default App
```

- Importing the default export:

```
import App from "./App"
```

- This time, the names do not have to match
  - Can be imported under any arbitrary name

Backend project with Node.js

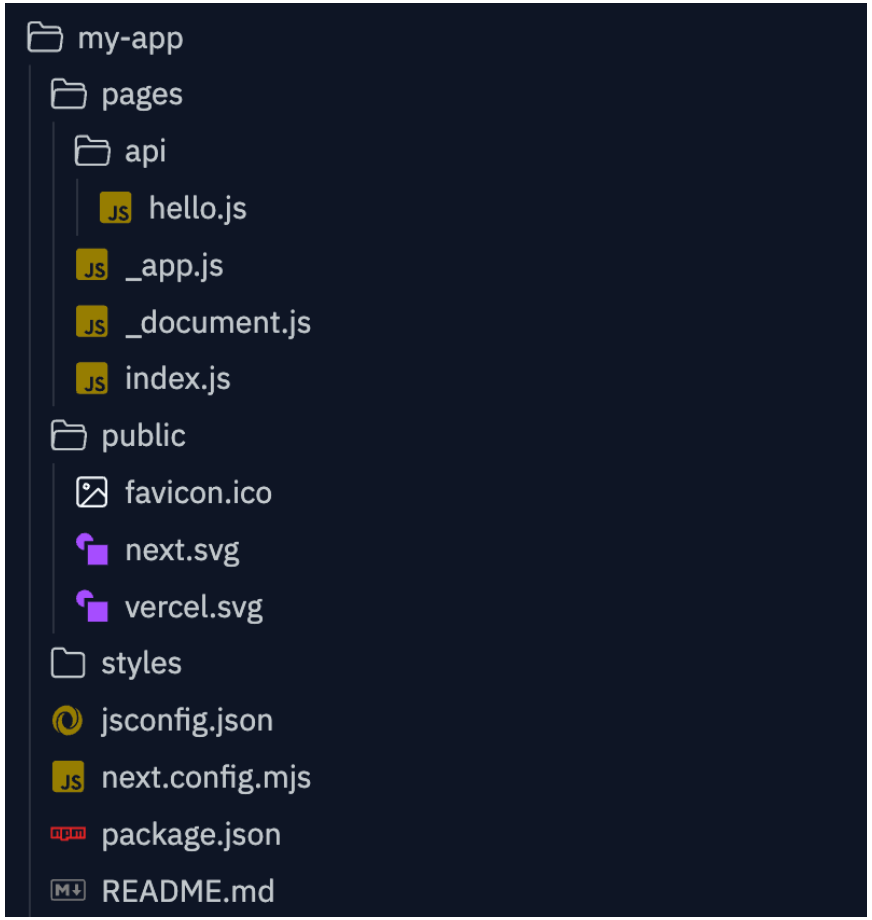
- In this course, we use Next.js as the backend (and frontend) framework
  - More on frontend later in the course!

- Create a project via Node Package Execute (npx)
  - Run `npx create-next-app@latest`
  - Answer No to all prompts for now
  - We will get to them later!

Next.js project

Visit https://nextjs.org/docs

- Looking at package.json
  - `next` and `react` are installed
  - Ignore `react` for now
- Ignore everything except for /pages/api folder
  - This is our main backend directory!

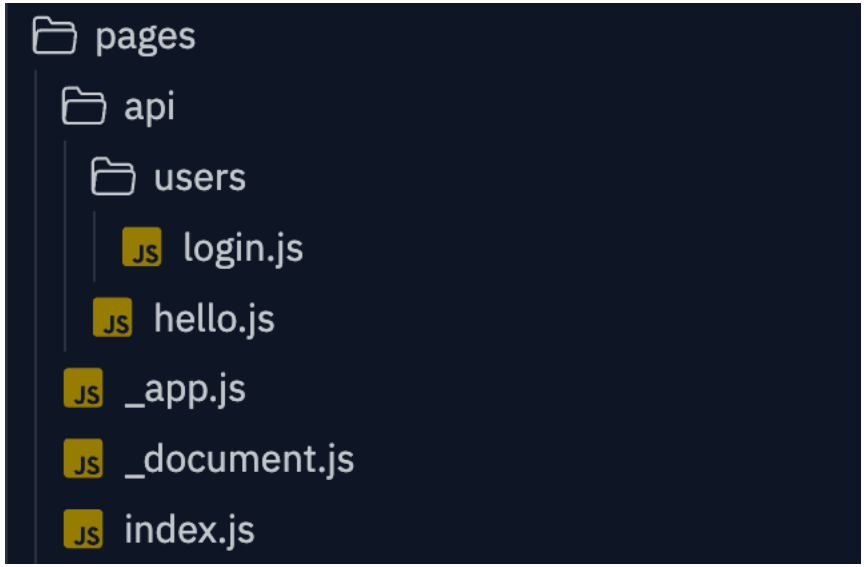


API directory

The concept of API is discussed later today!

- In the pages directory, every JS file will correspond to a URL path
  - `/api/users/login`
  - `/api/hello`

- Exception: files that start with an underscore
  - There will be no `/_app`



API handler (aka URL handler)

- The default export is the handler function
  - Executed when a request with the corresponding URL path arrives
- Inputs request and response objects
  - Does not have a return
- Example

```
export default function handler(req, res) {
  // Backend logic
}
```

Status & Responses

- Text response

```
res.status(200).send("hi there!")
```

- JSON response

```
res.status(200).json({message: "Hello"})
```

- Redirect

```
res.status(302).redirect("/api/users/login");
```

Status & Responses

- Error response

```
res.status(400).send("Bad request");
res.status(500).send("Oops! Internal error");
```

- HTML response

```
res.status(200).send(`
   <html>
     <head>
       <title>Success!</title>
     </head>
     <body>
       <h1>Login Successful!</h1>
     </body>
   </html>
 `);
```

Request object

- Method
```
if (req.method === 'POST') {...
```
- Headers
```
if (req.headers['content-type'] === 'application/json') {...
```
- Query params (after ? in the URL)
```
const search = req.query.search || null
```
- Request body (assumes JSON by default)
```
const {username, password} = req.body
```

How a web app works

- Browser requests a URL
- API handler returns a giant HTML with the appropriate CSS, and client-side JS content
  - Potentially reads it from a separate file
  - Could be dynamically filled based on the request
- Users clicks on links and/or fills out forms
- API handlers processes the GET/POST requests and returns another HTML response or a redirect

Does it, really?

Web apps worked this way before 2010s!

Some still do…

Can you think of some major drawbacks of this style of web apps?

Drawbacks

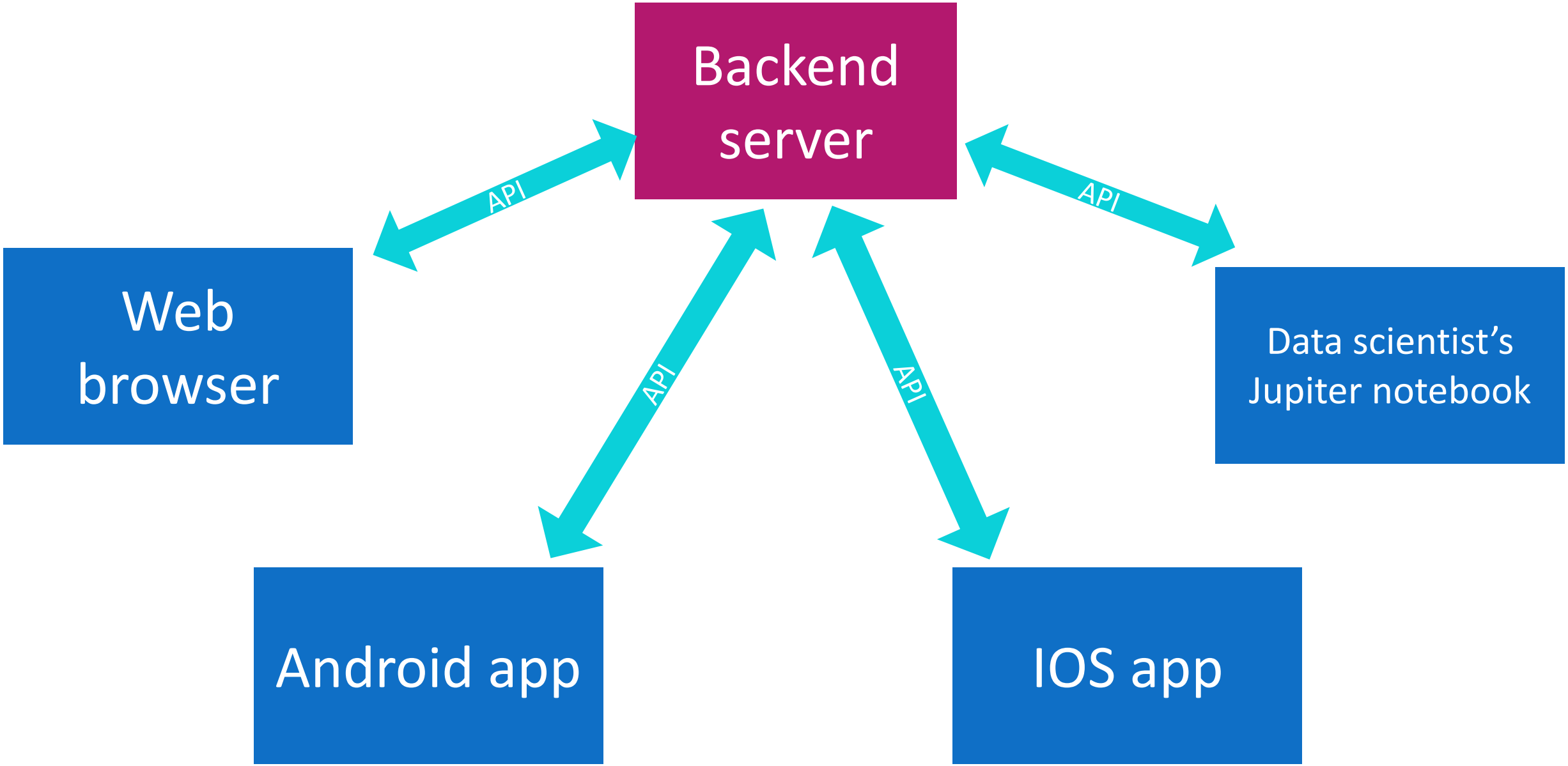
- Too backend-oriented
  - All frontend logic is served as part of backend handlers
  - Code gets messy and hard to understand

- Limits all frontends to web browsers
  - What about mobile, watch, assistant, etc. ?

- Frontend can't be as sophisticated
  - Example: Single-page application

Separate backend and frontend

- Modularity
  - Changes in frontend will not affect backend and vice versa
- Consolidation
  - One backend and multiple frontends (web, android, iOS)


Backend server
API
API
API
API
Web browser
Data scientist's Jupiter notebook
Android app
IOS app

Modularity

- Different services/apps talk to each other with a protocol

- API: The way an application can be talked to
  - Stands for Application Programming Interface

- Web applications: typically, a set of HTTP requests

Separate Backend and Frontend

- Backend views are only about data retrieval and manipulation
- Backend does not care about how data is shown, UI, or UX
- No HTML, CSS, client-side JS

Response format

- A popular standard is JavaScript Object Notation or JSON
  - Derived from JavaScript syntax for defining objects
- Easy, human-readable, and fast
  - Many languages (python, javascript, …) have built-in parsers and support

JSON

- Primitive types: number, string, boolean, null
- Array: ordered collection of elements
- Object: key-value pairs
  - Keys are strings
- Array elements and object values can be of any type (string, null, array, object, etc.)

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 27,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

Source: wikipedia

API architecture

- Representational State Transfer (REST)

- A set of URL endpoints that do a data management task
  - Login, signup, list of comments, create a post, edit profile, …

- All data is in the JSON format
  - Both request payload and response

- Example:
  exchange-docs.crypto.com/exchange/v1/rest-ws/index.html

Restful APIs in Next.js

- Next.js natively supports Restful APIs
- Request body is parsed from JSON into a JS object
  - Accessible in `req.body`
- Native support for returning JSON response
  - Via `req.status(…).json(…)`
  - Appropriate headers are also set

Next session

- Async programming
  - Event loop and promises
- Data management
  - Model design
  - The MVC design pattern
- ORMs