Next.js Training

Modern React Web Development

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About Me

- **Productboard** (since March 2025)
  - Product Staff Engineer
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- **React Experience**
  - React Lover (10+ years)
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  - Courses & Workshops (React, Next.js, QA)
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Agenda

4. Environments
5. Configuration & Instrumentation
6. Extra: Styling, Forms, Error Boundaries, MDX, Images, Testing

Pages Router

Pages Router (Legacy)

- Demonstrated in the separate project: **next-guide-pages** (`apps/next-guide-pages`)
- File-based routing in the `pages/` directory
- Each file in `pages/` is a route (e.g., `index.tsx` , `users/[id].tsx`)
- Dynamic routes: `[id].tsx` , catch-all: `[...slug].tsx`
- API routes: `pages/api/`

- Special files for advanced customization:
  - **_app.tsx**: Custom root component for all pages (see file). Use for global styles, context providers, etc.
  - **_document.tsx**: Customizes the HTML document structure (see file). Use for meta tags, lang, etc.
  - **_error.tsx**: Custom error page for runtime errors (see file).
  - **404.tsx**: Custom 404 Not Found page (see file).
  - **500.tsx**: Custom 500 Internal Server Error page (see file).

Demos:

- Homepage (/)
- User detail (dynamic route) (/users/1)
- API users route (/api/users)
- Catch-all route (/ssg)

API Routes

- Serverless functions as API endpoints in `pages/api/`
- Each file in `api/` is an endpoint (GET, POST, etc.)
- Use the built-in types: `NextApiRequest` and `NextApiResponse` from `next`
- Response helpers: `res.status`, `res.json`, `res.send`, `res.redirect`, `res.revalidate`
- Supports dynamic routes (`pages/api/post/[pid].ts`) and catch-all routes (`pages/api/post/[...slug].ts`)
- TypeScript support for type-safe APIs
- Official documentation

Example: Basic API Route

```
import type { NextApiRequest, NextApiResponse } from 'next';

export default function handler(req: NextApiRequest, res: NextApiResponse) {
  res.status(200).json({ message: 'Hello from Next.js!' });
}
```

Example: Dynamic API Route

```
// pages/api/post/[pid].ts
import type { NextApiRequest, NextApiResponse } from 'next';

export default function handler(req: NextApiRequest, res: NextApiResponse) {
  const { pid } = req.query;
  res.end(`Post: ${pid}`);
}
```

Example: Catch-all API Route

```
// pages/api/post/[...slug].ts
import type { NextApiRequest, NextApiResponse } from 'next';

export default function handler(req: NextApiRequest, res: NextApiResponse) {
  const { slug } = req.query;
  res.end(`Post: ${Array.isArray(slug) ? slug.join(', ') : slug}`);
}
```

Linking and Navigating

- Next.js provides a built-in `<Link>` component for client-side navigation between routes.
- Using `<Link>` enables fast, seamless transitions without full page reloads, preserving state and improving UX.
- `<Link>` automatically prefetches linked pages in the background for faster navigation (when visible in the viewport).
- Prefer `<Link>` over a plain `<a>` tag for internal navigation. Use `<a>` only for external links.
- You can disable prefetching with the `prefetch={false}` prop.
- `<Link>` works with dynamic routes, catch-all routes, and route groups.

Example:

```
import Link from 'next/link';

export default function Navigation() {
  return (
    <nav>
      <Link href="/about">About</Link>
      <Link href="/blog" prefetch={false}>
        Blog (no prefetch)
      </Link>
      <a href="https://nextjs.org" target="_blank" rel="noopener noreferrer">
        Next.js Docs
      </a>
    </nav>
  );
}
```

- For advanced use cases, you can use the `useRouter`, `usePathname`, and `useSearchParams` hooks from `next/navigation`.
- Official documentation: Linking and Navigating

Rendering & Data Fetching

- The Pages Router supports multiple rendering and data fetching strategies:
    - **SSR (Server-Side Rendering):** Use `getServerSideProps` to fetch data on every request.
        - SSR example (/ssr)
    - **SSG (Static Site Generation):** Use `getStaticProps` (and optionally `getStaticPaths`) to pre-render pages at build time.
        - SSG example (/ssg)

getStaticPaths fallback options:

- `fallback: false` – Only the paths returned by getStaticPaths are generated at build time. Any other route will show a 404 page.
- `fallback: true` – New paths not returned by getStaticPaths will be rendered on-demand on the first request, then cached for future requests. The page will show a loading state until the content is generated.
- `fallback: 'blocking'` – New paths are rendered on-demand like `true`, but the user will not see a loading state; the server waits until the page is generated and then serves the full page.

Use `false` for small/finite sets of pages, `true` or `'blocking'` for large or dynamic sets where not all paths are known at build time.

- getStaticPaths details

- **Client-side Fetching:** Use React hooks like `useEffect` to fetch data on the client after the page loads.
    - CSR example (/csr)
- You can combine these strategies as needed for your use case.
- See also: Next.js Data Fetching Docs

App Router

App Router (Modern)

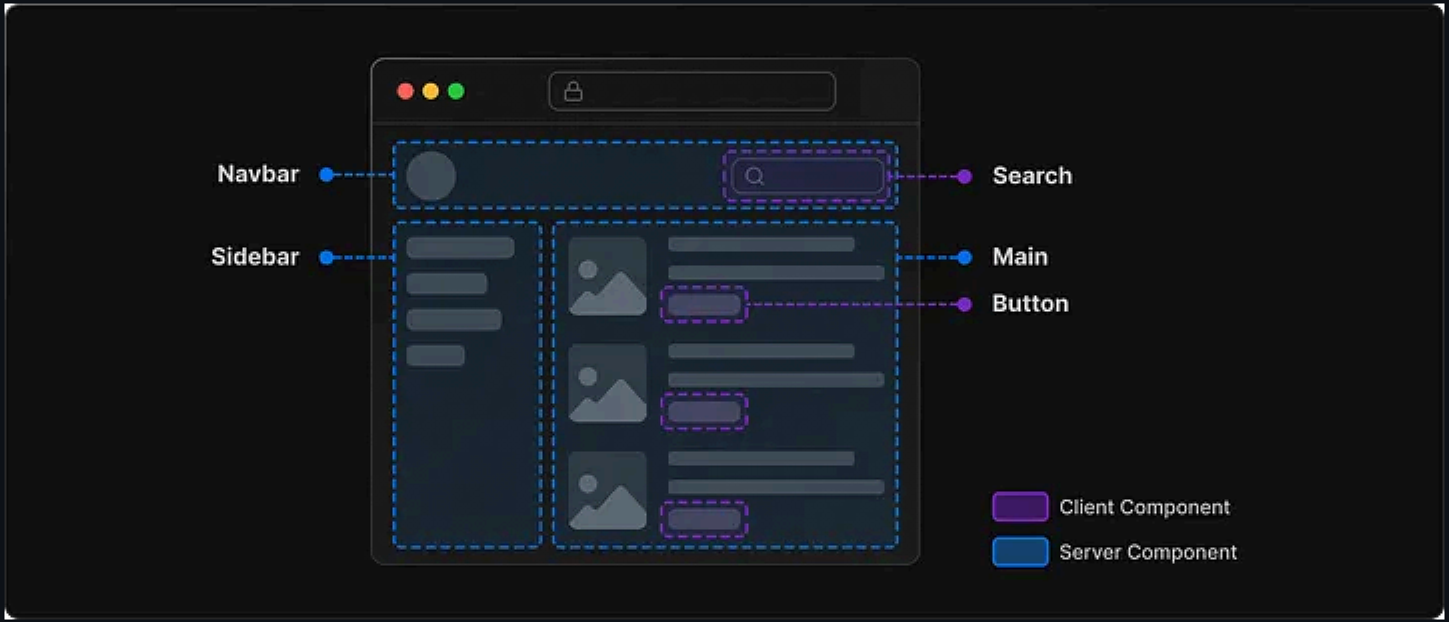
- File-based routing in `src/app/`
- Each folder with `page.tsx` = a route
- Supports layouts, nested routes, dynamic routes, catch-all routes
- **Layout:**
  - Root layout.tsx – defines the main structure, shared UI, and providers for the whole app.
- **Loading UI:**
  - You can add `loading.tsx` to any route folder for custom loading skeletons.
  - API loading
  - Dashboard loading
  - Blog post loading
- Official Project Structure documentation

Rendering & Data Fetching

Server vs Client Components

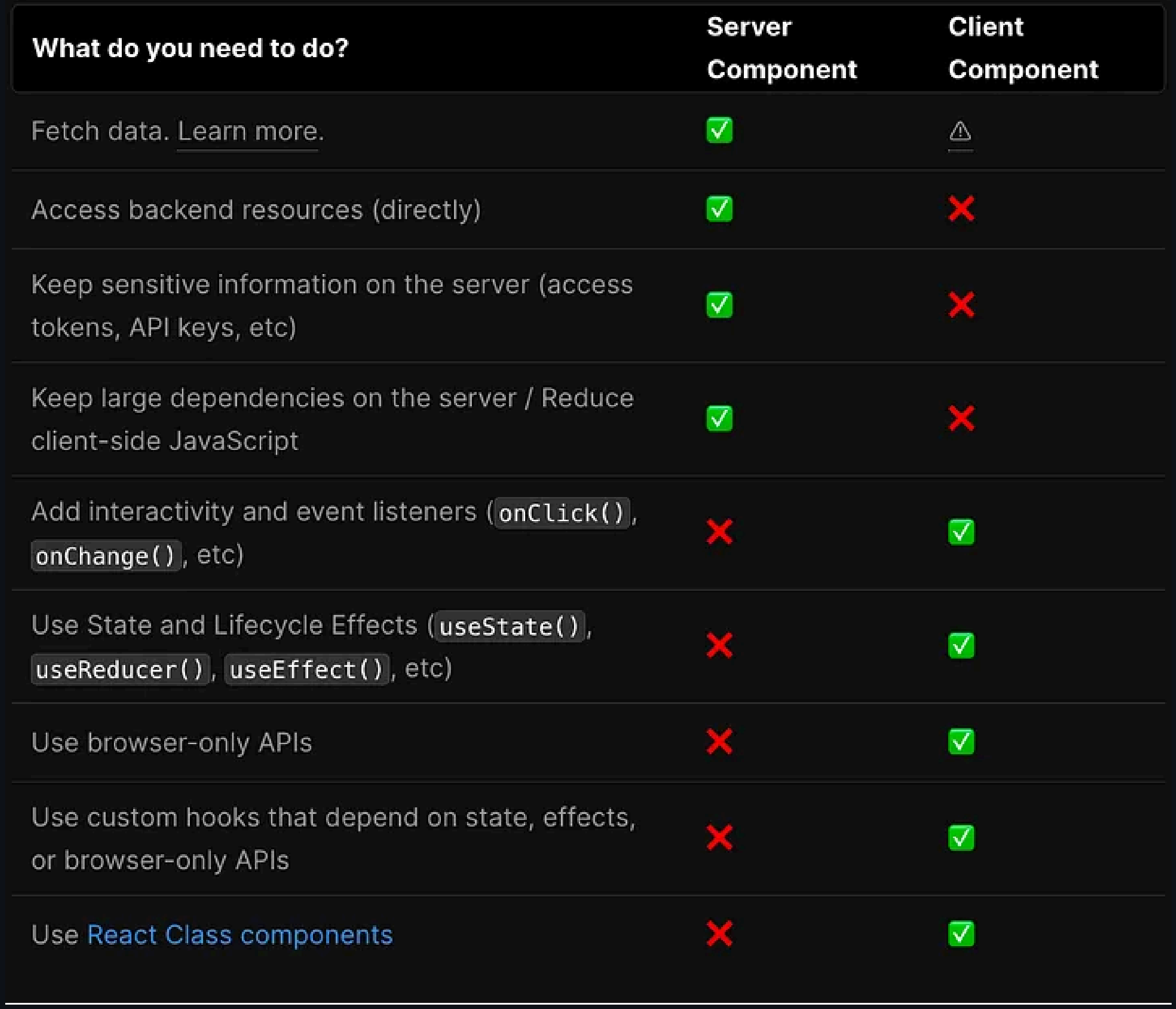
Server Components are rendered on the server and sent as HTML to the client, while Client Components are rendered in the browser. In Next.js App Router, **Server Components are the default**—you only need to use Client Components when you need interactivity, browser APIs, or React hooks like `useState`, `useEffect`, etc.

- Server Components improve performance by reducing the amount of JavaScript sent to the client.
- Client Components are needed for interactivity (event handlers, state, browser APIs).
- You can mix Server and Client Components on the same page.
- Mark a component as client by adding `"use client"` at the top of the file.


Navbar
Sidebar
Search
Main
Button
Client Component
Server Component

Demos:

- Server component example (/server-component)
- Blog post: Server vs Client Components(/blog/server-components-vs-client-components)



What do you need to do?	Server Component	Client Component
Fetch data. Learn more.	✅	⚠️
Access backend resources (directly)	✅	❌
Keep sensitive information on the server (access tokens, API keys, etc)	✅	❌
Keep large dependencies on the server / Reduce client-side JavaScript	✅	❌
Add interactivity and event listeners (`onClick()`, `onChange()`, etc)	❌	✅
Use State and Lifecycle Effects (`useState()`, `useReducer()`, `useEffect()`, etc)	❌	✅
Use browser-only APIs	❌	✅
Use custom hooks that depend on state, effects, or browser-only APIs	❌	✅
Use React Class components	❌	✅

Demos:

- Client component demo (/client-component)
- with Counter component

> For more, see Server Components vs. Client Components
>
> Nice explanation Ariel Shulman - WebExpo - from 29:38

SSR & SSG

- SSR: Server Side Rendering (on request)
- SSG: Static Site Generation (at build time)
- Use `generateStaticParams` for SSG

Demos:

- Dashboard (SSR) (/dashboard) - must be logged
- Blog (SSG) (/blog)

The `fetch` function

- Native fetch in server components
- Automatic caching

Demos:

- Client data fetching (/client-data-fetching)

Caching

- By default, fetch requests are **not** cached in Next.js 15+ (docs)
- Enable caching explicitly with `cache: 'force-cache'` or `next.revalidate` for ISR:

```
// Static caching
fetch(url, { cache: 'force-cache' });

// ISR (Incremental Static Regeneration)
fetch(url, { next: { revalidate: 3600 } });
```

- Use `cache: 'no-store'` to always fetch fresh data (SSR)

Controlling static/dynamic rendering with `dynamic` export:

- In App Router, you can control how a route is rendered and cached using the `dynamic` export at the top of your file:

```
// page.tsx, layout.tsx, or route.ts
export const dynamic = 'auto'; // (default) Next.js decides based on usage
// or
export const dynamic = 'force-static'; // always statically render and cache
// or
export const dynamic = 'force-dynamic'; // always render on the server, no cache
```

- **'auto'** (default): Next.js chooses static or dynamic based on your code (e.g. use of fetch, cookies, headers).
- **'force-static'**: Forces static rendering and caching, even if you use dynamic code (errors if truly dynamic).
- **'force-dynamic'**: Forces server-side rendering on every request, disables all caching.

Use these options to fine-tune performance and cache behavior for each route.

Dashboard page example (/dashboard) - see build report

Docs: Static and Dynamic Rendering

Demos:

- Caching demo(/caching-demo/)

Note on combining `dynamic` and `revalidate`:

- `revalidate` only has an effect when the route is statically rendered (default or `force-static`).
- If you set `dynamic = 'force-dynamic'`, any `revalidate` value is ignored—every request is always rendered on the server, no cache.
- Example:

  ```
  export const dynamic = 'force-dynamic';
  export const revalidate = 60; // This will be ignored
  ```

- Use `revalidate` for Incremental Static Regeneration (ISR) with static routes, not with `force-dynamic`.

Server Actions

- **Server Actions** let you run server-side code directly from your React components—no need to create a separate API route.
- Useful for mutations (create, update, delete), form submissions, and cache invalidation.
- Secure: code runs only on the server, never sent to the client.
- Can be called from forms or programmatically.
- Great for progressive enhancement (forms work even without JS).

Minimal example:

```
// In a server component
'use server';

export async function createUser(formData) {
  // Save to DB, revalidate cache, etc.
}

// In your page/component
<form action={createUser}>
  <input name="name" />
  <button type="submit">Create</button>
</form>;
```

- **Examples:**
    - User form server action - can be combined with useActionState
    - Database demo server actions
- You can also call `revalidateTag` or `revalidatePath` inside a server action after a mutation.
- Docs: Server Actions

On-demand Revalidation: `revalidateTag` and `revalidatePath`

- `revalidateTag(tag)` lets you purge the cache for a specific tag on demand. Use it after a mutation (e.g., creating or updating a record) to ensure that data with this tag is refetched on the next request.
- Add tags when fetching data:

  ```
  fetch(url, { next: { tags: ['users'] } });
  ```

- After a mutation, call on the server:

  ```
  import { revalidateTag } from 'next/cache';
  revalidateTag('users');
  ```

- `revalidatePath(path)` purges the cache for a specific path (page or API endpoint). Use it when you want to revalidate a particular page after a data change.

- See examples in the project:
  - User Form Server Action (revalidateTag) (/user-form-server-action)
  - Database Demo (revalidatePath) (/database-demo)
- More in the docs: revalidateTag, revalidatePath

Connecting to Database and Filesystem

- Use Prisma for DB, Node APIs for filesystem

Demos:

- Database demo (/database-demo)
- Prisma schema

Tip: To explore and edit your database visually, you can use Prisma Studio:

```
yarn prisma studio
```

API Routes

- In the App Router, API routes are implemented as **Route Handlers** using `route.ts` (or `route.js`) files inside the `app` directory.
- Each route handler can export HTTP methods as functions: `GET`, `POST`, `PUT`, `DELETE`, etc.
- You can use either the default Node.js runtime or opt-in to the Edge runtime by exporting `export const runtime = 'edge'`.
- Use the `NextRequest` object to access request data (body, query, headers, cookies).
- Use the `NextResponse` object to send responses.

- Route handlers are colocated with your routes, and support dynamic segments, catch-all, and route groups.
- **Difference from Pages Router:** No need for `api/` prefix in the URL, and you have full control over HTTP methods and runtime.
- Official documentation: Route Handlers

Example: Basic GET and POST handler

```
// app/api/hello/route.ts
import { NextRequest, NextResponse } from 'next/server';

export async function GET(request: NextRequest) {
  return NextResponse.json({ message: 'Hello from App Router!' });
}

export async function POST(request: NextRequest) {
  const data = await request.json();
  // process data...
  return NextResponse.json({ received: data });
}
```

- For dynamic API routes, use `[param]` or `[...slug]` in the folder name, just like for pages.
- You can also use middleware and Edge runtime for advanced use cases.

Route Groups & Segmented Sections

- In the App Router, you can separate sections using parentheses folders, e.g., `(marketing)`.
- Allows you to separate, for example, public and internal parts of the site, or marketing pages.
- **Example:**
  - Marketing group (/about)
- Official documentation

Parallel Routes & Slots

- Parallel routes allow you to render multiple independent parts of the page (slots) at the same time.
- Each slot is a folder starting with `@` (e.g., `@feed`, `@notifications`).
- Slots can also be nested.
- **Examples:**
  - Main parallel-demo (/parallel-demo)
  - Feed slot (/parallel-demo)
  - Notifications slot (/parallel-demo)
  - Nested slot feed/archive (/parallel-demo/archive)
- Official documentation

Conditional Routes & Slots

- Conditional routes allow you to dynamically change content based on a segment (e.g., user role).
- Slots like `@admin`, `@user` within a dynamic folder `[role]`.
- **Examples:**
  - Conditional routes demo (/conditional-routes-demo/user)
  - Admin slot (/conditional-routes-demo/admin)
  - User slot (/conditional-routes-demo/user)
- Official documentation

Progressive Enhancement

- Progressive enhancement means the form works even without JavaScript – validation and processing happen on the server.
- In Next.js, you can combine this with Server Actions.
- Benefits: better accessibility, SEO, fallback for older browsers.
- **Examples:**
    - Progressive enhancement form (/progressive-enhancement-form)
    - Server action
- Official documentation

Error Boundaries & Error Handling

- Next.js App Router has special files for error boundaries:
  - `error.tsx` – error boundary for a specific route
  - `global-error.tsx` – global error boundary for the whole app (global-error.tsx)
  - `not-found.tsx` – page for 404 errors (not-found.tsx)
- **Examples:**
  - error.tsx
  - global-error.tsx
  - not-found.tsx/not-found)
- Official documentation

4. Middleware

- Code that runs before a request is completed
- `src/app/middleware.ts`
- Use for auth, redirects, logging

Demos:

- Middleware file
- Middleware demo page (/middleware-demo)

5. Environments

Environment Variables

- Next.js supports environment variables via `.env` files in the project root.
- Supported files (loaded in this order):
    i. `.env.$(NODE_ENV).local`
    ii. `.env.local` (not loaded in test)
    iii. `.env.$(NODE_ENV)`
    iv. `.env`

- Variables prefixed with `NEXT_PUBLIC_` are exposed to the browser (client-side). Others are only available on the server.
- Example `.env`:

```
DATABASE_URL=postgres://user:pass@localhost:5432/db
NEXT_PUBLIC_API_URL=https://api.example.com
```

- Usage in code:

```
// Server only
const dbUrl = process.env.DATABASE_URL;
// Client or server
const apiUrl = process.env.NEXT_PUBLIC_API_URL;
```

- Variables are inlined at build time for the client. For runtime values, use server-side code or API endpoints.
- You can reference other variables in `.env` using `$VAR_NAME`.
- For advanced use (e.g. loading env in scripts), use `@next/env`:

```
import { loadEnvConfig } from '@next/env';
loadEnvConfig(process.cwd());
```

Official docs: Environment Variables

Passing Data Between Environments

When deploying Next.js in Docker or other environments, you often need to pass environment variables securely and correctly.

- **.env files**: Place `.env`, `.env.production`, etc. in the project root. These are loaded automatically at build/start time.
- **Server-side variables** (e.g. `DATABASE_URL`) are read at runtime and can be passed when starting the container:

```
docker run -e DATABASE_URL=postgres://user:pass@host/db my-next-app
# or
docker run --env-file .env my-next-app
```

- **Client-side variables** (must start with `NEXT_PUBLIC_`) are inlined at build time. They must be set before running `next build`:

  ```
  # Example Dockerfile snippet
  ENV NEXT_PUBLIC_API_URL=https://api.example.com
  RUN yarn build
  ```

- **Build-time vs. Run-time:**
  - Server envs can be changed at container start.
  - Client envs are "baked in" at build time—changing them later requires a rebuild.
- **Best practice:**
  - Use server envs for secrets and runtime config.
  - Use client envs only for values that can be public and are known at build time.

Example: Dockerfile for Next.js

```dockerfile
# Install dependencies only when needed
FROM node:18-alpine AS deps
WORKDIR /app
COPY package.json yarn.lock ./
RUN yarn install --frozen-lockfile

# Build the app
FROM node:18-alpine AS builder
WORKDIR /app
COPY . .
COPY --from=deps /app/node_modules ./node_modules
# Set build-time envs (client-side)
ENV NEXT_PUBLIC_API_URL=https://api.example.com
RUN yarn build

# Production image
FROM node:18-alpine AS runner
WORKDIR /app
ENV NODE_ENV=production
COPY --from=builder /app/.next ./.next
COPY --from=builder /app/public ./public
COPY --from=builder /app/package.json ./package.json
COPY --from=builder /app/node_modules ./node_modules

# Set runtime envs (server-side)
ENV DATABASE_URL=postgres://user:pass@host/db

EXPOSE 3000
CMD ["yarn", "start"]
```

- Set `NEXT_PUBLIC_` variables before `yarn build` (build-time, client-side)
- Set server-side variables (like `DATABASE_URL`) at runtime with `docker run -e ...`

Official docs:

- Environment Variables
- Docker deployment

Node.js vs. Edge

- Next.js can run on Node.js or Edge runtime
- Use `export const runtime = 'edge'` in a route/middleware

Demo:

- Runtime demo (/runtime-demo)

Different Types of API Routes (Edge/Node, request info)

- Next.js allows you to write API routes for different runtimes:
    - **Edge runtime:** faster, limited API (e.g., no fs)
    - **Node runtime:** full access to Node.js API
- You can also get request info (headers, cookies, etc.)
- **Examples:**
    - API route Edge
    - API route Node
    - API request info
- Official documentation

6. Configuration & Instrumentation

Next Config

Next.js allows you to configure various aspects of your application using the `next.config.js` or `next.config.ts` file.

- Mode settings (strict mode, experimental features)
- Image, headers, file types, build options
- **assetPrefix**: Set a custom prefix for serving static assets (e.g. from a CDN).
- **basePath**: Serve your app from a subpath (e.g. `/docs` or `/app`).
- **Redirects and Rewrites**

Example:

```
// next.config.ts
const nextConfig: NextConfig = {
  assetPrefix: 'https://cdn.example.com', // serve static assets from CDN
  basePath: '/docs', // app will be served from https://yourdomain.com/docs
};
```

Use `assetPrefix` when deploying static assets to a CDN. Use `basePath` when your app is not at the root of the domain.

Redirects and Rewrites

- **Redirects** let you send users from one URL to another (e.g., when migrating content or changing site structure).
- **Rewrites** let you map an incoming request path to a different destination path on the server, without changing the URL in the browser (e.g., for API proxying or pretty URLs).

Example from the project:

```
// apps/next-guide-app/next.config.ts
// Redirects
async redirects() {
  return [
    {
      source: '/old-blog',
      destination: '/blog',
      permanent: true,
    },
  ];
},
// Rewrites
async rewrites() {
  return [
    {
      source: '/api/legacy/:path*',
      destination: '/api/:path*',
    },
  ];
},
```

Instrumentation

- Instrumentation allows you to monitor performance, log, or connect OpenTelemetry.
- In Next.js, add an `instrumentation.js` or `instrumentation.ts` file to `app/`.
- Runs only on the server at process startup.
- **Examples:**
  - instrumentation.js
  - Instrumentation demo page
- Official documentation

Demos:

- Instrumentation demo (/instrumentation-demo)
- instrumentation.js example

7. Extra

- **Styling:** See globals.css
- **MDX:**
  - MDX demo
  - MDX layout (/mdx-demo)
  - MDX components (/mdx-demo)

- **Image Component:**
    - Image demo (/image-demo)

> **Note:** If you want to load images from external domains, you must add those domains to `remotePatterns` in your `next.config.ts`:
>
> ```
> // next.config.ts
> images: {
>   remotePatterns: [
>     {
>       protocol: 'https',
>       hostname: 'images.unsplash.com',
>     },
>   ],
> },
> ```
>
> Otherwise, images from those domains will not load and Next.js will show an error.

- **Shared Components:**
  - Counter component
  - Use a `/components` or `/_components` (private - non-routable) folder for reusable UI (best practice)
- **Public Assets:**
  - Use the `/public` folder for static assets (images, favicon, etc.) (public/)

What was not covered

Some advanced or less common Next.js topics are not covered in detail in this presentation:

- **Internationalization (i18n)** – Docs
- **Route Interception & Modals** – Docs
- **Partial Prerendering** – Docs
- **Advanced Metadata & SEO** (OpenGraph, dynamic metadata) – Docs
- **Testing (unit, e2e, integration)** – Docs
- **Analytics & Monitoring** – Docs

- **Deployment to Vercel/Netlify/Cloud** – Docs
- **Security, CORS, API rate limiting** – Docs, CORS Docs
- **Custom Webpack/Babel config** – Docs
- **Static Export (`next export`)** – Docs
- **Multi-zones** – Docs

For a full overview, see the Next.js Documentation.

Q&A / Discussion

- What challenges have you faced with Next.js?
- Which feature are you most excited to try?
- Any questions about the examples or exercises?

Thank You!

Martin Krištof

GitHub Repo

My Website