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DOCUMENTATION REPORT

Part of the BACHELOR DISSERTATION

Next-Gen Web Solutions

A comprehensive analysis of enterprise-focused web solutions,
unveiling strengths and weaknesses.

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Elective track Graduation	Software Engineer
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Availability for consultation

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May 8, 2024

Foreword

write the foreword

The foreword contains the usual thanks. All those who helped with the final paper are thanked. The persons who made the most significant contribution are thanked first. Write the name, position and title of persons correctly. Indicate your name, place and date at the bottom (optional). A signature is not appropriate here. Because the word in advance is strongly personal, it is often written in the I form.

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CHAPTER 1

Introduction

1.1 General

In web development, there are numerous solutions for creating websites. These solutions streamline website creation by simplifying complex tasks, standardizing and abstracting away common tasks, increasing DX and ultimately UX.

The Paradox of Choice

The abundance of web solutions/frameworks presents a challenge known as the paradox of choice [1]. This challenge is particularly pertinent for enterprises, which face additional criteria such as release cycles, licensing, support, state management complexities, backing, and longevity — all crucial factors considering the long-term maintenance requirements of the software.

Common Challenge

Whether you're a (*frontend*) Software Engineer, Project Manager, Technical Architect, Startup Founder, or simply someone intrigued by the web, you've likely encountered this dilemma.

Collaborative Project

This dissertation is a collaboration with the IT department of H. Essers, a major European Transport and Logistics company headquartered in Genk, Belgium. Their objective is to develop custom software solutions to optimize business processes. The department mainly comprises Java and IBM AS/400 (*now called "IBM i" [2]*) developers. They utilize the Vaadin full-stack framework for Java. Despite its advantages, the team has faced limitations within Vaadin that require more effort than initially anticipated.

1.2 The problem

User interfaces are crucial components of any application, and although websites have been around for many years, the industry is constantly evolving. Nowadays, development teams have a variety of web frameworks, architectures, and principles to choose from, making it difficult to decide which one is the best for a given task. This research aims to provide an answer to this difficult question.

1.3 Research question

What is the most suitable web solution for what kind of application?

1.3.1 Web Solutions

Research has been conducted into:

Solution	Year Released	Version Reviewed
React	2016	18.2.0
Vue	2014	3.4.15
Svelte	2016	4.2.12
Angular	2016	17.3.0
Lit	2019	3.1.2
Hilla	2022	2.5.7

Table 1.1: Researched Solutions

1.4 Experiment

The same project was built in each solution to ensure equal and objective evaluation.

1.4.1 Project Requirements

These requirements will provide valuable insights. The assessment is conducted objectively using the details stated in 1.4.2.

- General Layout (*see Figure B.1*)
- Interactive Search (*with URL query reflection*) (*see Figure B.2*)
- (*data*) Grid (*see Figure B.3*)
- (*data*) Grid in (*data*) Grid (*see Figure B.4*)
- Normal Forms (*with validation*) (*see Figure B.5 and Figure B.6*)
- Wizard Forms (*see Figure B.7 and Figure B.8*)
- Internationalization
- Drag and Drop (*see Figure B.9*)
- Progressive Loading
- Global State Management and Reactions
- Reflective Routing (*see Figure B.10, Figure B.11, Figure B.12, Figure B.13, and Figure B.14*)

1.4.2 Evaluation

Because the research question is broad, it will be answered by dividing it into smaller evaluation points, which are ranked objectively using a suitable method.

- Community ¹
- Professional Support ²
- Documentation (*interactive?*) ³
- Ecosystem ⁴
- Usage by other enterprises ³
- (*added*) Size of solution ⁵
- Relative performance of solution ³
- Complexity ⁶
- Server Side Rendered (SSR) ^{7, 8}

Likert Scale

Some evaluation will be done using a Likert Scale [3], with the values:

BAD/NOT PRESENT < MEDIUM/OK < GREAT.

¹Points by size, see A.1

²Predicate

³Likert Scale

⁴Points are 70% by quality and 30% by size, see A.2.2 and A.2.3 respectively

⁵Likert Scale, but smaller is better

⁶Evaluated using the Likert Scale by easiness/speed to learn, state management, boilerplate, and API integration

⁷Likert Scale, MEDIUM/OK being available through a well-supported and known extension

⁸SSR is better for SEO dependent applications

CHAPTER 2

Experiment

2.1 Angular

2.1.1 Overview

Angular, developed by Google, stands as a powerful web framework renowned for its versatility and rich ecosystem. This section explores its key features and considerations.

Angular's Versatility and Strengths

Angular boasts a plethora of built-in dependencies, streamlining development and eliminating the need to start from scratch. Notably, it offers Server-Side Rendering (SSR), enhancing deployment flexibility.

Expansive Ecosystem and Ease of Use

The framework benefits from extensive documentation, making it accessible to developers of all levels. Leveraging standard TypeScript and HTML files, Angular incorporates a custom templating language within HTML, facilitating development.

Enhanced Styling and Project Setup

Angular's CSS scoping mechanism ensures clarity in styling scope, thereby improving code maintainability. Additionally, its CLI application expedites project setup by generating boilerplate code efficiently.

Stable Updates and Routing Framework

Angular's updating process is notably stable, accompanied by comprehensive migration guides for seamless transitions between major versions. Moreover, its built-in routing framework offers stability and robustness.

Unique Features and Challenges

Angular's use of CSS selectors instead of components provides developers with greater control over component behavior. However, challenges exist, particularly in state management, which offers two methods with limited interoperability.

Templating Limitations and Internationalization

While Angular's templating language is powerful, it may lag behind alternative solutions in certain aspects, such as argument passing to slots/content projection, potentially steepening the learning curve for new developers. Additionally, its approach to internationalization necessitates separate builds for each language, hindering development flexibility.

Boilerplate and Type System Concerns

Angular requires a significant amount of boilerplate, primarily due to legacy considerations. Moreover, it lacks consistency in utilizing type systems, leading to explicit declarations for certain features like input validation.

Conclusion

In summary, Angular emerges as a robust framework with an extensive feature set and supportive ecosystem. However, developers must navigate its complexities and limitations, especially in state management and templating flexibility, to leverage its full potential effectively.

2.1.2 Strengths

- no VDOM overhead
- great documentation
- standard typescript and HTML files (custom templating language in HTML)
- CSS scope can be chosen with ease
- big Community (*over 40,000 members on Discord*)
- CLI application to help generate boilerplate
- standardized approach/libraries for many features
- uses CSS selectors instead of tags for components, providing more flexibility to the developer component usage
- baked in SSR support
- you can easily set the scope for styles
- stable and consistent release process [4]

2.1.3 Weaknesses

- uses different terminology than all other frameworks which makes switching more difficult
- HMR doesn't work great/smoothly out of the box

- you are unable to change the language for I18N in development mode as it requires a separate build for each language
- state management is complex
- two ways of managing state, signals and non signals, which are non interoperable with each other (*you can not directly pass a (non) signal to its counterpart without applying a conversion*)

2.2 Lit

2.2.1 Overview

write this

2.2.2 Strengths

write
strengths

- strength!

2.2.3 Weaknesses

write
weaknesses

- weakness! :(

2.3 React

2.3.1 Overview

React is a library [5] created by Meta (*originally known as Facebook*). Its recommended usage is in combination with JSX [6] (*see 2.3.2*). The library is primarily intended for the render layer and does not include native support for features such as routing and I18N. However, this does not mean that you cannot easily incorporate these features, as the library is part of a vast community ecosystem that includes many high-quality packages that specialize in various areas.

React uses a different approach than plain JavaScript by utilizing the VDOM [7] (*see 2.3.4*) to manage content instead of directly manipulating the DOM. It attempts to detect changes using the reconciliation algorithm (*see 2.3.5*) in the browser at runtime [8].

2.3.2 JSX

The rendering logic often gets tightly coupled with other UI logic. Instead of separating things by putting markup and logic in separate files, we can achieve our separation of concerns [9] by creating loosely coupled units called *components*. These components should ideally be pure, making the logic predictable, testable, and allowing us to make render optimizations like memoization [10], [11].

We can use JavaScript XML (JSX), which is neither JS nor a string. Instead, it combines (*as the name implies*) XML/HTML syntax with JS capabilities

(demonstrated in Listing 2.1). We can easily create components by defining a method that returns JSX, essentially currying [12] its context (*arguments, state, and more; demonstrated in Listing 2.2*).

```
1 const example = "NGWS";
2 const element = <p>This variable is interpolated {example}</p>
```

Listing 2.1: Simple JSX interpolation [6], [13]

```
1 function AnswerToTheUniverse() {
2   const theAnswer = 42;
3   return <p>The answer to the universe is: {theAnser}</p>;
4 }
```

Listing 2.2: Simple JSX component

2.3.3 Update Process

The update process of React is highly reliable. It involves testing the entire React-meta codebase, which comprises over 50,000 components, to determine if deprecating a method requires many changes. Only after this testing, does the React team decide if deprecation is necessary. If it is, they release a warning to the open-source community, which remains for one version. After that, the deprecated item is completely removed. In case many changes are needed to address the deprecation warning, scripts are built to make the migration as automatic as possible [14].

2.3.4 Virtual DOM

The Virtual DOM (VDOM) is a mirrored version of the real DOM. Represented as in-memory objects (*eg. Listing 2.3*) which can easily be traversed (*as no DOM needs to be parsed*), checked for changes, and used for other optimizations. For example, if a type of a VDOM element is changed it will tear down the old tree and rebuild the tree from scratch, but if the type is the same it will only update the attributes. Or if a key is set the reconciler can easily detect what items need to update (2.3.5, [8], [15]).

Although the VDOM incurs more overhead as the browser has to keep the entirety in memory, it offers greater flexibility for the reconciler. For instance, the React reconciler can not only process the DOM but also native iOS and Android displays (*with React Native*) [15]. Additionally, the VDOM enables more unique optimizations such as the pull technique instead of push, which allows the prioritization of user interactions over background tasks [14]. Moreover, it allows the renders to be batched instead of each one being its own operation.

```
1 {
2   type: "button",
3   props: {
4     className: "button button-blue",
5     children: {
6       type: "b",
7       props: {
8         children: "OK!"
9       }
10    }
```



```
11   }  
12 }
```

Listing 2.3: JSON representation of VDOM element [16], [17]

```
1 <button class="button button-blue">  
2   <b>OK!</b>  
3 </button>
```

Listing 2.4: HTML equivalent of Listing 2.3

2.3.5 Reconciliation Algorithm

There are generic solutions to the algorithmic problem of diffing and transforming one tree into another. However, the existing algorithms are expensive at $O(n^3)$ [18]. Because this is too expensive for a web framework, the react reconciler implements a $O(n)$ algorithm based on two assumptions [8].

1. “Two elements of different types will produce different tries.” which is why if the type is different the tear will be torn down.
2. “The developer can hint at which child elements may be stable across different renders with a *key* prop.”

2.3.6 State Management

State management in React relies on hooks, which are specialized functions. These hooks serve specific purposes within React components. Unlike traditional JavaScript assignments, manipulating state in React requires the use of hooks and their associated methods. Additionally, React enforces immutability, meaning once state is set, it cannot be directly changed. This immutability adds complexity to learning React, as it imposes restrictions on how actions can be performed.

When a state is updated in React, the reconciler detects these changes and initiates a refresh of the entire component in the next tick. To optimize performance and avoid unnecessary refreshes, it is recommended to:

- Split components into smaller, more manageable pieces.
- Minimize side effects within components.
- Utilize memoization where applicable.

By following these practices, developers can ensure efficient state management and enhance the performance of React applications [10].

Sharing State

In React, there are various methods for sharing state, with one popular approach being to lift the state up (*Figure 2.2*) [19]. This method aligns with the principle of a “*single source of truth*” [20], meaning that while the state isn’t confined to just one place, there’s a central component responsible for managing it. This eliminates the need for duplicating state across components, thus reducing error-prone practices.

However, this approach has its drawbacks. For nested components, the state must be passed down through each level, leading to code bloat and unnecessary dependencies between components. To address this issue, a context provider can be employed. This provider enables all nested children, regardless of depth, to access and respond to the state without requiring explicit prop drilling or predefined component structures (*Figure 2.3*) [21].

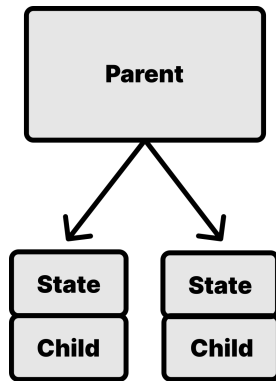


Figure 2.1: per component state

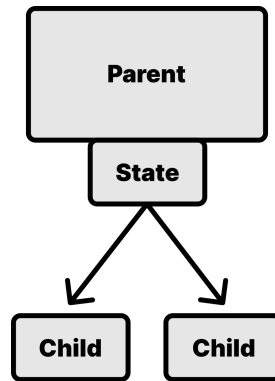


Figure 2.2: state lifted up (*shared state*)

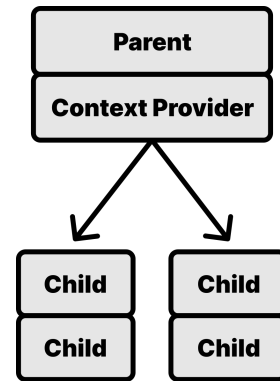


Figure 2.3: context provides state to all

2.3.7 Redux

Incorporating context to manage state is useful, but it's typically confined to the parent component. In most projects, developers opt to place the global state in the root (*app*) component (*Figure 2.4*). While this approach suffices for a few states, it becomes unwieldy when multiple states need to be shared.

To mitigate this challenge, developers often turn to Redux, a state management library. Redux operates akin to a global context, with each state, termed a “store”, linked directly to the Redux provider (*Figure 2.5*) [22]. This setup ensures that each state maintains its own logic and adheres to consistent, standardized definitions.

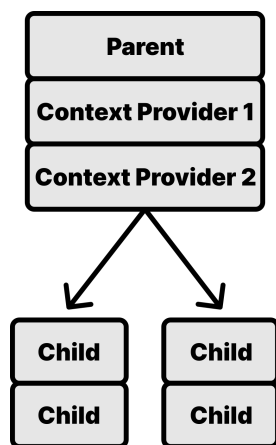


Figure 2.4: several providers provide state to all

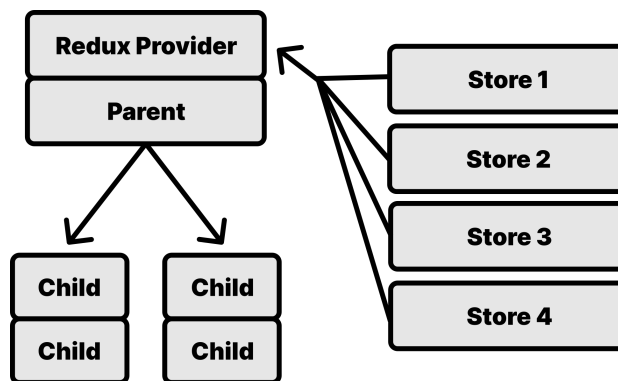


Figure 2.5: several Redux stores provide state to all

2.3.8 Strengths

- JSX is intuitive and easy to write
- big ecosystem
- well-known and used among developers
- documentation is great (*includes interactive examples*)
- big community (*over 230,000 members on Discord*)
- lots of enterprise usage, even in the Fortune 500 companies [23]
- not that performant compared to native JS, but a one-click addon called *Million* [24] makes this problem go away
- professional support is widely available through 3rd parties

2.3.9 Weaknesses

- VDOM overhead
- Component tries can cause unexpected behavior
- client-side rendered (*solution: Next.js or canary “use server” directive [25]*)
- State management can easily become complex in bigger components.
- basic dependencies (*React, Redux, I18N*) that get sent to the client are about 12MB which is relatively big and can slow down the initial load

2.3.10 Scores

Method	Score
Easiness/speed to learn	1
State management	0.5
Boilerplate	0.5 (<i>components: 1, state management: 0</i>)
API integration	0 (<i>default browser fetch API</i>)

Table 2.1: complexity

relative performance

Method	Score
Community	1 (<i>Table A.1</i>)
Professional Support	1
Documentation (interactive walkthrough?)	0.5
Ecosystem	0.9 (<i>Table A.4</i>)
Usage by other enterprises	1
(added) Size of solution	0.5
Relative performance of solution	-
Complexity	0.5 (<i>Table 2.1</i>)
Server Side Rendered (SSR)	0.5

Table 2.2: React general scores

2.4 Hilla

2.4.1 Overview

write this

2.4.2 Strengths

- strength!

write strengths

2.4.3 Weaknesses

- weakness! :(

write weaknesses

2.5 Svelte

2.5.1 Overview

write this

2.5.2 Strengths

- strength!

write strengths

2.5.3 Weaknesses

- weakness! :(

write weaknesses

2.6 Vue

2.6.1 Overview

write this

2.6.2 Strengths

write
strengths

- strength!

2.6.3 Weaknesses

write
weaknesses

- weakness! :(

CHAPTER 3

Conclusion

conclusion and recommendation

Here you formulate the answer to the research question. This does not include any new results that you have not previously cited. Do not use subsections here. Conclude your conclusion with a powerful closing sentence that briefly summarises your conclusion in one sentence.

Acronyms

API Application Programming Interface. 10

CLI Command Line Interface. 5

CSS Cascading Style Sheets. 5

DOM document object model. 6, 7, 14

DX developer experience. 1, 15

HMR Hot Module Replacement [26]. 5

HTML Hypertext Markup Language. 5, 6, 8

I18N internationalisation. 6, 10

JS JavaScript. 6

JSON JavaScript Object Notation. 8

JSX JavaScript XML. 6, 7, 10

SEO Search Engine Optimisation. 3

SSR Server Side Rendered. 3–5

UI user interface. 6

UX user experience. 1, 15

VDOM Virtual DOM. 5–8, 10

XML Extensible Markup Language. 6, 14

Glossary

boolean a value which is either true or false (*0 or 1*). 15

developer experience refers to the overall quality of interaction and satisfaction developers encounter while using tools, libraries, frameworks, or platforms to build software solutions. It encompasses various aspects such as ease of use, clarity of documentation, efficiency of workflows, availability of support, and the overall enjoyment of the development process. A positive DX contributes to increased productivity, reduced frustration, and greater motivation among developers, ultimately creating higher-quality software products. 14

document object model “connects web pages to scripts or programming languages by representing the structure of a document—such as the HTML representing a web page—in memory” [27]. 14

full-stack Encompasses the complete spectrum of web development, including both frontend and backend components, typically unified within a single codebase and language. 1

internationalisation is the process of designing applications to support multiple languages and cultures without altering the core code. It involves enabling language support, considering regional formats, supporting diverse character sets, managing content for localization, and adapting the user interface. Techniques include using resource bundles, language negotiation, dynamic content rendering, and ensuring Unicode compliance. Internationalization expands reach, improves user experience, and ensures regulatory compliance, making applications accessible to diverse global audiences. 14

library a collection of pre-existing code that can be utilized to create new code [28]. 6

predicate something that results in a boolean. 3, 21

user experience user experience refers to how people feel and interact with a product, service, or system. It encompasses aspects such as ease of use, visual appeal, and the emotions it evokes. A positive UX keeps people satisfied, interested, and returning for more. 14

AI Engineering Prompts

Note: While LLMs are excellent, they are not flawless, so the prompts have been used as a guide rather than a definitive one. There has been no copy-pasting, but rather a rewriting process to match the AI's output.

3.1 Rewriting of text

Role: English Language Expert

Language: English

Context: Computer Science Thesis

Task: Rewrite the following text slightly according to the notes

Notes:

- Clarity: Ensure that the main ideas are clearly expressed and easy to understand.
- Simplicity: Use plain language and avoid jargon or complex terminology whenever possible.
- Conciseness: Trim unnecessary words or phrases to make the text more concise and to the point.
- Structure: Organize the text logically with clear headings, subheadings, and transitions between paragraphs.
- Consistency: Maintain consistent formatting, tone, and style throughout the text.
- Active Voice: Use active voice to make sentences more direct and engaging.
- Variety: Vary sentence length and structure to keep the reader's attention and avoid monotony.
- Clarity of Purpose: Ensure that each section or paragraph serves a clear purpose and contributes to the overall message.
- Audience Awareness: Consider the needs and knowledge level of the target audience when choosing language and examples.
- Visual Elements: Incorporate bullet points, lists, and visuals where appropriate to break up dense text and improve readability.
- Transition Words: Use transition words and phrases to guide the reader through the text and connect ideas smoothly.
- Contextualization: Provide context or background information where necessary to help readers understand unfamiliar concepts or terms.
- Parallelism: Use parallel structure for lists or series of items to improve clarity and readability.
- Avoidance of Ambiguity: Clarify ambiguous terms or phrases to prevent confusion or misinterpretation.
- Proofreading: Correct any grammatical errors, typos, or inconsistencies.
- Output: The text is formatted using LaTeX, if there are any terms or acronyms that should be defined, define them and put them at the top separated from the text.
- Do not include LaTeX document boilerplate

Text:

<text here>

Role: English Language Expert Language: English Context: Computer Science Thesis Task: Rewrite the following text slightly according to the notes Notes: - Clarity: Ensure that the main ideas are clearly expressed and easy to understand. - Simplicity: Use plain language and avoid jargon or complex terminology whenever possible. - Conciseness: Trim unnecessary words or phrases to make the text more concise and to the point. - Structure: Organize the text logically with clear headings, subheadings, and transitions between paragraphs. - Consistency: Maintain

consistent formatting, tone, and style throughout the text. - Active Voice: Use active voice to make sentences more direct and engaging. - Variety: Vary sentence length and structure to keep the reader's attention and avoid monotony. - Clarity of Purpose: Ensure that each section or paragraph serves a clear purpose and contributes to the overall message. - Audience Awareness: Consider the needs and knowledge level of the target audience when choosing language and examples. - Visual Elements: Incorporate bullet points, lists, and visuals where appropriate to break up dense text and improve readability. - Transition Words: Use transition words and phrases to guide the reader through the text and connect ideas smoothly. - Contextualization: Provide context or background information where necessary to help readers understand unfamiliar concepts or terms. - Parallelism: Use parallel structure for lists or series of items to improve clarity and readability. - Avoidance of Ambiguity: Clarify ambiguous terms or phrases to prevent confusion or misinterpretation. - Proofreading: Correct any grammatical errors, typos, or inconsistencies. - Output: The text is formatted using LaTeX, if there are any terms or acronyms that should be defined, define them and put them at the top separated from the text. - Do not include LaTeX document boilerplate Text: <text here>

Role: English Language Expert Language: English Context: Computer Science Thesis Task: Rewrite the following text slightly according to the notes Notes: - Clarity: Ensure that the main ideas are clearly expressed and easy to understand. - Simplicity: Use plain language and avoid jargon or complex terminology whenever possible. - Conciseness: Trim unnecessary words or phrases to make the text more concise and to the point. - Structure: Organize the text logically with clear headings, subheadings, and transitions between paragraphs. - Consistency: Maintain consistent formatting, tone, and style throughout the text. - Active Voice: Use active voice to make sentences more direct and engaging. - Variety: Vary sentence length and structure to keep the reader's attention and avoid monotony. - Clarity of Purpose: Ensure that each section or paragraph serves a clear purpose and contributes to the overall message. - Audience Awareness: Consider the needs and knowledge level of the target audience when choosing language and examples. - Visual Elements: Incorporate bullet points, lists, and visuals where appropriate to break up dense text and improve readability. - Transition Words: Use transition words and phrases to guide the reader through the text and connect ideas smoothly. - Contextualization: Provide context or background information where necessary to help readers understand unfamiliar concepts or terms. - Parallelism: Use parallel structure for lists or series of items to improve clarity and readability. - Avoidance of Ambiguity: Clarify ambiguous terms or phrases to prevent confusion or misinterpretation. - Proofreading: Correct any grammatical errors, typos, or inconsistencies. - Output: The text is formatted using LaTeX, if there are any terms or acronyms that should be defined, define them and put them at the top separated from the text. Text: <text here>

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APPENDIX A

Metrics

A.1 Community Size Rating

The largest statistic gets chosen out of: GitHub stars or Discord members.

Range	Score
< 500	0
< 1,000	1
< 3,000	2
< 6,000	3
< 12,000	4
< 25,000	5
< 50,000	6
< 100,000	7
< 150,000	8
< 200,000	9
> 200,000	10

Table A.1: scores for size of community

A.2 Ecosystem Ratings

A.2.1 GitHub Stars

Range	Score
< 500	0
< 1,000	1
< 3,000	2
< 6,000	3
< 12,000	4
< 25,000	5
< 50,000	6
< 100,000	7
< 150,000	8
< 200,000	9
> 200,000	10

Table A.2: scores for amount of stars

A.2.2 Quality

Quality is determined by stars, documentation, and testing coverage. It is assumed that libraries with many users/stars and great documentation coverage have high quality. For feasibility reasons, this is checked for the top 25 downloaded dependencies.

Symbol	Note
*	predicate
-	not applicable
+	refers to the scores from Table A.2

Table A.3: special symbols

React

nr	Tag	Stars ⁺	Documentation*	Tests*
1	facebook/react	10	yes	yes
2	vercel/next.js	8	yes	yes
3	facebook/react-native	8	yes	yes
4	facebook/create-react-app	8	yes	yes
5	mui/material-ui	7	yes	yes
6	ant-design/ant-design	7	yes	yes
7	storybookjs/storybook	7	yes	yes
8	enaqx/awesome-react	7	yes	-
9	leonardomso/33-js-concepts	7	yes	-
10	shadcn-ui/ui	7	yes	yes
11	gatsbyjs/gatsby	7	yes	yes
12	facebook/docusaurus	7	yes	yes
13	remix-run/react-router	7	yes	yes
14	ionic-team/ionic-framework	7	yes	yes
15	meteor/meteor	6	yes	yes
16	pmndrs/zustand	6	yes	yes
17	appwrite/appwrite	6	yes	yes
18	streamich/react-use	6	yes	yes
19	brillout/awesome-react-components	6	yes	-
20	styled-components/styled-components	6	yes	yes
21	TanStack/query	6	yes	yes
22	react-hook-form/react-hook-form	6	yes	yes
23	chakra-ui/chakra-ui	6	yes	no
24	preactjs/preact	6	yes	yes
25	jaredpalmer/formik	6	yes	yes
-	Average	6.8	1	0.956

Table A.4: react ecosystem ratings

Score: $(6.8/10 + 1 + 0.956)/3 = 0.878666 \dots \approx 0.9$

A.2.3 Size

The size is based on the amount of GitHub results for the solution name.

Range	Score
< 10,000	0
< 20,000	1
< 50,000	2
< 100,000	3
< 250,000	4
< 500,000	5
< 750,000	6
< 1,000,000	7
< 2,500,000	8
< 5,000,000	9
> 5,000,000	10

Table A.5: scores for size

Project Requirements

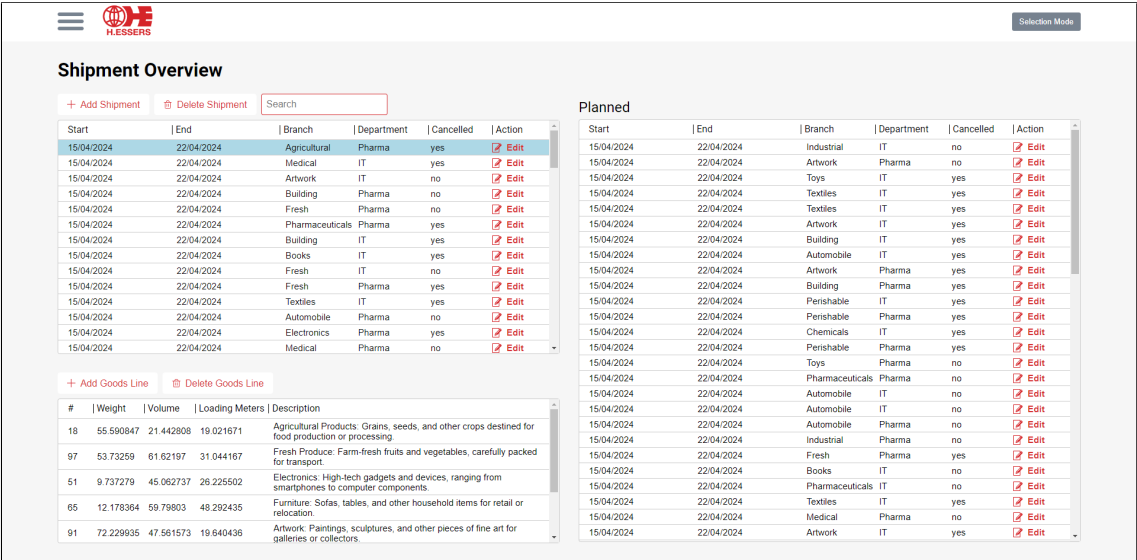


Figure B.1: general layout - <https://link.arthurdw.com/ngws-layout>

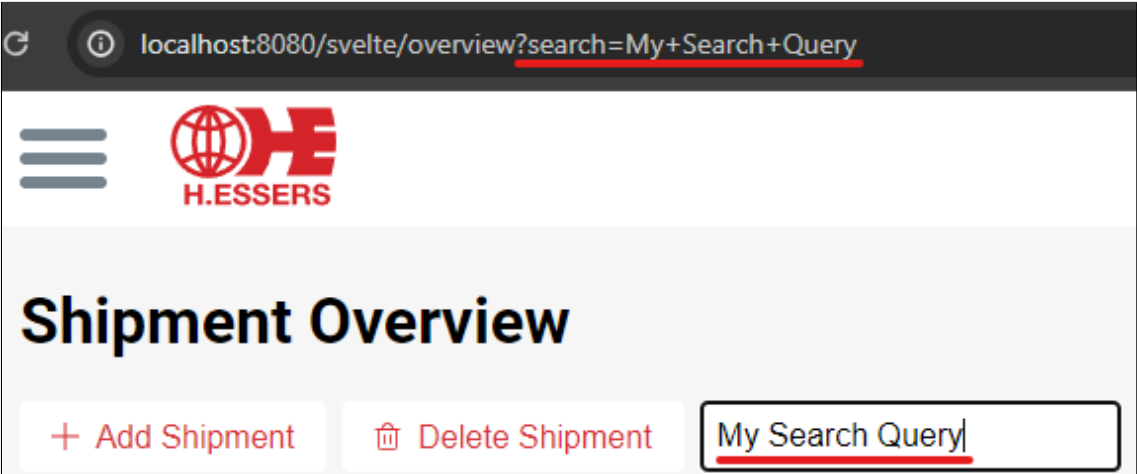


Figure B.2: interactive search - <https://link.arthurdw.com/ngws-search>

Start	End	Branch	Department	Cancelled	Action
15/04/2024	22/04/2024	Agricultural	Pharma	yes	Edit
15/04/2024	22/04/2024	Medical	IT	yes	Edit
15/04/2024	22/04/2024	Artwork	IT	no	Edit
15/04/2024	22/04/2024	Building	Pharma	no	Edit
15/04/2024	22/04/2024	Fresh	Pharma	no	Edit
15/04/2024	22/04/2024	Pharmaceuticals	Pharma	yes	Edit
15/04/2024	22/04/2024	Building	IT	yes	Edit
15/04/2024	22/04/2024	Books	IT	yes	Edit
15/04/2024	22/04/2024	Fresh	IT	no	Edit
15/04/2024	22/04/2024	Fresh	Pharma	yes	Edit
15/04/2024	22/04/2024	Textiles	IT	yes	Edit
15/04/2024	22/04/2024	Automobile	Pharma	no	Edit
15/04/2024	22/04/2024	Electronics	Pharma	yes	Edit
15/04/2024	22/04/2024	Medical	Pharma	no	Edit

Figure B.3: grid - <https://link.arthurdw.com/ngws-grid>

Start	End	Branch	Department	Cancelled	Action
15/04/2024	22/04/2024	Industrial	IT	no	Edit
#	Weight	Volume	Loading Meters	Description	
65	27.126638	64.966286	31.183498	Books and Printed Material: Novels, textbooks, and periodicals bound for libraries or retailers.	
79	2.9077778	96.06974	25.74276	Chemicals: Various substances used in manufacturing, agriculture, or research.	
15/04/2024	22/04/2024	Artwork	Pharma	no	Edit
15/04/2024	22/04/2024	Toys	IT	yes	Edit
15/04/2024	22/04/2024	Textiles	IT	yes	Edit
15/04/2024	22/04/2024	Textiles	IT	yes	Edit
#	Weight	Volume	Loading Meters	Description	
40	79.72203	54.74606	48.205166	Fresh Produce: Farm-fresh fruits and vegetables, carefully packed for transport.	
54	91.31288	21.084251	45.297527	Books and Printed Material: Novels, textbooks, and periodicals bound for libraries or retailers.	
18	34.621483	87.52795	31.122179	Agricultural Products: Grains, seeds, and other crops destined for food production or processing.	
15/04/2024	22/04/2024	Artwork	IT	yes	Edit
15/04/2024	22/04/2024	Building	IT	yes	Edit
#	Weight	Volume	Loading Meters	Description	
47	42.280685	33.08796	39.832283	Medical Supplies: Life-saving equipment, pharmaceuticals, and surgical instruments.	
54	50.115967	94.481834	2.2499146	Books and Printed Material: Novels, textbooks, and periodicals bound for libraries or retailers.	
81	49.358315	30.164183	8.355484	Agricultural Products: Grains, seeds, and other crops destined for food production or processing.	
6	90.32398	97.41022	13.202429	Chemicals: Various substances used in manufacturing, agriculture, or research.	
16	88.578188	48.855888	45.83888	Automobile Parts: Components such as engines, tires, and body	

Figure B.4: grid in grid - https://link.arthurdw.com/ngws-grid_in_grid

Edit Shipment

EXTERNAL RELATION ID

810a29f5-7f24-4427-966e-304aea93be85

BRANCH

Agricultural

DEPARTMENT

Pharma

PICKUP

15 / 04 / 2024

DELIVERY

22 / 04 / 2024

Cancel

Submit

Figure B.5: form: https://link.arthurdw.com/ngws-form_1

Edit Goods Lines

NUMBER

WEIGHT

VOLUME

LOADING METERS

Provide a number.

DESCRIPTION

Add

#	Weight	Volume	Loading Meters	Description	Action
18	55.590...	21.442...	19.021671	Agricultural Products: Grains, seeds, and other crops destined for food production or processing.	
97	53.73259	61.62197	31.044167	Fresh Produce: Farm-fresh fruits and vegetables, carefully packed for transport.	
51	9.737279	45.062...	26.225502	Electronics: High-tech gadgets and devices, ranging from smartphones to computer components.	
65	12.178...	59.79803	48.292435	Furniture: Sofas, tables, and other household items for retail or relocation.	
91	72.229...	47.561...	19.640436	Artwork: Paintings, sculptures, and other pieces of fine art for galleries or collectors.	
77	38.35904	70.86745	45.38122	Electronics: High-tech gadgets and devices, ranging from smartphones to computer components.	
64	93.228...	43.245...	40.926376	Medical Supplies: Life-saving equipment, pharmaceuticals, and surgical instruments.	
74	82.90547	77.645...	11.974808	Textiles: Rolls of fabric or finished garments, ready for distribution.	

Cancel

Submit

Figure B.6: form with grid - https://link.arthurdw.com/ngws-form_2

Add Shipment → Add Goods Lines

EXTERNAL RELATION ID

BRANCH

Enter the external identifier/relation id for this shipment!

DEPARTMENT

PICKUP

DELIVERY

Cancel

Next

Figure B.7: wizard form: https://link.arthurdw.com/ngws-wizard_1

Add Shipment → Add Goods Lines

NUMBER

WEIGHT

VOLUME

LOADING METERS

DESCRIPTION

Add

A description for the goods line is expected.

#	Weight	Volume	Loading Meters	Description	Action
5	10	10	5	My Goods Line	

Cancel

Back

Submit

Figure B.8: wizard form with grid - https://link.arthurdw.com/ngws-wizard_2

Start	End	Branch	Department	Cancelled	Action
15/04/2024	22/04/2024	Agricultural	Pharma	yes	
15/04/2024	22/04/2024	Medical	IT	yes	
15/04/2024	22/04/2024	Artwork	IT	no	
15/04/2024	22/04/2024	Building	Pharma	no	
15/04/2024	22/04/2024	Drag to plan or un-plan			
15/04/2024	22/04/2024	Pharmaceuticals	Pharma	yes	
15/04/2024	22/04/2024	Building	IT	yes	
15/04/2024	22/04/2024	Books	IT	yes	
15/04/2024	22/04/2024	Fresh	IT	no	
15/04/2024	22/04/2024	Fresh	Pharma	yes	
15/04/2024	22/04/2024	Textiles	IT	yes	
15/04/2024	22/04/2024	Automobile	Pharma	no	
15/04/2024	22/04/2024	Electronics	Pharma	yes	
15/04/2024	22/04/2024	Medical	Pharma	no	

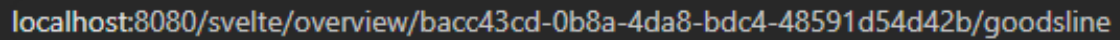
+ Add Goods Line

Delete Goods Line

#	Weight	Volume	Loading Meters	Description
16	64.75768	72.58953	33.20275	Furniture: Sofas, tables, and other household items for retail or relocation.
40	9.081994	24.780798	19.071985	Fresh Produce: Farm-fresh fruits and vegetables, carefully packed for transport.

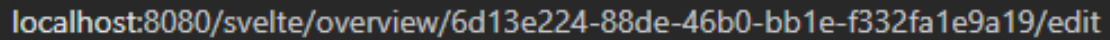
Start	End	Branch	Department	Cancelled	Action
15/04/2024	22/04/2024	Industrial	IT	no	
15/04/2024	22/04/2024	Artwork	Pharma	no	
15/04/2024	22/04/2024	Toys	IT	yes	
15/04/2024	22/04/2024	Textiles	IT	yes	
15/04/2024	22/04/2024	Textiles	IT	yes	
15/04/2024	22/04/2024	Artwork	IT	yes	
15/04/2024	22/04/2024	Building	IT	yes	
15/04/2024	22/04/2024	Automobile	IT	yes	
15/04/2024	22/04/2024	Artwork	Pharma	yes	
15/04/2024	22/04/2024	Building	Pharma	yes	
15/04/2024	22/04/2024	Perishable	IT	yes	
15/04/2024	22/04/2024	Perishable	Pharma	yes	
15/04/2024	22/04/2024	Chemicals	IT	yes	
15/04/2024	22/04/2024	Perishable	Pharma	yes	
15/04/2024	22/04/2024	Toys	Pharma	no	
15/04/2024	22/04/2024	Pharmaceuticals	Pharma	no	
15/04/2024	22/04/2024	Automobile	IT	no	
15/04/2024	22/04/2024	Automobile	IT	no	
15/04/2024	22/04/2024	Automobile	Pharma	no	
15/04/2024	22/04/2024	Industrial	Pharma	no	
15/04/2024	22/04/2024	Fresh	Pharma	yes	
15/04/2024	22/04/2024	Books	IT	no	
15/04/2024	22/04/2024	Pharmaceuticals	IT	no	
15/04/2024	22/04/2024	Textiles	IT	yes	
15/04/2024	22/04/2024	Medical	Pharma	no	
15/04/2024	22/04/2024	Artwork	IT	yes	

Figure B.9: drag and drop - <https://link.arthurdw.com/ngws-dnd>



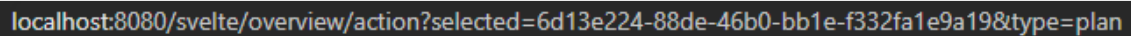
```
localhost:8080/svelte/overview/bacc43cd-0b8a-4da8-bdc4-48591d54d42b/goodslines
```

Figure B.10: reflective routing - https://link.arthurdw.com/ngws-routing_1



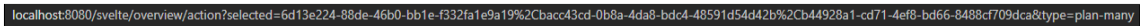
```
localhost:8080/svelte/overview/6d13e224-88de-46b0-bb1e-f332fa1e9a19/edit
```

Figure B.11: reflective routing - https://link.arthurdw.com/ngws-routing_2



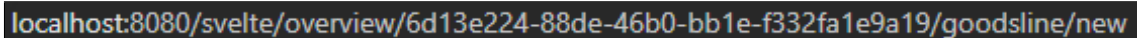
```
localhost:8080/svelte/overview/action?selected=6d13e224-88de-46b0-bb1e-f332fa1e9a19&type=plan
```

Figure B.12: reflective routing - https://link.arthurdw.com/ngws-routing_3



```
localhost:8080/svelte/overview/action?selected=6d13e224-88de-46b0-bb1e-f332fa1e9a19%2Cbacc43cd-0b8a-4da8-bdc4-48591d54d42b%2Cb44928a1-cd71-4ef8-bd66-8488cf709dca&type=plan-many
```

Figure B.13: reflective routing - https://link.arthurdw.com/ngws-routing_4



```
localhost:8080/svelte/overview/6d13e224-88de-46b0-bb1e-f332fa1e9a19/goodslines/new
```

Figure B.14: reflective routing - https://link.arthurdw.com/ngws-routing_5