



ADVANCED DATA-FETCHING PATTERNS IN REACT

A modern guide to building fast, responsive, and maintainable React applications.

JUNTAO QIU

Advanced Data Fetching Patterns in React

Fast, User-Friendly Data Fetching for Developers

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Preface

As your React applications grow richer with API integrations, do you find them increasingly bogged down and sluggish? You're wrestling with a common dilemma in the modern web development landscape: the more features and data connections you add, the more complex and slower your app becomes. Add to this the often baffling world of asynchronous programming, where debugging and troubleshooting can feel like navigating a labyrinth in the dark.

And it doesn't stop there. The React ecosystem is rapidly evolving, bombarding you with a flurry of new terms and concepts. **React Server Components**, **SSR (Server-Side Rendering)**, **Suspense API** – these aren't just fancy buzzwords; they're game-changers in how we think about building and optimizing our applications. But understanding and implementing them can feel overwhelming.

Embark on this journey with me, and together we'll take these intricate concepts and break them down into digestible, actionable insights. From unraveling the challenges of parallel requests and mastering lazy loading to demystifying SSR and exploring the cutting-edge realms of Server Components and Suspense, I've got you covered. You'll not only learn how to keep your applications lightning-fast but also discover strategies for efficient debugging and problem-solving in the asynchronous realm of React.

Join me, and transform the way you develop, optimize, and debug your React applications. It's time to turn those pain points into your strongest assets.

Chapter 1: Introduction

Kicking off the tutorial ‘Advanced Network Patterns in React’, this chapter sets the stage for exploring diverse network request patterns in React applications. It establishes the foundational knowledge needed for handling complex network scenarios in frontend development.

In this chapter, you will learn the following content:

- Setting up the development environment with Vite and Tailwind CSS.
- Ensuring all necessary tools and configurations are in place for the tutorial.
- Introduction to the mock server for backend simulation.

This tutorial is designed to explore a range of patterns for executing network requests in React applications. Although the focus is on React, the principles and challenges discussed are relevant to other frontend libraries and frameworks.

Starting with a basic user profile, the tutorial progressively introduces more complex scenarios. These scenarios are intended to illuminate common problems and solutions encountered in large-scale applications, with a primary aim of demystifying the often-overlooked performance pitfalls in frontend development.

While React serves as the primary example, the patterns and strategies discussed are broadly applicable across various frontend technologies. They offer universal insights that can be valuable in diverse development contexts.

The tutorial assumes you have a foundational understanding of React, including familiarity with JSX and common hooks such as `useState` and `useEffect`.

Key learning outcomes of this tutorial include:

- Gaining a deep understanding of the challenges inherent in network programming and why it can be difficult to get right.
- Unraveling and demystifying the most commonly misunderstood yet widely used patterns.
- Exploring ways to make asynchronous service calls more manageable and less error-prone.
- Investigating alternative approaches for enhancing user experience.
- Learning how to apply different strategies in both frontend and backend development.
- Looking ahead to the future of server-side work and its implications for frontend development.

This tutorial aims to equip you with the knowledge and tools to navigate the complexities of network requests in React and other frontend frameworks, enhancing both your understanding and practical skills.

The page we're going to build is a `Home` page in an imaginary social media website. It doesn't do much but showing a user their home page when then log in.

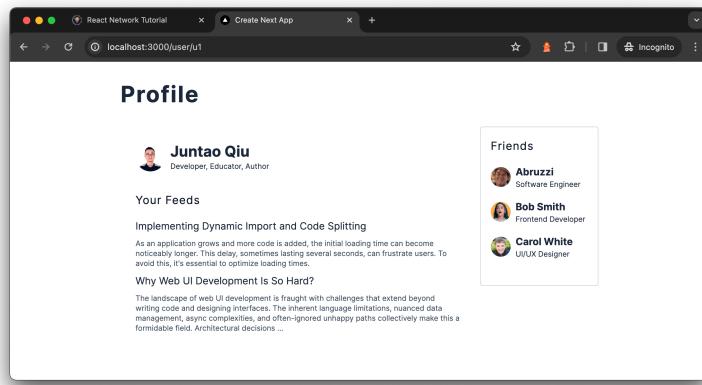


Figure 1. The home page we will build in the tutorial

Setting up the environment

We're going to use vite as the scaffolding tool to generate the structure of the application, use the following command to create a React with TypeScript enabled.

```
1 npm create vite@latest react-network-advanced -- --template react-ts
2
3 cd react-network-advanced
```

Let's clean up the generated template file, open up the `src/App.tsx`, and put the following code:

```
1 function App() {  
2     return (  
3         <div className="max-w-3xl m-auto my-4 text-slate-80\  
4         0">  
5             <h1 className="text-4xl py-4 mb-4 tracking-wider \  
6             font-bold">Profile</h1>  
7         </div>  
8     );  
9 }  
10  
11 export default App;
```

We are going to use Tailwind Css for styling in this tutorial.

Tailwind is a utility-first CSS framework packed with classes like flex, pt-4, text-center and rotate-90 that can be composed to build any design, directly in your markup.

Utility-first CSS frameworks provide a comprehensive set of CSS utility classes for common styling tasks. Instead of writing custom CSS, developers can construct designs by combining these utility classes directly in their markup. This approach promotes rapid UI development, consistency across pages, and can lead to more maintainable codebases.

To install Tailwind, go to the `react-network-advanced` folder we created above, and execute the following command in Terminal (if you're on Mac OS)

```
1 npm install -D tailwindcss postcss autoprefixer  
2 npx tailwindcss init -p
```

And then you will need to config Tailwind to allow it scan `index.html` and all `tsx` files under `src` folder.

Figure 2. tailwind.config.js

```
1  /** @type {import('tailwindcss').Config} */
2  export default {
3    content: [
4      "./index.html",
5      "./src/**/*.{ts,tsx}",
6    ],
7    theme: {
8      extend: {},
9    },
10   plugins: [],
11 }
```

Lastly, you will need to use `@tailwind` directives in `src/index.css` to actually enable it:

Figure 3. src/index.css

```
1 @tailwind base;
2 @tailwind components;
3 @tailwind utilities;
```

I prefer to make the background a bit gray, so I'll add the following line in `src/index.css`

Figure 4. src/index.css

```
1 body {
2   background-color: #fefefe;
3 }
```

With these changes in place, let's launch the application now in command line:

```
1 npm run dev
```

It by default will launch your React application on “<http://localhost:5173/>”, And in your browser, you should be able to see the text **Profile**

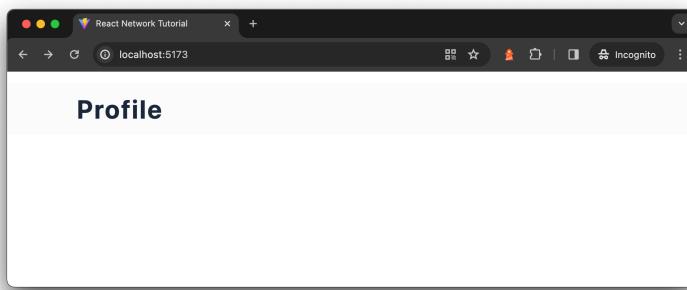


Figure 5. Check Vite and Tailwind CSS are working together

Setting up the backend service

We are going to call some API endpoints in the course of the tutorial, I have published them into a [Github repo](#)¹, go ahead and clone the repo to your local (assume it's in folder: `mock-server-network-react-tutorial`.

Run the following command to launch the mock server:

```
1 cd mock-server-network-react-tutorial  
2 yarn start
```

You would be able to see something like this in your console:

¹<https://github.com/abruzzi/mock-server-network-react-tutorial>

```
1  yarn run v1.22.19
2  $ node index.js
3  Mock server listening at http://localhost:1573
```

And if you try to access the one of the following API endpoint:

```
1  curl http://localhost:1573/users/u1
```

Or if you prefer, you could use jq to format the output, which is a bit easier to read (`curl http://localhost:1573/users/u1 | jq .`). And you should be able to see response like the following:

```
1  {
2    "id": "u1",
3    "name": "Juntao Qiu",
4    "bio": "Developer, Educator, Author",
5    "interests": [
6      "Technology",
7      "Outdoors",
8      "Travel"
9    ]
10 }
```

This introductory chapter equips learners with the essential setup and context for tackling advanced network patterns in React, paving the way for more complex concepts and practical applications in subsequent chapters. The next chapter will dive into using useEffect for building a basic profile page, demonstrating sequential network requests.

Chapter 2: Basics of Data Fetching in React

This chapter dives into the essentials of data fetching in React applications, starting from a simple user profile page. It highlights the initial steps of making API calls, dealing with network delays, and managing state with React's useEffect hook.

In this chapter, you will learn the following content:

- Understanding and implementing basic data fetching using useEffect in React.
- Exploring the impact of network delays on frontend performance.
- Practical implementation of a user profile and friends list component with API integration.

Imagine a simple React application: a profile page where a logged-in user can view their profile. To achieve this, we need to fetch the user's information from an API using their ID.

The API endpoint we'll use returns basic user information. It's designed to include a delay, allowing us to later examine how slow API responses can impact frontend performance.

Consider this API call:

```
1 curl http://localhost:1573/users/u1
```

And the expected response:

```
1 {
2   "id": "u1",
3   "name": "Juntao Qiu",
4   "bio": "Developer, Educator, Author",
5   "interests": [
6     "Technology",
7     "Outdoors",
8     "Travel"
9   ]
10 }
```

In a typical React setup, we would handle this data fetching within a `useEffect` call. React triggers this effect after completing the initial render.

Here's how you might implement this in `src/profile.tsx`:

Figure 6. `src/profile.tsx`

```
1 const Profile = ({ id }: { id: string }) => {
2   const [user, setUser] = useState<User | undefined>();
3
4   useEffect(() => {
5     const fetchUser = async () => {
6       const data = await get<User>(`/users/${id}`);
7       setUser(data);
8     };
9
10    fetchUser();
11  }, [id]);
12
13  return (
14    <div>
```

```
15      {user && user.name}
16    </div>
17  );
18 }
```

The `get` function is a straightforward wrapper around the native `fetch`. You can replace it with `axios.get` or any other preferred method.

Here's the utility function in `utils.ts`:

Figure 7. `utils.ts`

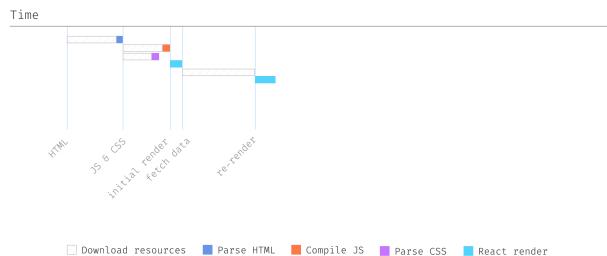
```
1 const baseurl = "http://localhost:1573";
2
3 async function get<T>(url: string): Promise<T> {
4   const response = await fetch(` ${baseurl}${url}`);
5
6   if (!response.ok) {
7     throw new Error("Network response was not ok");
8   }
9
10  return await response.json() as Promise<T>;
11 }
12
13 export { get };
```

To render the `Profile` component, update `App.tsx` as follows:

Figure 8. App.tsx

```
1 import { Profile } from "./src/profile.tsx";
2
3 function App() {
4     return (
5         <div>
6             <h1>Profile</h1>
7             <div>
8                 <Profile id="u1" />
9             </div>
10        </div>
11    );
12 }
13
14 export default App;
```

Visualizing the rendering sequence over time, it would look something like this diagram:

**Figure 9. Fetch and then render**

When a user accesses a React application, a typical flow begins with the browser downloading the initial HTML. As it parses the

HTML, it encounters links to resources like JS and CSS. This process involves downloading, parsing, and executing JS bundles, building the CSSOM, and so on.

Note: HTML parsing is usually done in a streaming manner, meaning it starts as soon as some bytes are received rather than waiting for the entire HTML to download. For simplicity, our illustration assumes the entire HTML is downloaded before DOM construction. More details can be found in [Rendering on the Web¹](#), [Client-side rendering of HTML and interactivity²](#), and [Populating the page: how browsers work³](#).

As JavaScript executes, React begins rendering and manipulating the DOM, then triggers a network request through `useEffect`. It waits until data returns from the server before re-rendering with the new data.

Adding loading and error handling

To enhance user experience, we can introduce a `Spinner` component during data loading and an `Error` component for handling issues like unresponsive backends or nonexistent users.

With these additions, the `Profile` component now includes additional states:

¹<https://web.dev/articles/rendering-on-the-web>

²<https://web.dev/articles/client-side-rendering-of-html-and-interactivity>

³https://developer.mozilla.org/en-US/docs/Web/Performance/How_browsers_work

Figure 10. src/profile.tsx

```
1 const Profile = ({ id }: { id: string }) => {
2   const [loading, setLoading] = useState<boolean>(false);
3   const [error, setError] = useState<Error | undefined>();
4
5   const [user, setUser] = useState<User | undefined>();
6
7   useEffect(() => {
8     const fetchUser = async () => {
9       try {
10         setLoading(true);
11         const data = await get<User>(`/users/${id}`);
12         setUser(data);
13     } catch (e) {
14       setError(e as Error);
15     } finally {
16       setLoading(false);
17     }
18   };
19
20   fetchUser();
21 }, [id]);
22
23   if (loading) {
24     return <div>Loading...</div>;
25   }
26
27   if (error) {
28     return <div>Something went wrong...</div>;
29   }
30
31   return (
32     <>
33       {user && user.name}
34     </>

```

```
35     );
36 }
```

This structure should be familiar if you've worked with React before.

Next, let's add more than just the username. We'll create an About component to display user information, adding simple styles for visual appeal.

For brevity, I'm omitting Tailwind CSS from the code snippets. You can view the full styled components in the corresponding code repository.

Figure 11. src/about.tsx

```
1 const About = ({ user }: { user: User }) => {
2   return (
3     <div>
4       <div>
5         <img
6           src={user.avatar}
7           alt={`User ${user.name} Avatar`}
8         />
9       </div>
10      <div>
11        <div>{user.name}</div>
12        <p>{user.bio}</p>
13      </div>
14    </div>
15  );
16}
```

When data is correctly fetched, it renders as shown:

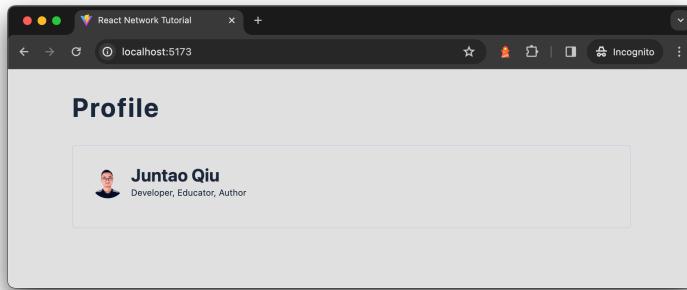


Figure 12. User basic information fetched and rendered

We now have a basic Profile page, retrieving data from a backend API intentionally delayed by 1.5 seconds.

Implementing the User's Friends List

Consider the user's friends list, typically stored in a separate table and accessed via a different API endpoint. For example, `/users/<id>/friends`. We'll fetch this data in a new component, `Friends`.

Figure 13. `src/friends.tsx`

```
1 const Friends = ({ id }: { id: string }) => {
2   const [loading, setLoading] = useState<boolean>(false);
3   const [users, setUsers] = useState<User[]>([]);
4
5   useEffect(() => {
6     const fetchFriends = async () => {
7       setLoading(true);
8       const data = await get<User>(`/users/${id}/friends`)\
```

```
9  );
10     setLoading(false);
11     setUsers(data);
12   };
13
14   fetchFriends();
15 }, [id]);
16
17 if(loading) {
18   return <div>Loading...</div>
19 }
20
21 return (
22   <div>
23     <h2>Friends</h2>
24     <div>
25       {users.map((user) => (
26         <div>
27           <img
28             src={`https://i.pravatar.cc/150?u=${user.id}\`}
29           alt={`User ${user.name} avatar`}
30           />
31           <span>{user.name}</span>
32         </div>
33       ))}
34     </div>
35   </div>
36 );
37 );
38 };
39
40 export { Friends };
```

The structure of the `Friends` component mirrors that of `Profile`: managing state, fetching data in `useEffect`, and rendering based

on loading, error, and successful data retrieval states.

We can incorporate `Friends` into the `Profile` component like any regular React component:

Figure 14. `src/profile.tsx`

```
1 const Profile = () => {
2     //...
3
4     return (
5         <>
6             {user && <About user={user} />}
7             <Friends id={id} />
8         </>
9     );
10 }
```

At first glance, this implementation seems fine. However, if you consider the time taken for each API call, you might spot a potential issue. What if the `/friends` API also takes 1.5 seconds to respond? The total time to display the full page would be 3 seconds.

This chapter lays the groundwork for mastering network requests in React. It provides a practical example of fetching and rendering data, setting the stage for more advanced patterns and performance considerations in subsequent chapters. The next chapter will further explore complex data fetching scenarios, addressing performance challenges in frontend applications.

Chapter 3: Fetching Resources in Parallel

Chapter 3 tackles the challenge of optimizing network requests in React applications. It focuses on implementing parallel data fetching strategies to minimize the impact of the network waterfall effect, enhancing application performance and user experience.

In this chapter, you will learn the following content:

- Understanding and mitigating the request waterfall effect.
- Implementing parallel requests for efficiency.
- Handling dependencies in network requests.

The first issue we encounter is with the rendering order. Initially, in the `Profile` component, `useEffect` triggers a network request. However, since data takes 1.5 seconds to return, we display a loading indicator in the meantime.

Once the data arrives, we render the `About` section, and a similar process occurs in the `Friends` component. Here, `useEffect` initiates another network request, waiting for the data to return.

Visualizing the request timeline, it looks like this:

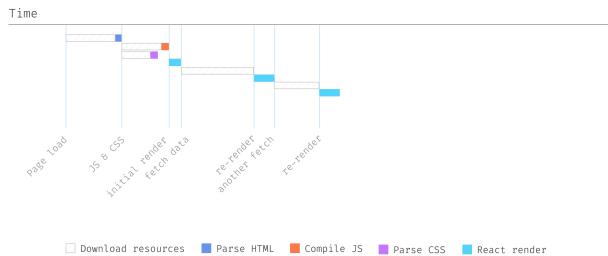


Figure 15. The request waterfall issue

The process involves three renderings. After the first render, the page displays a `loading...` message while initiating the `/users/u1` request. When the server responds, the `About` section is displayed. As `Friends` renders, lacking available data, it shows a `loading...` message in its section and sends out the `/users/u1/friends` request. Upon receiving this data, the third rendering occurs.

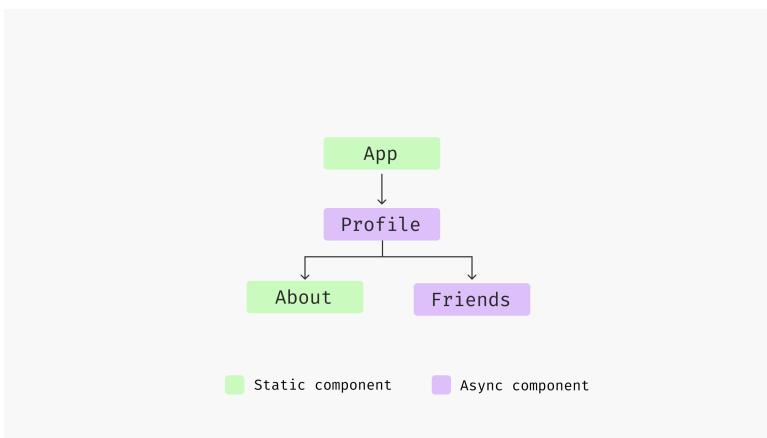


Figure 16. The component tree of About + Friends

This sequence might be obvious in our current setup, but consider more complex scenarios. Imagine the `Friends` component nested deeper in the component tree or used in different pages or sections. In such cases, identifying the problem by statically reading the code becomes challenging.

The situation worsens with more nested components following the same `useEffect + loading + error` pattern, potentially leading to cumulative performance issues:

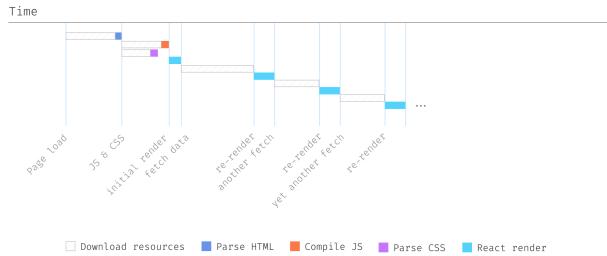


Figure 17. Request waterfall could be even worse

Over time, as the component tree grows, the page becomes increasingly slower.

However, one might wonder if initiating data fetching simultaneously could mitigate this wait time.

Sending Requests in Parallel

We can address this issue by sending parallel requests. In the `Profile` component, we can start both requests simultaneously using `Promise.all`, passing the fetched `friends` list to the `Friends` component:

Figure 18. src/profile.tsx

```
1 const Profile = ({ id }: { id: string }) => {
2     //...
3     const [user, setUser] = useState<User | undefined>();
4     const [friends, setFriends] = useState<User[]>([]);
5
6     useEffect(() => {
7         const fetchUserAndFriends = async () => {
8             try {
9                 setLoading(true);
10
11                 const [user, friends] = await Promise.all([
12                     get<User>(`/users/${id}`),
13                     get<User[]>(`/users/${id}/friends`),
14                 ]);
15
16                 setUser(user);
17                 setFriends(friends);
18             } catch (e) {
19                 setError(e as Error);
20             } finally {
21                 setLoading(false);
22             }
23         };
24
25         fetchUserAndFriends();
26     }, [id]);
27
28     //...
29 };
30
31 export { Profile };
```

The `Promise.all()` static method accepts an iterable of promises, returning a single Promise. This promise resolves when all input promises fulfill (including for an empty iterable), resulting in an array of fulfillment values. If any input promises reject, the returned promise rejects with the first rejection reason.

Consequently, we modify `Friends` into a presentational component, responding only to the passed `users` list, rather than making its own requests:

Figure 19. `src/friends.tsx`

```
1 const Friends = ({ users }: { users: User[] }) => {
2   return (
3     <div>
4       <h2>Friends</h2>
5       <div>
6         {users.map((user) => (
7           <div>
8             <img
9               src={`https://i.pravatar.cc/150?u=${user.id}\`}
10            }
11            alt={`User ${user.name} avatar`}
12          />
13          <span>{user.name}</span>
14        </div>
15      )));
16    </div>
17  </div>
18);
19};
20
21 export { Friends };
```

Now, the total wait time is reduced to $\max(1.5, 1.5) = 1.5$ seconds, a significant improvement:

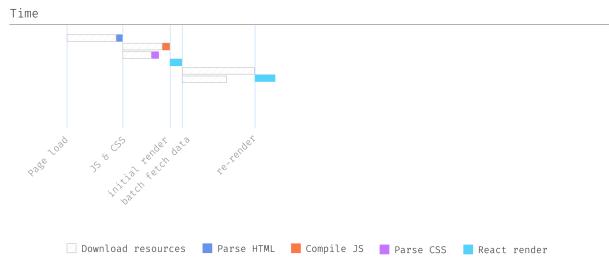


Figure 20. Send requests in parallel

The only remaining issue is the potential wait for the slower request in extreme cases. We'll accept this limitation for now and explore solutions in subsequent chapters.

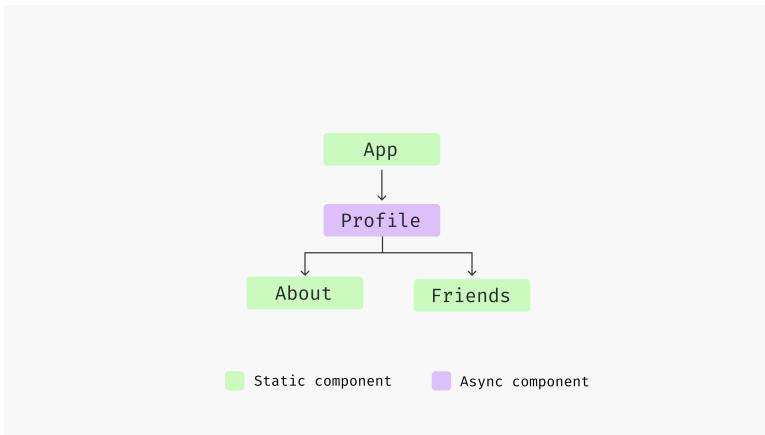


Figure 21. The only async component now is Profile

Request Dependency

Parallel requests expedite the loading of independent data. However, some requests depend on others. For example, we might need to fetch user information first and use the `interests` array from the response to retrieve recommended feeds for the user. This sequential dependency necessitates a return to the initial approach.

In the `Feeds` component, we define loading, error, and data states, and `useEffect` initiates network fetching after the initial render:

Figure 22. src/feeds.tsx

```
1 const Feeds = ({ category }: { category: string }) => {
2     const [loading, setLoading] = useState<boolean>(false);
3     const [feeds, setFeeds] = useState<Feed[]>([]);
4
5     useEffect(() => {
6         const fetchFeeds = async () => {
7             setLoading(true);
8             const data = await get(`/articles/${category}`);
9
10            setLoading(false);
11            setFeeds(data);
12        };
13
14        fetchFeeds();
15    }, [category]);
16
17    if (loading) {
18        return <div>Loading...</div>;
19    }
20
21    return (
22        <div>
23            <h2>Your Feeds</h2>
24            <div>
25                {feeds.map((feed) => (
26                    <>
27                        <h3>{feed.title}</h3>
28                        <p>{feed.description}</p>
29                    </>
30                )));
31            </div>
32        </div>
33    );
34};
```

In the `Profile` component, we include `Feeds` as follows:

Figure 23. `src/profile.tsx`

```
1 return (
2   <>
3     {user && <About user={user} />}
4     <Friends users={friends} />
5     {user && <Feeds category={user.interests[0]} />}
6   </>
7 );
```

Initially, `About` and `Friends` load, and as soon as the `user` data is available, we use `interests[0]` to fetch feeds, potentially taking another second. The overall wait time amounts to $\max(1.5, 1.5) + 1 = 2.5$ seconds.

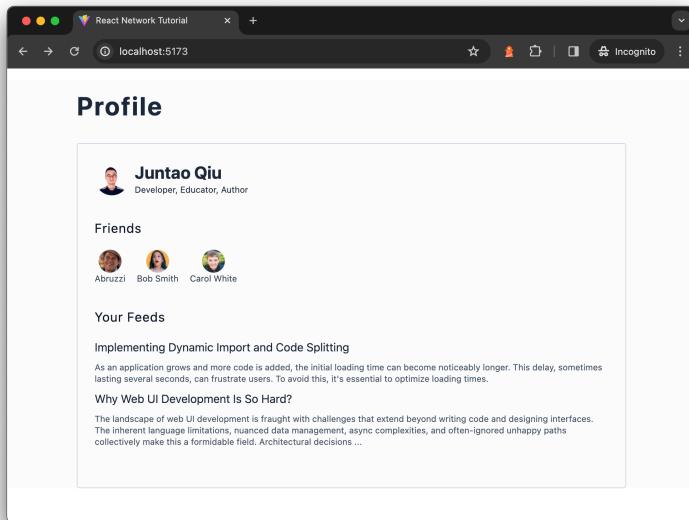


Figure 24. The UI after all components are rendered

This approach combines parallel and sequential requests, yielding better performance than the initial method.

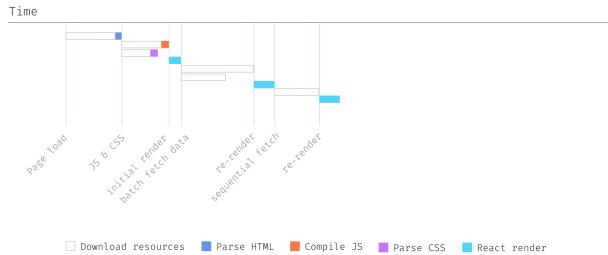


Figure 25. The mix of parallel and sequential requests

The feeds request must wait for the completion of the previous two requests, displaying a large spinner in the interim. While this solution is functional, we must consider the runtime data requirements for each specific user.

By mastering parallel requests and managing dependencies in network calls, this chapter sets the foundation for building faster and more responsive React applications. Join us as we continue to navigate the intricate world of advanced network patterns in React. In the next chapter, we explore further optimization strategies and delve into more complex scenarios of network fetching in React.

Chapter 4: Optimizing Friend List Interactions

This chapter focuses on enhancing the user experience in React applications by implementing a detailed user profile popover. It explores the integration of external UI libraries like NextUI for building interactive features and discusses efficient data fetching strategies.

In this chapter, you will learn the following content:

- Leveraging NextUI for dynamic UI components.
- Efficient data fetching for enhanced features.
- Balancing performance with interactive design.

Let's delve further into typical frontend application scenarios, uncovering new patterns and potential avenues for performance improvement.

Consider enhancing the current Profile page. Suppose a user clicks on a friend's avatar, and we display a popover with additional details fetched from a `/users/1/details` endpoint. This feature, common in platforms like Twitter or LinkedIn, adds depth to user interaction.

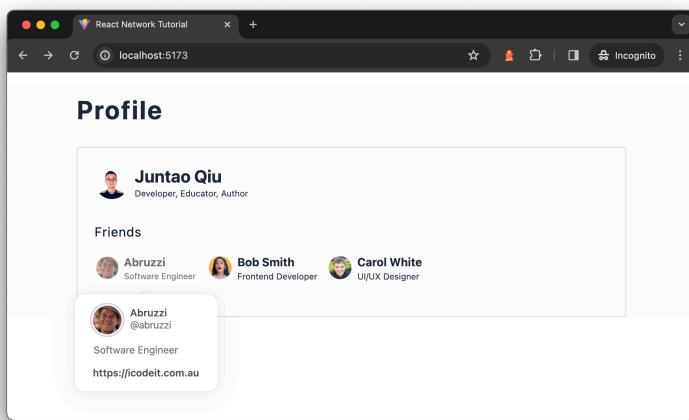


Figure 26. User Detail Popover

To maintain focus on our main topic, I'll skip the detailed implementation of the popover itself. Instead, we'll utilize components from `nextui` for the popover behavior and `UserDetailCard`.

NextUI is a React UI library built on top of Tailwind CSS and React Aria, offering beautiful and accessible user interfaces. Despite its name similarity and website design, it's an independent community project and is not affiliated with Vercel or Next.js.

Install and config NextUI

Firstly, let's install NextUI into our project:

```
1 yarn add @nextui-org/react framer-motion
```

And the we will need to edit tailwind.config.cjs

Figure 27. tailwind.config.cjs

```
1 const {nextui} = require("@nextui-org/react");
2
3 /** @type {import('tailwindcss').Config} */
4 module.exports = {
5   content: [
6     "./index.html",
7     "./src/**/*.{jsx,tsx}",
8     "./node_modules/@nextui-org/theme/dist/**/*.{js,ts,js\
9 x,tsx}",
10    ],
11   theme: {
12     extend: {},
13   },
14   darkMode: "class",
15   plugins: [nextui()],
16 }
```

And finally we'll need to wrap the Application with a NextUIProvider:

```
1 import { NextUIProvider } from "@nextui-org/react";
2
3 function App() {
4   return (
5     <NextUIProvider>
6       <div>
7         <h1>Profile</h1>
8         <div>
9           <Profile id="u1" />
10        </div>
```

```
1      </div>
2    </NextUIProvider>
3  );
4 }
```

Next let's implement the popover component with `Friend`.

Implementing a Popover Component

A popover is a non-modal dialog that appears adjacent to its trigger element. It's often used to display additional rich content.

Here's a basic implementation using `@nextui-org/react`:

```
1 import React from "react";
2 import {Popover, PopoverTrigger, PopoverContent, Button} \
3 from "@nextui-org/react";
4
5 export default function App() {
6   return (
7     <Popover placement="right">
8       <PopoverTrigger>
9         <Button>Open Popover</Button>
10      </PopoverTrigger>
11      <PopoverContent>
12        <div>
13          <div>Popover Content</div>
14          <div>This is the popover content</div>
15        </div>
16      </PopoverContent>
17    </Popover>
18  );
19 }
```

Clicking the “Open Popover” button reveals a popover box to the right. This box contains a header “Popover Content” in bold, followed by a descriptive text. It’s styled with padding and font adjustments for better presentation.

Defining a Trigger Component

The `Friend` component can act as a trigger for the popover. We wrap it with `PopoverTrigger` as follows:

Figure 28. `src/friend.tsx`

```
1 import { User } from "../types";
2 import { Popover, PopoverContent, PopoverTrigger } from "\\\\
3 @nextui-org/react";
4 import { Brief } from "./brief.tsx";
5
6 import UserDetailCard from "./user-detail-card.tsx";
7
8 export const Friend = ({ user }: { user: User }) => {
9   return (
10     <Popover placement="bottom" showArrow offset={10}>
11       <PopoverTrigger>
12         <button>
13           <Brief user={user} />
14         </button>
15       </PopoverTrigger>
16       <PopoverContent>
17         <UserDetailCard id={user.id} />
18       </PopoverContent>
19     </Popover>
20   );
21 }
```

The `Brief` component accepts a `User` object and renders its details:

Figure 29. src/brief.tsx

```
1 export function Brief({user}: { user: User }) {
2     return (
3         <div>
4             <div>
5                 <img
6                     src={`https://i.praavatar.cc/150?u=${user.id}`}
7                     alt={`User ${user.name} avatar`}
8                     width={32}
9                     height={32}
10                />
11            </div>
12            <div>
13                <div>{user.name}</div>
14                <p>{user.bio}</p>
15            </div>
16        </div>
17    );
18 }
```

A click on the `Brief` component activates the popover.

Implementing UserDetailCard Component (Fetching Data)

`UserDetailCard` is designed to fetch and display user details. The user detail includes:

Figure 30. types.ts

```
1 export type UserDetail = {
2     id: string;
3     name: string;
4     bio: string;
5     twitter: string;
6     homepage: string;
7 };
```

We use our reusable get function to fetch these details from the /users/<id>/details endpoint:

Figure 31. src/user-detail-card.tsx

```
1 export function UserDetailCard({ id }: { id: string }) {
2     const [loading, setLoading] = useState<boolean>(false);
3     const [detail, setDetail] = useState<UserDetail | undefined>();
4
5     useEffect(() => {
6         const fetchFeeds = async () => {
7             setLoading(true);
8             const data = await get<UserDetail>(`/users/${id}/details`);
9             setLoading(false);
10            setDetail(data);
11        };
12    });
13
14    fetchFeeds();
15 }, [id]);
16
17 if (loading || !detail) {
18     return <div>Loading...</div>;
19 }
20
21 }
```

```
23     return (
24       <Card shadow="none">
25         <CardHeader>
26           <div>
27             <Avatar
28               isBordered
29               radius="full"
30               size="md"
31               src={`https://i.pravatar.cc/150?u=${detail.id}\`}
32     )
33   />
34   <div>
35     <h4>{detail.name}</h4>
36     <p>{detail.twitter}</p>
37   </div>
38   </div>
39 </CardHeader>
40 <CardBody>
41   <p>{detail.bio}</p>
42 </CardBody>
43 <CardFooter>
44   <div>
45     <p>
46       <a href={detail.homepage}>{detail.homepage}</\`a>
47     </p>
48   </div>
49 </CardFooter>
50   </Card>
51 );
52 }
53 }
54
55 export default UserDetailCard;
```

If we could visualise the current component tree

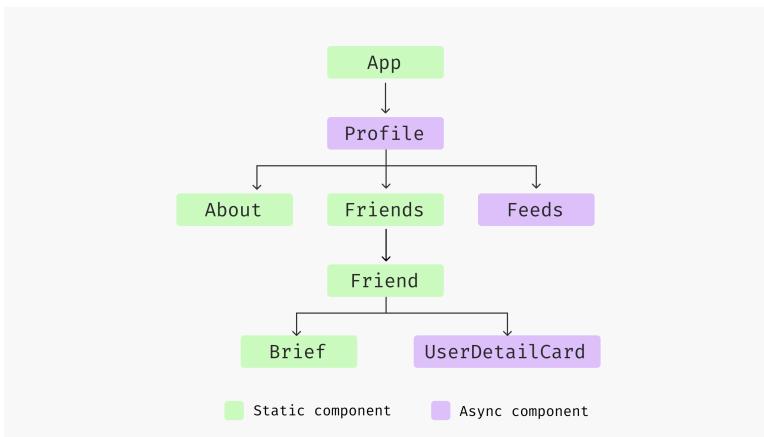


Figure 32. Component Tree with User Detail Card

This implementation appears efficient. However, a network inspection reveals increasing data transfer to the client as more third-party libraries are integrated. The additional JavaScript and CSS for the popover and `UserDetailCard` could be unnecessary for users who don't interact with these features.

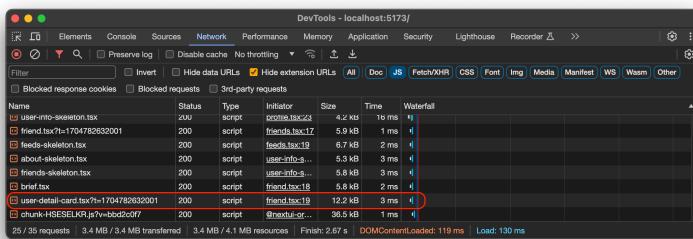


Figure 33. More data transferred through network

Is it possible to delay loading these resources until needed? For instance, only loading the `UserDetailCard` JS bundle when a user clicks on a `Friend` avatar, followed by a request to `/users/1/details` for detailed information. Let's find out in the

next chapter.

With the introduction of advanced UI elements and thoughtful data fetching strategies, this chapter elevates the user experience in React applications, paving the way for more engaging and efficient frontend designs. In the next chapter, we'll dive into code splitting and lazy load to reduce the initial load, that also the foundation of React concurrent we'll learn later.

Chapter 5: Leveraging Lazy Load and Suspense in React

Chapter 5 of the ‘Advanced Network Patterns in React’ tutorial explores the concepts of Lazy Loading and React Suspense for optimizing performance. It demonstrates how to dynamically load components only when they are required, reducing initial load times and improving user experience.

In this chapter, you will learn the following content:

- Introduction to Lazy Loading in React
- Utilizing React Suspense for better loading handling
- Practical implementation in a user profile application

At the end of the previous chapter, we noticed that the page now has more bytes to load initially, which might not fair for user who don’t hover on a Friend component - they still need to pay for the extra network requests and JavaScript bundles.

We could delay such extra (not immediate useful) content into another request as late as possible (maybe never if the users don’t ask). For example, we could split `UserDetailCard` (and its dependency) into a separate JavaScript bundle and load it whenever the user hover on it.

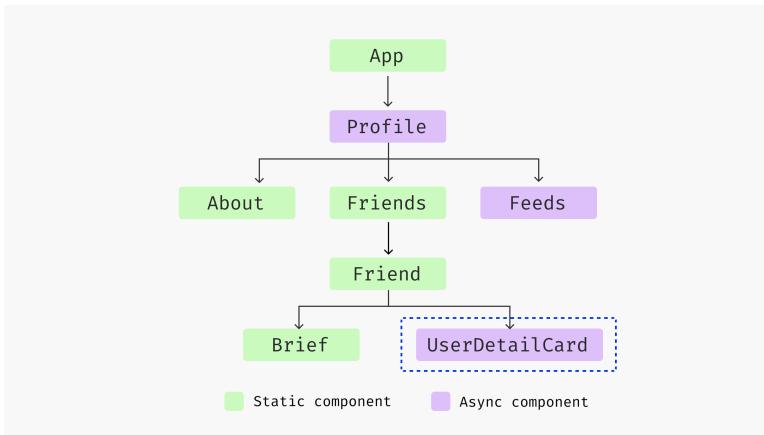


Figure 34. Separate UserDetailCard as another bundle

Let's see how to implement it in React with lazy load and suspense.

Introducing Lazy Loading

Lazy loading in React is a strategy to dynamically load components on-demand, improving performance for larger applications by minimizing the initial code load. React's `lazy` function, used alongside `Suspense`, renders dynamic imports as regular components, enhancing user experience and resource efficiency.

Consider this implementation:

```
1 import React, { Suspense, lazy } from 'react';
2
3 // Lazy load the component
4 const LazyComponent = lazy(() => import('./LazyComponent')\n5 );
6
7 function App() {
8   return (
9     <div>
10       <Suspense fallback={<div>Loading...</div>}>
11         <LazyComponent />
12       </Suspense>
13     </div>
14   );
15 }
16
17 export default App;
```

Here, `LazyComponent` is dynamically imported using `lazy()`. The `Suspense` component wraps around `LazyComponent`, providing a fallback UI during its loading phase. When `LazyComponent` is needed, it loads on demand, improving performance by splitting the code into smaller chunks.

Code splitting is a technique in React that enables splitting your code into various bundles, which can then be loaded on demand or in parallel. This is particularly beneficial for improving the performance of large applications. When a user navigates to a part of your application that requires a component or library, only then does the necessary bundle get loaded, significantly reducing the initial load time of the application. This is especially useful for users with slower internet connections or on mobile devices. React's `lazy` func-

tion, coupled with Suspense, provides a straightforward way to implement code splitting, leading to more efficient resource usage and enhanced user experience.

Implementing UserDetailCard with lazy loading

Applying this concept, we've updated the Friend component in `src/friend.tsx` to use `React.lazy` for importing `UserDetailCard`. This change ensures that `UserDetailCard` loads only when necessary:

Figure 35. `src/friend.tsx`

```
1 import { User } from "../types";
2 import { Popover, PopoverContent, PopoverTrigger } from "\\\n
3 @nextui-org/react";
4 import React, { Suspense } from "react";
5 import { Brief } from "./brief.tsx";
6
7 const UserDetailCard = React.lazy(() => import("./user-de\\
8 tail-card.tsx"));
9
10 export const Friend = ({ user }: { user: User }) => {
11   return (
12     <Popover placement="bottom" showArrow offset={10}>
13       <PopoverTrigger>
14         <button>
15           <Brief user={user} />
16         </button>
17       </PopoverTrigger>
18       <PopoverContent>
```

```
19      <Suspense fallback={<div>Loading...</div>}>
20          <UserDetailCard id={user.id} />
21      </Suspense>
22      </PopoverContent>
23  </Popover>
24 );
25 };
```

The code defines a `Friend` component in React that displays user information using a popover. It imports user-related types and components from `@nextui-org/react` and a local `Brief` component for displaying a summary of the user.

The `UserDetailCard` component is dynamically imported using `React.lazy` for performance efficiency, loading only when needed.

```
1 const UserDetailCard = React.lazy(() => import("./user-de\
2 tail-card.tsx"));
```

Within the `Friend` component, a `Popover` is set up with its trigger wrapping a button that shows the `Brief` user summary. When clicked, the popover displays, containing the `UserDetailCard` within a `Suspense` component. This setup ensures a loading fallback is shown while the `UserDetailCard` loads, providing detailed user information based on the user's ID. This approach optimizes loading performance by fetching detailed user data only when the popover is activated.

```
1 <Suspense fallback={<div>Loading...</div>}>
2     <UserDetailCard id={user.id} />
3 </Suspense>
```

Suspense is a React component that lets your components “wait” for something before rendering. Initially introduced for React.lazy (lazy loading of components), its use has expanded to include data fetching and other asynchronous operations (we’ll see how to do that in later Chapter with Next.js). Suspense provides a way to specify a fallback UI – for example, a loading indicator – that shows up while waiting for the component to load or data to be fetched. This helps in creating smoother user experiences in React applications, as it allows for more control over what gets displayed during the waiting period of an asynchronous operation. The integration of Suspense with lazy loading and other React features reflects the framework’s ongoing evolution to meet modern web development needs.

This lazy loading approach is evident in the network panel of devtools, where two requests are made upon clicking Friend: one for the JavaScript bundle of `UserDetailCard`, and another for the user’s details from the API.

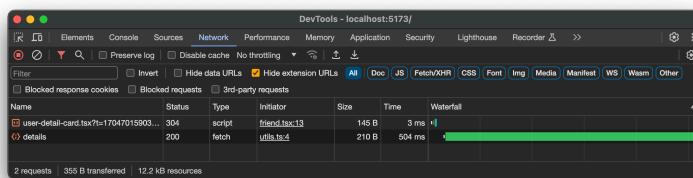


Figure 36. Waterfall with lazy load

Analysis the current bundles, it doesn’t seem help a lot:

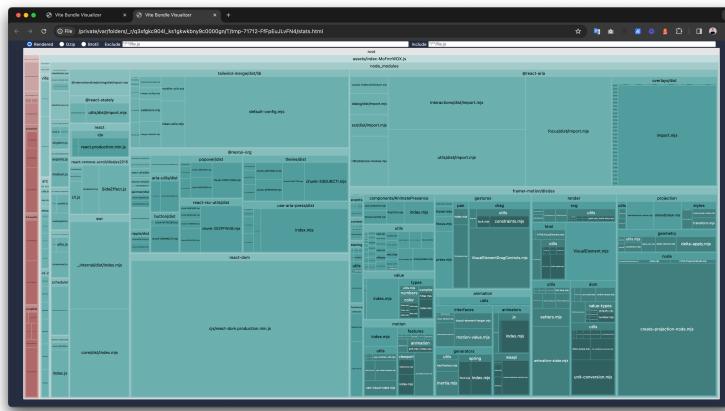


Figure 37. Bundle size analysis

Note in the chart above, the thin slice on the left hand side is the `UserDetailCard`, while the big one on the right is everything else. And if we look closely we'll find the biggest one is `framer-motion` - a package that adds the animation in React - shipped within NextUI. Obviously we don't really need animation for everything, it only used when the popover shows up.

We could further split the `Friend` into a separate bundle with NextUI components, and leave the index lightweight.

So firstly we don't import `Friend` in `Friends`, instead we lazy load it with suspense:

```
1 import { User } from "../types.ts";
2 import React, { Suspense } from "react";
3 import { FriendSkeleton } from "../misc/friend-skeleton.tsx";
4
5
6 const Friend = React.lazy(() => import("./friend.tsx"));
7
8 const Friends = ({ users }: { users: User[] }) => {
9   return (
10     <div>
11       <h2>Friends</h2>
12       <div>
13         {users.map((user) => (
14           <Suspense fallback={<FriendSkeleton />}>
15             <Friend user={user} key={user.id} />
16           </Suspense>
17         )));
18       </div>
19     </div>
20   );
21 };
22
23 export { Friends };
```

And in the Profile.tsx, we will remove NextUIProvider and add it as a wrapper to Friend, because we don't need NextUI for the whole application but the popover in Friend.

Figure 38. src/friend.tsx

```
1 //...
2 const UserDetailCard = React.lazy(() => import("./user-de\
3 tail-card.tsx"));
4
5 const Friend = ({ user }: { user: User }) => {
6   return (
7     <NextUIProvider>
8       <Popover placement="bottom" showArrow offset={10}>
9         <PopoverTrigger>
10          <button>
11            <Brief user={user} />
12          </button>
13        </PopoverTrigger>
14        <PopoverContent>
15          <Suspense fallback={<div>Loading...</div>}>
16            <UserDetailCard id={user.id} />
17          </Suspense>
18        </PopoverContent>
19      </Popover>
20    </NextUIProvider>
21  );
22};
23
24 export default Friend;
```

With these updates, our new analysis reveals that we have three distinct bundles: `UserDetail`, `Friend`, and `Profile`.

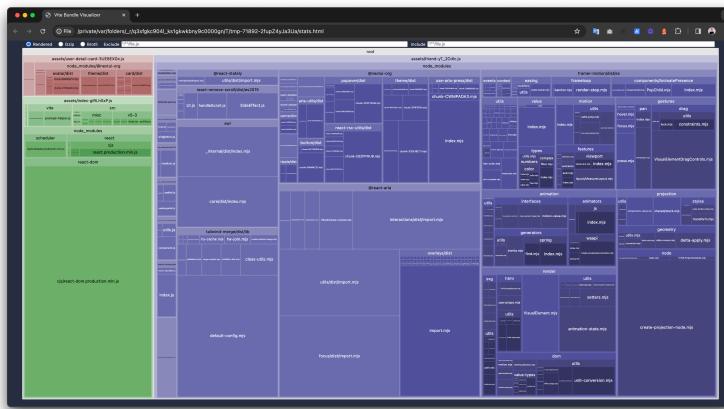


Figure 39. Bundle size analysis after splitting Friend

The largest bundle, shown in blue, corresponds to the `Friend` component. The smaller, red-tinted one at the top-left is the `UserDetailCard`, and the green-tinted one represents the `Profile` component.

This is a significant improvement. Now, the loading process works as follows: When the `Profile` component initiates parallel requests for `/users/u1` and `/users/u1/friends`, we display skeleton screens for the About section and the Friends list. As the friends data arrives and the `Friends` component starts rendering, the browser concurrently downloads the related bundle. During this time, a `FriendSkeleton` is displayed, transitioning to the `Friend` component once the bundle is fully downloaded.

Moreover, if the user doesn't hover over a `Friend`, there's no additional action. The `UserDetail` data is fetched only when the user hovers over a `Friend`, optimizing resource loading and enhancing performance.

The potential issue

Visualizing the request process, we see a sequence similar to the network waterfall discussed in Chapter 2:

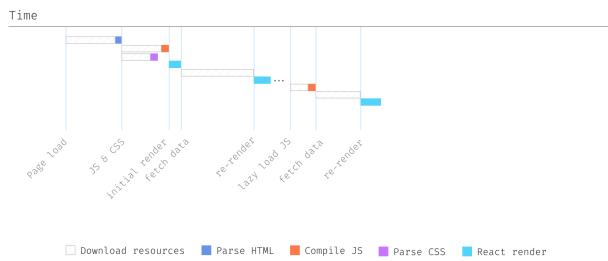


Figure 40. Waterfall with lazy load visualized

This observation leads to a question: is it possible to parallelize these requests to further reduce delays? Exploring this possibility could unlock more performance enhancements, especially in complex application structures.

This chapter is a deep dive into optimizing React applications using Lazy Load and Suspense. It provides practical examples and insights into improving load times and overall application efficiency. In the next chapter, we'll explore more advanced networking patterns and continue enhancing the performance and user experience of React applications.

Chapter 6: Prefetching Techniques in React Applications

Chapter 6 delves into advanced prefetching techniques in React applications, using SWR for efficient data fetching. It highlights how to enhance application responsiveness and user experience through strategic data loading and parallel network requests.

- Implementing SWR for optimized data fetching
- Strategic use of preload for earlier data loading
- Balancing JavaScript bundle loading with data fetching for enhanced interactivity

In the last chapter, we explored how lazy loading and the Suspense API can defer the loading of larger, performance-impacting chunks, thereby enhancing the initial load speed and user experience. This approach, leveraging lazy loading, successfully reduced unnecessary requests and improved overall performance. Yet, as we wrapped up the chapter, a question arose: could we further optimize this?

Now, in this chapter, our focus shifts to employing the preload technique to accelerate user interactions even more. Our specific goal is to boost performance when users access the `UserDetail`.

Preloading in JavaScript is a technique used to instruct the browser to load certain resources early in the page lifecycle. This is particularly useful for resources that are needed soon after the initial page load, but not immediately. By preloading these resources, you can ensure they are available right when needed, thus reducing load times and improving user interactivity. Preloading is often used for images, scripts, stylesheets, and other critical assets that contribute to smoother user experiences. Implementing preload can be a strategic choice in web development to enhance the performance and responsiveness of web applications.

Introducing SWR

We're introducing a package named `SWR` in this chapter, which will streamline our data fetching process and implement a `preload` feature.

SWR, standing for Stale-While-Revalidate, is a caching strategy from Vercel, designed for efficient data fetching in React applications. It first delivers stale data from the cache (if available), then revalidates by fetching fresh data in the background. This approach enhances speed and user experience, as users see immediate data, albeit potentially stale. SWR automatically updates the data once fresh content is available and intelligently handles background updating, automatic revalidation, and error retries. It's ideal for data that frequently changes, where brief displays of slightly outdated information are acceptable.

Implementing SWR for Preloading

First, let's add `swr` to our project:

```
1 yarn add swr
```

To use `swr`, we define a `fetcher` function, which is essentially a wrapper around the native `fetch` method:

```
1 const fetcher = (...args) => fetch(...args).then(res => res.json())
```

Let's see `swr` in action within the `Profile` component:

Figure 41. `src/profile.tsx`

```
1 import useSWR from 'swr'
2
3 function Profile () {
4   const { data, error, isLoading } = useSWR('/api/user/12\
5 3', fetcher)
6
7   if (error) return <div>failed to load</div>
8   if (isLoading) return <div>loading...</div>
9
10  // render data
11  return <div>hello {data.name}!</div>
12 }
```

Here, `useSWR` fetches and returns user data, handling loading states and errors seamlessly.

Integrating `preload` with SWR

Prefetching with SWR is a technique to fetch and cache data before it's actually needed in the UI. This is done to improve the user experience by reducing the loading time when the user eventually requests that data. The idea is to proactively fetch data in the background, leveraging SWR's efficient caching and revalidation strategy.

Here's a revised approach to implement prefetching in a React component with SWR:

```
1 import { preload } from "swr";
2
3 function Component({ user }) {
4   const handleMouseEnter = () => {
5     preload(`/api/user/${user.id}/details`, fetcher);
6   };
7
8   return (
9     <div onMouseEnter={handleMouseEnter}>
10       {/* Render the rest of the component */}
11     </div>
12   );
13 }
```

In this implementation, the `preload` function is used to initiate a data fetch using SWR. It doesn't directly return or use the fetched data but relies on SWR's caching mechanism.

SWR optimizes data fetching in React with an efficient caching strategy. On the initial data fetch, SWR stores the response

in a cache using the fetch URL as the key. For subsequent requests with the same key, SWR first checks this cache. If the cached data is recent (within the deduping interval), it's used immediately, reducing network requests. Meanwhile, SWR revalidates the data in the background to ensure freshness, updating the cache and UI if new data is fetched. This approach leads to faster load times and a seamless user experience, especially for frequently updated data.

When the `Component` component detects a mouse entering its area (via `onMouseEnter`), it calls `preload`. This proactively fetches and caches the detailed user data for that friend. Later, when the component that actually needs to display this data is rendered, the data will be retrieved from the SWR cache, making it available immediately if it's within the deduping interval.

This method of preloading with SWR is particularly useful for scenarios where you can predict which data the user will need next, thereby subtly improving the responsiveness and fluidity of the user experience.

Let's now modify the `Friend` component:

Figure 42. `src/friend.tsx`

```
1 export const Friend = ({ user }: { user: User }) => {
2   const handleMouseEnter = () => {
3     preload(`/user/${user.id}/details`, () => getUserData\
4     il(user.id));
5   };
6
7   return (
8     <Popover placement="bottom" showArrow offset={10}>
9       <PopoverTrigger>
10         <button onMouseEnter={handleMouseEnter}>
11           <Brief user={user} />
```

```
12      </button>
13    </PopoverTrigger>
14    {/* existing logic */}
15  </Popover>
16);
17};
```

In `UserDetailCard`, we utilize `useSWR` for fetching user details:

Figure 43. `src/user-detail-card.tsx`

```
1 import useSWR from "swr";
2 import { getUserDetail } from "../api.ts";
3
4 export function UserDetailCard({ id }: { id: string }) {
5   const { data: detail, isLoading: loading } = useSWR(
6     `/user/${id}/details`,
7     () => getUserDetail(id)
8   );
9
10 //...
11}
```

With this setup, hovering over a `Friend` triggers a preloading of the network call to `/user/<id>/details`. Clicking on it renders the detailed information. `SWR` handles caching and revalidation, enhancing the user experience.

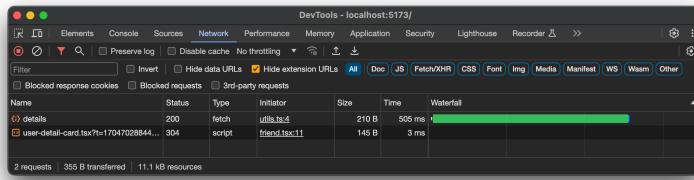


Figure 44. Request JS bundle and data in parallel

Visualizing this, we see separate and parallel loading of data and the JavaScript bundle, significantly improving interactivity.

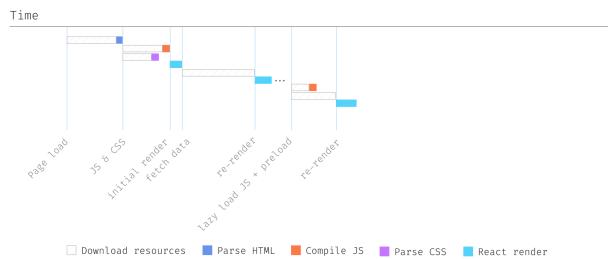


Figure 45. Request JS bundle and data in parallel

To recap our progress, let's review key strategies we've employed to enhance performance:

- Initially load only essential content by splitting and employing lazy loading.
- Whenever feasible, execute network requests in parallel.
- Implement preloading to retrieve data ahead of user interaction with components.

- For any third-party libraries, consider code splitting into separate bundles and apply lazy loading as needed.

By applying these methods, we've significantly boosted our application's performance. But so far, our focus has been predominantly on frontend optimizations. What if we broaden our perspective? Can we streamline our application further by shifting more data fetching to the backend? Or is it possible to pre-render content, updating it only as necessary on the frontend?

These considerations lead us into backend techniques, which will be our focus in upcoming chapters. We'll explore and discuss Server Side Rendering, Static Site Generation, and React Server Components. We'll delve into how and when to use these approaches to ensure our application is performance-optimized before it even reaches the client side. Stay tuned for more insights.

This chapter wraps up our exploration of network patterns in React, on the client side. We've covered parallel requests, code splitting, and prefetching to improve performance. Up next, we'll explore server-side technologies to further enhance application performance.

Chapter 7: Introducing Server Side Rendering

This chapter dives into leveraging Server-Side Rendering (SSR) in React applications. It discusses how SSR, combined with React Server Components, can optimize initial page load times and enhance overall application performance.

- Understanding and implementing SSR in React
- Integrating React Server Components for efficient rendering
- Enhancing user experience with faster initial page loads

In the previous chapters, we've explored various client-side techniques to enhance initial page rendering speed. However, significant optimizations can also be achieved server-side, sometimes even before a user sends a request. What if we could complete some tasks during the request, leveraging backend efficiencies?

Let's delve into Server-Side Rendering (SSR) in this chapter, particularly focusing on React Server Components within Next.js.

Server-Side Rendering is a web development technique where the server generates the complete HTML of a webpage in response to a user request. Each time a user accesses a URL or refreshes their browser, the server executes the necessary JavaScript code, renders all dynamic content, and sends this fully prepared HTML to the browser. While this involves some processing time on the server, it allows for a quicker display of a fully rendered page compared to waiting for client-side JavaScript to render content.

SSR significantly enhances the user experience, especially for initial page loads, and improves a website's search engine optimization by ensuring all content is immediately accessible.

Implementing SSR requires backend techniques. There are many alternatives: building a full-featured backend service is time-consuming and effort-intensive, but we don't need to start from scratch. In this chapter, we will use Next.js for SSR and React Server Components.

Introducing Next.js

If you're not familiar with Next.js, I recommend going through its [dashboard tutorial](#)¹. It's beneficial to follow along with the tutorial, experiment with it, and then return here.

Next.js is an open-source web development framework built on Node.js, designed to simplify the building of server-rendered React applications. Created by Vercel (formerly Zeit), it aims to streamline the process of building performant, scalable, and user-friendly web applications. It enhances the developer experience with features like automatic code splitting, server-side rendering, static site generation, and built-in CSS support. In this chapter, we'll focus on its app router feature for SSR, which functions similarly to client-side React components.

To start, we'll create a dynamic route – `app/user/[id]/page.tsx`. This path signifies a dynamic route within the `app` directory in Next.js. For instance, accessing `/user/123` renders the `page.tsx` component for the user with ID 123, changing content based on the URL parameter.

¹<https://nextjs.org/learn/dashboard-app>

Next.js version 13 introduced an App Router utilizing React Server Components, supporting shared layouts, nested routing, loading states, error handling, and more. This system bases its routes on the file structure in the “app” directory.

Learn more about [Routing Fundamentals²](#) and [Pages and Layouts³](#).

In contrast, static rendering generates HTML at build time with pre-fetched data, resulting in super-fast page loads due to static HTML. We’ll explore this further in the next chapter.

In `page.tsx`, we define a Page component to fetch data and pass it to the frontend:

Figure 46. `app/user/[id]/page.tsx`

```
1 export default async function Page({ params }: PageProps)\n2 {\n3   const { user, friends } = await getUserBasicInfo(params\\n\n4 .id);\n5\n6   return (<Profile user={user} friends={friends} />);\n7 }
```

The `PageProps` interface is:

²<https://nextjs.org/docs/app/building-your-application/routing>

³<https://nextjs.org/docs/app/building-your-application/routing/pages-and-layouts>

```
1 interface PageProps {
2   params: {
3     id: string;
4   };
5 }
```

The `params` object is part of Next.js's routing feature, which allows you to access dynamic parts of the URL. In the case of `app/user/[id]/page.tsx`, `params` would contain an `id` property. This `id` corresponds to the dynamic segment in the URL. For example, if the URL is `/user/123`, `params.id` will be `123`. This allows the `Page` component to fetch or compute data specific to that user ID.

The function `getUserBasicInfo` is defined as follows for actual data fetching at request time:

Figure 47. `app/user/[id]/page.tsx`

```
1 async function getUserBasicInfo(id: string) {
2   const [user, friends] = await Promise.all([
3     get<User>(`/users/${id}`),
4     get<User[]>(`/users/${id}/friends`),
5   );
6
7   return { user, friends };
8 }
```

The `Profile` component, defined as a simple presentational component, receives data directly from the `Page` component. We are using `About` and `Friends` components from Chapter 3, they are all presentational component and only render whatever passed in:

Figure 48. components/profile.tsx

```
1 const Profile = ({ user, friends }: { user: User; friends: User[] }) => {
2   return (
3     <>
4       <About user={user} />
5       <Friends users={friends} />
6       <Feeds category={user.interests[0]} />
7     </>
8   );
9 };
10 }
```

Next.js by default uses Server Components, meaning they are rendered server-side without additional setup. We can define traditional, or client components, for contrast. Let's make the Feeds component a client component to demonstrate its use alongside Server Components.

Figure 49. components/feeds.tsx

```
1 'use client';
2
3 import { useEffect, useState } from "react";
4
5 const Feeds = ({ category }: { category: string }) => {
6   const [loading, setLoading] = useState<boolean>(false);
7   const [feeds, setFeeds] = useState<Feed[]>([]);
8
9   useEffect(() => {
10     const fetchFeeds = async () => {
11       setLoading(true);
12       const response = await fetch(
13         `http://localhost:1573/articles/${category}`
14       );
15       const data = await response.json();
16     };
17   }, [category]);
18
19   return (
20     <Feeds category={category}>
21       <Loading>
22       <List feeds={feeds} />
23     </Feeds>
24   );
25 };
26
27 export default Feeds;
```

```
17     setLoading(false);
18     setFeeds(data);
19   };
20
21   fetchFeeds();
22 }, [category]);
23
24 if (loading) {
25   return <div>Loading...</div>;
26 }
27
28 return (
29   <div>
30     <h2>Your Feeds</h2>
31     <div>
32       {feeds.map((feed) => (
33         <>
34           <h3>{feed.title}</h3>
35           <p>{feed.description}</p>
36         </>
37       )));
38     </div>
39   </div>
40 );
41 };
42
43 export { Feeds };
```

Pay special attention to the `use client` directive employed in our example. This directive explicitly marks a component as a client-side component in Next.js.

This distinction is crucial because it dictates the use of certain React hooks. In client components, you have the freedom to use hooks like `useState` and `useEffect`, just as you would in a standard React application. These hooks are essential for managing state and side

effects on the client side.

However, it's important to note that these APIs are not available for Server Components. Server Components are designed for different purposes, mainly focused on preparing and delivering content from the server without interactive or stateful behavior.

React Server Components

React Server Components represent a paradigm shift in application architecture, as defined on the React homepage. They run ahead of time, separate from your JavaScript bundle, and are instrumental in optimizing your app's performance.

React's research introduced Server Components as a novel component type that operates before the browser load and is not included in the JavaScript bundle. These components can execute during the build process, allowing access to the filesystem or static content without the need for an API. They facilitate data transfer to interactive Client Components in the browser through props.

Server Components are best suited for non-interactive elements that form the content's framework, while Client Components handle interactive aspects like mouse and keyboard events.

When a page loads, you might notice a slight delay initially. Soon, components like `About` and `Friends` appear, followed by a loading phase for `Feeds`. Once the API call for feeds completes, the entire content is displayed.

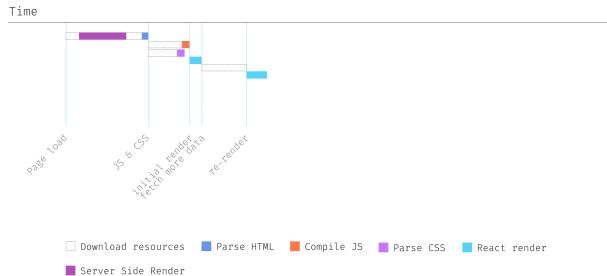


Figure 50. Server Side Rendering

Why shift requests from the frontend to the backend? Several benefits include:

- Faster data retrieval, as servers are usually closer to data storage.
- Simplified data caching and control on the server side.
- Enhanced security and power in backend processing.
- Frontend transparency in security setups like API keys or tokens.

Though the initial load may take slightly longer, subsequent operations become more responsive, as no additional data loading is required. This approach enhances the user experience and allows for various caching levels, speeding up future data requests.

In this chapter, we explore Server-Side Rendering (SSR) and its integration with React Server Components. We delve into how SSR improves initial page load times, making React applications more performant and user-friendly. Up next: Static Site Generation. With key insights from this chapter, we pave the way to explore the synergy between SSR and React Server Components, setting the stage for the next topic: Static Site Generation.

Chapter 8: Introducing Static Site Generation

Chapter 8 explores Static Site Generation (SSG) in React, emphasizing how to optimize webpages at build time for enhanced performance and user experience. It differentiates between runtime and build-time data fetching, providing practical examples using Next.js.

Chapter highlights:

- Understanding and implementing SSG in React applications
- Differentiating between runtime and build-time data fetching
- Techniques for mixing Server-Side Rendering and SSG for optimized performance

Static Site Generation (SSG) is a vital technique in modern web development for pre-rendering pages at build time, contrasting with on-demand rendering in traditional server-side rendering. This approach, especially within frameworks like Next.js, involves creating static HTML files for each page during the build process.

SSG does not restrict your site from being dynamic. Post the initial rendering, client-side JavaScript can still enable dynamic behaviors. The ‘static’ aspect pertains to the first render of the page, after which interactivity is managed by client-side JavaScript.

So far, we’ve seen runtime requests where the data required, like a user’s profile, is unknown until the client makes a request. In

contrast, certain data, such as universal advertisements or announcements, can be known and generated at build time. These types of data, which don't change per request, are ideal candidates for SSG.

For instance, in a Home page displaying advertisements (which are static for all visitors), Next.js can pre-render this content at build time using static routing. A sample implementation might look like this:

Figure 51. app/page.tsx

```
1 export default async function Home() {
2   const ads = await getAds();
3   return (<Ads ads={ads} />);
4 }
```

Accessing the home page (/) results in almost no latency, as the HTML content is already rendered, akin to a traditional static website.

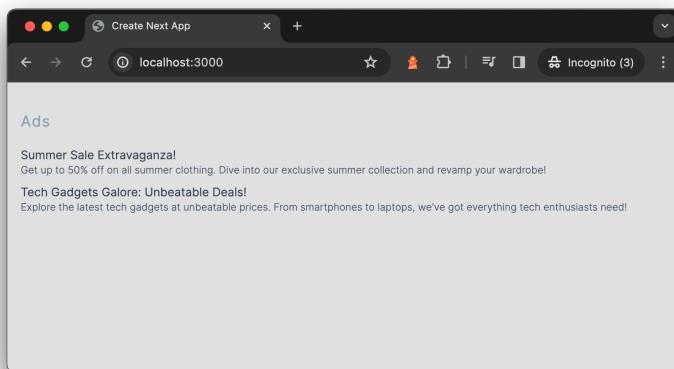


Figure 52. Advertisement Screen

However, routes like `/user/<id>` are different, as they require information at request time, like `/users/u1/friends`.

Mixing Server-Side Rendering and Static Site Generation

In Next.js, you can blend SSG and SSR in dynamic routing. For instance, pre-generating certain user profiles can be achieved with `generateStaticParams`.

Figure 53. app/user/[id]/page.tsx

```
1 export function generateStaticParams() {
2   return [{ id: "u1" }, { id: "u2" }, { id: "u3" }];
3 }
4
5 export default async function Page({ params }: PageProps) {
6
7   return <Profile id={params.id} />;
8 }
```

At build time, Next.js calls `generateStaticParams`, using the results to pre-render pages:

```
1 generateStaticParams().forEach(param => <Page params={par\
2 am} />)
```

The result is pre-rendered HTML pages, so when users in `generateStaticParams` visit their profiles, the content is already there and loads blazingly fast.

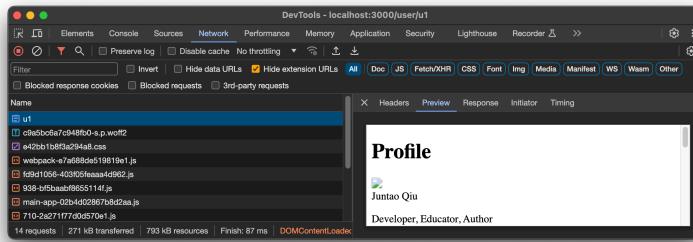


Figure 54. Profile Pre-Rendered

This approach eliminates frontend data requests for pre-rendered users:

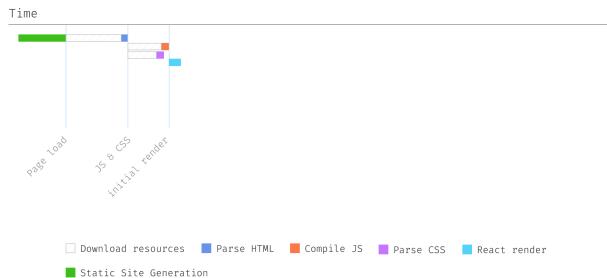


Figure 55. Static Generation Diagram

However, pre-rendering all data at build time can be impractical due to the volume of data and its dynamic nature. That's where a mix of SSG, SSR, and client-side fetching becomes crucial:

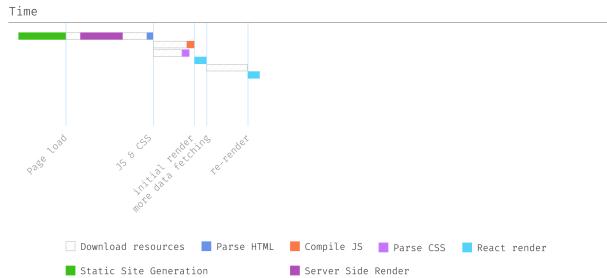


Figure 56. SSR and SSG Mix Diagram

Initially, non-real-time data (like user bio, friends list) is pre-rendered into static HTML. For each request, SSR can be used for up-to-date information, and user interactions trigger further client-side data fetching.

This chapter delves into the intricacies of Static Site Generation in React. We discuss how SSG optimizes performance by pre-rendering pages and explore the balance between SSG, Server-Side Rendering, and client-side data fetching. Next, we'll look at user skeleton components to further enhance user experience. Moving forward from server-side rendering, this chapter introduces the concepts and practical implementation of Static Site Generation, setting the stage for enhancing user experience with skeleton components in the next chapter.

Chapter 9: Optimizing User Experience with Skeleton Loading in React

This chapter offers a detailed walkthrough on enhancing user experience in React applications by implementing skeleton components. Learn how to create and use these components to provide users with a visual cue during data loading, reducing perceived wait times and improving interaction.

Chapter highlights:

- Building skeleton components in React for effective loading indicators
- Demonstrating the use of subtle animations and colors in skeleton design
- Techniques to reduce Cumulative Layout Shift (CLS) for a smoother user experience

In this chapter, we will look into the loading indicator, there are two common ways of showing the users that something is happening and we can not show the data right away: skeleton and spinner.

A skeleton component is a user interface design used to indicate data loading, where a placeholder mimicking the actual content layout is displayed. These are usually grey blocks or lines that show

where and how the final content, like text or images, will appear. The skeleton component enhances the user experience by reducing the element of surprise during loading, providing a preview of the content's structure.



Figure 57. Skeleton Components

On the other hand, a spinner is a more generic loading indicator, often a circular animation, signifying that an operation such as data fetching or processing is in progress. Unlike skeleton components, spinners do not give any hint about the content's layout or the loading duration.

The main difference between the two lies in the level of context they offer. Skeleton components provide a glimpse of the content's layout, making the loading process feel more integrated and smoother. In contrast, spinners are used when the exact content layout is unknown or the loading time is brief, serving as a universal sign of an ongoing process without specific layout information. Skeleton components are about enhancing the user experience with specific layout anticipation, while spinners are more about universally indicating activity.

Skeleton is surprisingly easy to implement, let's see how we can make one for the `About` component when the content is loading:

```
1  function AboutSkeleton() {
2      return (
3          <div className="flex flex-row gap-2 pb-4 items-center\>
4              animate-pulse">
5                  <div>
6                      <div className="w-12 h-12 rounded-full animate-pu\>
7                          lse bg-slate-300" />
8                  </div>
9                  <div className="flex flex-col gap-2">
10                     <div className="text-2xl font-bold w-20 h-6 bg-sl\>
11                         ate-200" />
12                     <p className="text-xs w-24 h-2 bg-slate-200" />
13                 </div>
14             </div>
15         );
16     }
```

The `AboutSkeleton` component creates a row layout with centered items and a gap between them. The `animate-pulse` class applies a shimmering animation effect. The component includes a circular shape to mimic an avatar and two rectangular blocks to represent text lines, all with different shades of gray for a placeholder effect. The use of Tailwind CSS classes like `flex`, `gap-2`, `rounded-full`, and `bg-slate-300` controls the layout and appearance, ensuring the skeleton mimics the structure of the content it represents.

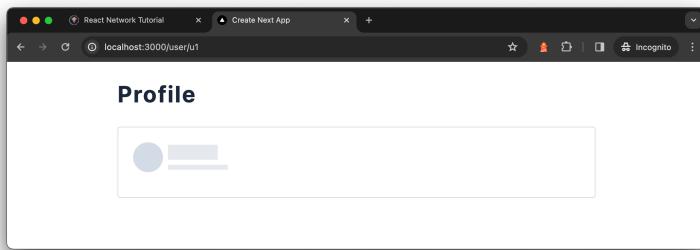


Figure 58. Skeleton for About component

This placeholder doesn't need to be perfect but should give an idea of the actual component's layout. Aiming for a close height match with the actual component can help in reducing CLS (Cumulative Layout Shift).

Cumulative Layout Shift (CLS) is a metric used to quantify how much elements on a webpage move around during loading. It's part of the Core Web Vitals, a set of metrics from Google designed to measure user experience on web pages. CLS specifically measures the stability of a page as it loads, with a focus on how unexpected layout shifts can affect a user's experience.

[Cumulative Layout Shift \(CLS\)¹](#)

For those interested in a hands-on guide, [my video²](#) demonstrates creating a skeleton component from the ground up.

Key takeaways for creating custom skeleton components are:

- Choosing subdued colors for the background shapes

¹<https://web.dev/articles/cls>

²<https://youtu.be/g5u9LzKydAA>

- Aligning the size and position of placeholders as close to the actual UI as possible
- Employing animation to convey a dynamic loading state

This chapter closes our exploration of enhancing user interfaces in React with skeleton loading. We've covered design principles, implementation techniques, and best practices. Next, we'll shift our focus to server-side technologies for further performance improvements. As this chapter concludes, we encapsulate the essence of effective loading indicators and set the stage for the next chapter on server-side technologies.

Chapter 10: The New Suspense API in React

Chapter 10 explores the innovative Suspense API in React 18, focusing on its application in asynchronous data fetching and UI streaming. The chapter demonstrates how Suspense, combined with streaming in Next.js, enhances UI interactivity and responsiveness.

Chapter highlights

- Exploring the new Suspense API for data fetching in React 18
- Implementing UI streaming with Next.js for dynamic content rendering
- Enhancing user experience with progressive loading and structured data fetching

We've previously explored code splitting and lazy loading using Suspense in Chapter 5. The Suspense API's ability to wait for components to be ready for rendering is impressive, but what if we could apply this pattern to all asynchronous data fetching?

Consider the following scenario: In About, we fetch data and wrap it in Suspense. While fetching user details, a skeleton component is displayed, and upon data retrieval, the actual content is rendered.

```
1 const About = async ({ id }) => {
2   const user = await get(`/users/${id}`);
3
4   return <div>{user.name}</div>;
5 };
6
7 const App = () => {
8   return (
9     <Suspense fallback={<AboutSkeleton />}>
10       <About id={id} />
11     </Suspense>
12   );
13 };
```

This approach wasn't feasible until the release of React 18, which expanded the use of Suspense beyond just code splitting.

It's important to note that this new application of Suspense is still experimental and not yet widely considered production-ready. However, libraries like SWR and React Query, and frameworks such as Next.js, are already experimenting with it.

Let's examine how to implement data-fetching with Suspense.

Re-Introducing Suspense & Fallback

First, create a `UserInfo` component as a wrapper for `About` and `Friends`:

Figure 59. components/userinfo.tsx

```
1 export async function UserInfo({ id }: { id: string }) {
2     const user = await getUser(id);
3
4     return (
5         <>
6             <About user={user} />
7             <Suspense fallback={<FeedsSkeleton />}>
8                 <Feeds category={user.interests[0]} />
9             </Suspense>
10        </>
11    );
12 }
```

The `UserInfo` component, defined as an asynchronous function, fetches user data based on the given `id`. The fetched user data is then passed to the `About` component. However, since `getUser(id)` is an `async` call, the entire `UserInfo` component, including the `About` component, will only render once the user data is successfully fetched.

For the `Feeds` component, it's wrapped in a `Suspense` component. This means if `Feeds` is waiting for its data (like fetching additional information based on the user's interests), the `Suspense` component will display the `FeedsSkeleton` as a fallback. Once the data required by `Feeds` is available, the `Feeds` component will render with the actual data.

Therefore, both `About` and `Feeds` depend on the asynchronous fetching of user data, but `Feeds` specifically leverages React's `Suspense` for a smoother loading experience. The use of `Suspense` for `Feeds` allows for a part of the component tree to wait on its own data fetching independently, providing a fallback during the wait.

Here, we use `Suspense` for the `Feeds` component. The `Friends` component is defined as follows:

Figure 60. components/friends.tsx

```
1 import { Friend } from "@/components/friend";
2
3 async function Friends({ id }: { id: string }) {
4   const friends = await getFriends(id);
5
6   return (
7     <div>
8       <h2>Friends</h2>
9       <div>
10         {friends.map((user) => (
11           <Friend user={user} key={user.id} />
12         ))}
13       </div>
14     </div>
15   );
16 }
17
18 export { Friends };
```

We define another asynchronous `Friends` function component in React, upon receiving a user id as a prop, the component fetches the user's friends using the `getFriends(id)` function. After fetching the friends' data, we map the users into `Friend` components.

These components are then utilized in the `Profile` container:

Figure 61. components/profile.tsx

```
1 import { Suspense } from "react";
2 import { Friends } from "@/components/v4/friends";
3 import { UserInfo } from "@/components/v4/userInfo";
4
5 import { FriendsSkeleton } from "@/components/misc/friend\
6 s-skeleton";
7 import { UserInfoSkeleton } from "@/components/misc/user-\
8 info-skeleton";
9
10 export async function Profile({ id }: { id: string }) {
11   return (
12     <div>
13       <h1>Profile</h1>
14       <div>
15         <Suspense fallback={<UserInfoSkeleton />}>
16           <UserInfo id={id} />
17         </Suspense>
18
19         <Suspense fallback={<FriendsSkeleton />}>
20           <Friends id={id} />
21         </Suspense>
22       </div>
23     </div>
24   );
25 }
```

Let's visualise the component tree to have a more direct perspective, we'll learn how such boundary can help the performance in the section **Streaming in Next.js** later.

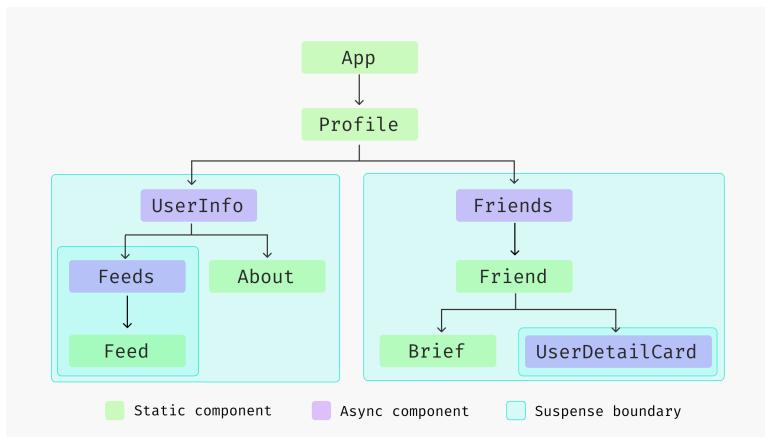


Figure 62. Suspense boundaries

Using skeletons in different layers

Initially, skeleton components `UserInfoSkeleton` and `FriendsSkeleton` are displayed. As data fetched inside each component correspondingly, we can then render the component with data.

In this segment of the code, we define two components in React: `UserInfoSkeleton` and `UserInfo`.

Figure 63. components/misc/user-info-skeleton.tsx

```

1 const UserInfoSkeleton = () => {
2   return (
3     <>
4       <AboutSkeleton />
5       <FeedsSkeleton />
6     </>
7   );
8 };

```

`UserInfoSkeleton` is a simple functional component that serves as a placeholder while the actual user information is being fetched. It combines two skeleton components, `AboutSkeleton` and `FeedsSkeleton`, indicating that the `UserInfo` component will consist of two main parts: one for ‘About’ information and another for ‘Feeds’.

Figure 64. `components/userinfo.tsx`

```
1 export async function UserInfo({ id }: { id: string }) {
2     const user = await getUser(id);
3
4     return (
5         <>
6             <About user={user} />
7             <Suspense fallback={<FeedsSkeleton />}>
8                 <Feeds category={user.interests[0]} />
9             </Suspense>
10        </>
11    );
12 }
```

The `UserInfo` component is more complex. It is an asynchronous function that takes a user id as a prop and fetches the user’s data with `getUser(id)`. Once the data is fetched, it renders two components: `About` and `Feeds`. The `About` component is rendered directly with the fetched user data. For the `Feeds` component, React’s `Suspense` is used. The `Feeds` component is responsible for displaying content based on the user’s interests, and while it’s fetching this data, the `FeedsSkeleton` is shown as a fallback. Once the `Feeds` data is ready, the actual `Feeds` component replaces the skeleton.

This setup allows for a smooth and progressive loading experience. Initially, the `UserinfoSkeleton` is displayed. As data is fetched, the actual components (`About` and `Feeds`) gradually replace their

respective skeleton components. This approach enhances the user experience by providing visual feedback during data loading and progressively revealing content as it becomes available.

Streaming in Next.js

Next.js documentation explains streaming as a technique to progressively render UI from the server. It splits work into chunks streamed to the client as they're ready. This allows for immediate rendering of parts of the page.

In Next.js, streaming can be achieved through:

- A special `loading.tsx` file in your app router.
- Using the Suspense API.

We've seen Suspense above. Alternatively, you can define a `loading.tsx` in `app/user/[id]/loading.tsx`:

Figure 65. `app/user/[id]/loading.tsx`

```
1 export default function Loading() {
2     return (
3         <div>
4             <h1>Profile</h1>
5             <div>
6                 <AboutSkeleton />
7                 <FeedsSkeleton />
8                 <FriendsSkeleton />
9             </div>
10        </div>
11    );
12 }
```

In `page.tsx`, you can await all data before rendering:

```
1 export default async function Page({ params }: PageProps) \  
2 {  
3   const { user, friends } = await getUserBasicInfo(params \  
4 .id);  
5  
6   return (<Profile user={user} friends={friends} />);  
7 }
```

Alternatively, you can push streaming to individual components, allowing earlier user interaction. This is the approach we're using now as it's more flexible, we can define more granular skeleton and suspense boundary, that also means potentially more content can be static thus rendered much faster (think of the headline, section header, etc.).

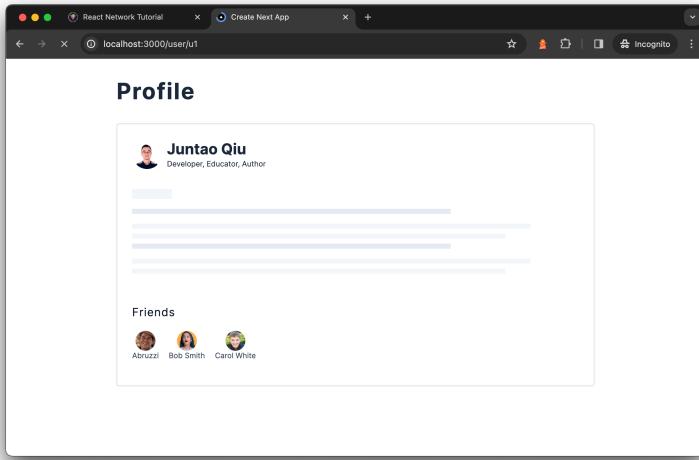


Figure 66. Partial Rendering with Skeletons

We aim to shift content generation to the server side as much as possible, but client components remain essential for high interactivity.

Optimizing UI by Grouping Related Data Components

A key strategy to enhance user experience is to group related data components in the UI. This approach ensures that related information is displayed together, aligning with the user's expectations and the logical flow of data. For instance, in our application, user information displayed in the `About` component is closely related to the `Feeds`, as both pertain to the user's interests. Conversely, the `Friends` component, which can function independently, might be more suitably placed in a separate section of the UI.

To implement this, we consider a left-right layout that visually and functionally groups related components together. Such an arrangement not only improves the coherence of the displayed information but also enhances the overall aesthetic and navigability of the UI.

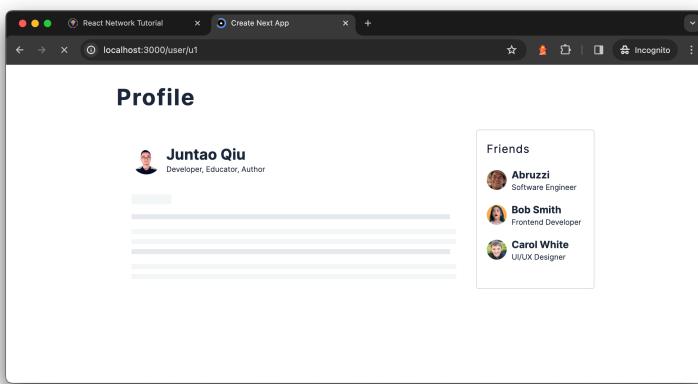


Figure 67. UI Rearrangement Based on Data Grouping

In practice, this layout adjustment requires minimal changes to the code. We introduce a vertical version of the `FriendsSkeleton`,

named `FriendsSkeletonVertical`, to align with the new layout. The `Profile` component is then updated to reflect this new structure:

```
1  export async function Profile({ id }: { id: string }) {
2      return (
3          <div>
4              <h1>Profile</h1>
5              <div>
6                  <div>
7                      <Suspense fallback={<UserInfoSkeleton />}>
8                          <UserInfo id={id} />
9                      </Suspense>
10                 </div>
11                 <div>
12                     <Suspense fallback={<FriendsSkeletonVertical />}>
13                         <Friends id={id} />
14                     </Suspense>
15                 </div>
16             </div>
17         </div>
18     );
19 }
20 }
```

This updated layout ensures that each component manages its own data fetching, maintaining a clean separation of concerns. The use of Suspense boundaries for each component enhances the experience by providing immediate visual feedback (through skeletons) and progressively loading the content. This approach not only streamlines the rendering process but also optimizes the interactivity and responsiveness of the application, ensuring users have a smooth and engaging experience navigating through different sections of the user profile.

In Chapter 10, we investigate the new Suspense API in React

18, highlighting its role in asynchronous data fetching and UI streaming. The chapter provides insights into using this API with Next.js to progressively render content and improve user interaction. This chapter delves into React 18's new Suspense API, showcasing its capabilities in transforming data fetching and user interface rendering. We explore how to utilize this API alongside Next.js for a more interactive and responsive user experience.

Chapter 11: Lazy Load, Dynamic Import, and Preload in Next.js

Chapter 11 focuses on enhancing Next.js applications by implementing lazy loading, dynamic importing, and preloading techniques. It discusses how these strategies contribute to efficient data handling and improve user experience.

Chapter highlights:

- Utilizing `next/dynamic` for lazy loading and dynamic import
- Techniques for preloading data to enhance responsiveness
- Integrating lazy loading with user interaction for efficient content delivery

Chapter 5 introduced lazy loading in the client-side context, demonstrating how separating non-essential content into different bundles can enhance initial rendering and user experience. While Next.js accelerates initial rendering with static rendering, streaming, and server-side rendering, implementing lazy loading and preloading further optimizes the application. These techniques are especially beneficial for users who don't require access to all content immediately.

Dynamic Load in Next.js

In Next.js, `next/dynamic` is a tool for dynamic component importing, it is a composite of `React.lazy()` and `Suspense`. It's particularly useful for optimizing the loading of components that are not immediately necessary on the initial render, thereby enhancing the performance and user experience of your application.

In the example below, the `Gallery` component is imported dynamically using `next/dynamic`. This means that `Gallery` will not be part of the main JavaScript bundle that loads when the page initially loads. Instead, it will be loaded only when the `App` component renders it:

```
1  'use client'  
2  
3  const Gallery = dynamic(() => import("./gallery"));  
4  
5  const App = () => {  
6    return <Gallery />  
7 }
```

In this case, the `Gallery` component is fetched and loaded asynchronously, only when the `App` component needs it. This approach reduces the initial load time of your application because the browser downloads fewer resources upfront.

Furthermore, `next/dynamic` allows for specifying a fallback component that is displayed while the dynamic component is being loaded:

```
1  'use client'  
2  
3  const Gallery = dynamic(() => import("./gallery"), {  
4    loading: () => <GallerySkeleton />  
5  });  
6  
7  const App = () => {  
8    return <Gallery />  
9  }
```

This technique is useful for client components, allowing them to be bundled separately and loaded as needed.

Implementing the UserDetailCard

Consider a `UserDetailCard` component that might not be immediately needed by every user. We can apply lazy loading to enhance performance:

Figure 68. `components/friend.tsx`

```
1  const UserDetailCard = dynamic(() => import("./user-detail\\  
2  l-card"));  
3  
4  export const Friend = ({ user }: { user: User }) => {  
5    return (  
6      <NextUIProvider>  
7        <Popover placement="bottom" showArrow offset={10}>  
8          <PopoverTrigger>  
9            <button>  
10              <Image src={`https://i.pravatar.cc/150?u=${us\\  
11 er.id}`} />  
12              <span>{user.name}</span>  
13            </button>  
14          </PopoverTrigger>
```

```
15      <PopoverContent>
16          <UserDetailCard id={user.id} />
17      </PopoverContent>
18  </Popover>
19 </NextUIProvider>
20 );
21 }
```

Here, the `UserDetailCard` is dynamically loaded only when required, reducing the initial load.

And in the `UserDetailCard` we could do the skeleton just like above:

Figure 69. components/user-details-card.tsx

```
1 async function UserDetailCard({ id }: { id: string }) {
2     const detail = await getUserDetail(id);
3
4     return (
5         <Card>
6             /* same to the UserDetailCard defined in Chapter 6\
7             */
8         </Card>
9     );
10 }
```

And when we click a `Friend` you can see there is an additional request send (for a JavaScript chunk), and then following a network request.

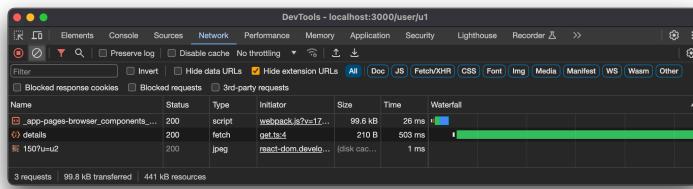


Figure 70. Code Split with lazy loading

You might be wondering if we could do the same `preload` technique as we have seen in Chapter 6, and the answer is yes. We could use the same `useSWR` package in Next.js, but let's try alternative - define a cache and see how we can use Server-Side Rendering to hide the request details.

Preload in Next.js

Preloading can be used to fetch data in advance, such as when a user hovers over a button:

Figure 71. components/friend.tsx

```
1 "use client";
2
3 const UserDetailCard = dynamic(() => import("./user-detail-card"));
4
5
6 export const Friend = ({ user }: { user: User }) => {
7   const handleHover = () => {
8     preload(user.id);
9   };
10
11   return (
12     <NextUIProvider>
```

```
13      <Popover placement="bottom" showArrow offset={10}>
14        <PopoverTrigger>
15          <button
16            tabIndex={0}
17            onMouseEnter={handleHover}
18          >
19            <Brief user={user} />
20          </button>
21        </PopoverTrigger>
22        <PopoverContent>
23          <UserDetailCard id={user.id} />
24        </PopoverContent>
25      </Popover>
26    </NextUIProvider>
27  );
28 };
```

While `preload` is defined as:

```
1 import { get } from "@/utils/get";
2
3 export const getUserDetail = async (id: string) => {
4   return await get<UserDetail>(`/users/${id}/details`);
5 };
6
7 export const preload = (id: string) => {
8   void getUserDetail(id);
9 };
```

The `preload` function fetches the user's details when the user hovers over the `Friend` component. This is accomplished by triggering the `preload` function on the `onMouseEnter` event of the button element. When the mouse pointer enters the button's area, `getUserDetail(id)` is called, and it fetches the details of the user associated with the `Friend` component.

Note here in line 8 above, [the void operator¹](#) evaluates the expression (`getUserDetail(id)`) and then returns undefined, which is handy if we want to execute a function but don't care of the return value.

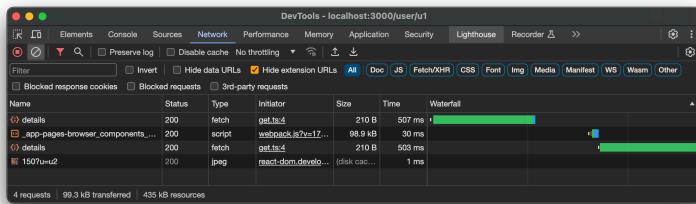


Figure 72. Preload data when user hover

To optimize the preloading process and prevent unnecessary repeated data fetches, we implement an internal caching mechanism using a Set. Here's the refined explanation for the provided code snippet:

Figure 73. apis.ts

```

1 import { cache } from "react";
2
3 const preloadedUserIds = new Set();
4
5 export const getUserDetail = cache(async (id: string) => {
6   preloadedUserIds.add(id);
7   return await get<UserDetail>(`/users/${id}/details`);
8 });
9
10 export const preload = (id: string) => {
11   if (!preloadedUserIds.has(id)) {
12     void getUserDetail(id);
13   }

```

¹<https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Operators/void>

14 };

In the `apis.ts` file, we introduce a caching strategy using a Set to manage the preloading of user details efficiently. The Set, named `preloadedUserIds`, stores user IDs for which details have been preloaded. This unique collection ensures that each user's details are fetched only once, avoiding redundant network requests.

The `cache` function [in React²](#), currently in the Canary (experimental) version, is designed for use with React Server Components. It allows you to create a cached version of a function, which can be particularly useful for data fetching or expensive computations. When you call the cached function with specific arguments, it first checks if there's a cached result. If so, it returns this result; if not, it executes the function, stores the result in the cache, and then returns it.

This approach can significantly optimize performance by avoiding repeated executions of the same function with the same arguments. However, it's important to note that each call to `cache` creates a new function, so calling it multiple times with the same function will not share the cache. Additionally, `cache` only works in Server Components and is for experimental use as of now.

The `getUserDetail` function fetches user details and is enhanced with React's `cache` function. This caching mechanism ensures the asynchronous operation's results are stored, reducing unnecessary data fetching. When the `preload` function is called with a user ID, it first checks if the ID is already in `preloadedUserIds`. If not present, it fetches and caches the user's details. This approach optimizes

²<https://react.dev/reference/react/cache#cache>

the preloading process, ensuring it only occurs when necessary and thereby enhancing application performance.

The effective use of caching in the `preload` function demonstrates a keen understanding of optimizing network interactions, ensuring that data fetching is both efficient and necessary. This consideration for performance leads us to another crucial aspect of building web applications in Next.js: the client component strategy.

Client Component Strategy

Pushing client components to the leaf of the component tree, particularly in a server-side rendering environment like Next.js, is a strategic approach for optimizing web application performance. By doing so, you ensure that most of the page is server-rendered, which speeds up the initial load time. Interactive elements that require client-side JavaScript are loaded only where necessary, making the page interactive more quickly without overburdening the initial load.

In the provided code snippets, we have two versions of the `Friends` component. The first version marks the entire component as a client component, while the second version pushes the client-side logic down to the individual `Friend` component.

First Version - Entire Component as Client-Side

The first `Friends` component is wrapped with `use client`, making the entire component and all its children client-side only. This means that even simple, non-interactive parts of this component won't render until the client-side JavaScript loads and executes, which can delay the initial rendering and interactivity of the page.

Figure 74. components/friends.tsx

```
1 'use client';
2
3 async function Friends({ id }: { id: string }) {
4   const friends = await getFriends(id);
5
6   return (
7     <NextUIProvider>
8       <div>
9         <h2>Friends</h2>
10        {/**/}
11      </div>
12    </NextUIProvider>
13  );
14 }
```

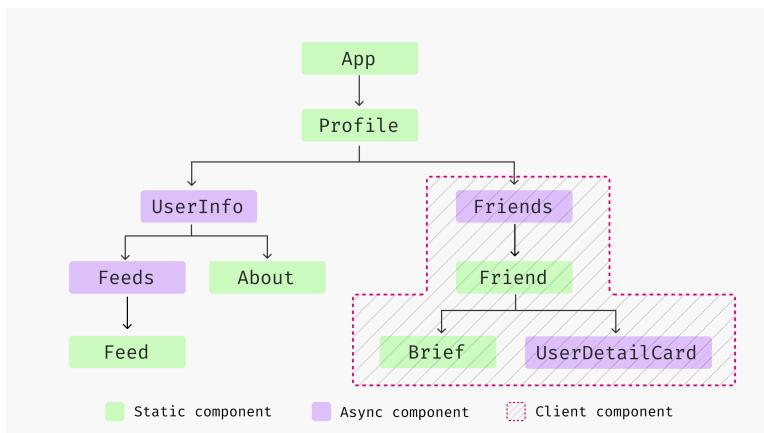


Figure 75. The boundary is set to Friends

Second Version - Client Logic at Leaf Node

The second approach optimizes performance by removing the `use client` directive from the `Friends` component. Instead, it delegates client-specific logic to the `Friend` component. This way, the `Friends` component itself can be pre-rendered on the server, and only the interactive parts within each `Friend` component are handled on the client-side. This granular approach speeds up the initial page load, as less JavaScript needs to be downloaded and executed to render the initial view.

Figure 76. components/friends.tsx

```
1  async function Friends({ id }: { id: string }) {
2      const friends = await getFriends(id);
3
4      return (
5          <div>
6              <h2>Friends</h2>
7              <div>
8                  {friends.map((user) => (
9                      <Friend user={user} key={user.id} />
10                 )));
11             </div>
12         </div>
13     );
14 }
```

And we then move `NextUIProvider` usage into `friend` component.

Figure 77. components/friend.tsx

```

1 "use client";
2
3 export const Friend = ({ user }: { user: User }) => {
4   return (
5     <NextUIProvider>
6       {/* popover code */}
7     </NextUIProvider>
8   );
9 };

```

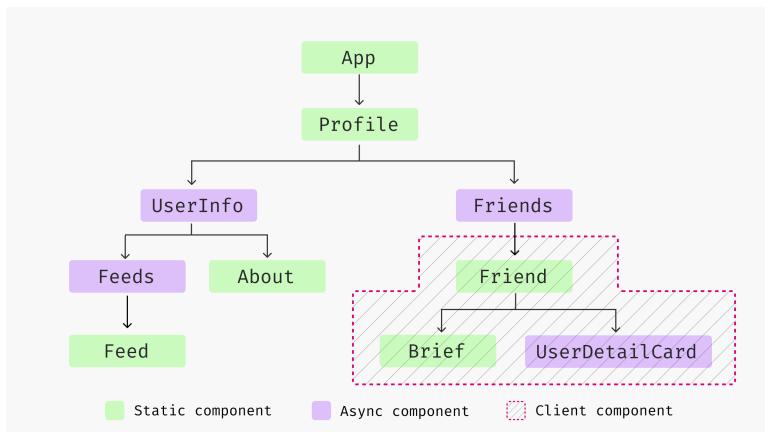


Figure 78. The boundary is set to Friend

By applying the client component at the leaf node (**Friend**), you enhance the user experience with faster initial load times and progressively enhance the page with interactive elements as needed. This approach aligns well with modern web development best practices, particularly in frameworks like Next.js, where balancing server-side and client-side rendering is key to achieving optimal performance and user experience.

In the final chapter our focus shifts to the concepts of lazy loading and preloading within the context of Next.js. Here, we illustrate

how these methods enhance both performance and user experience. By employing practical examples, the chapter provides a comprehensive exploration of dynamic importing and effective data management in Next.js applications. We delve deeper into these advanced techniques, demonstrating their practical application in optimizing performance, improving data handling, and refining user interactions in Next.js.