Bachelorarbeit am Institut für Informatik der Freien Universität Berlin

Human-Centered Computing (HCC)

How does an editor for dynamic resources for users with different levels of expertise look like and how can it be conceptualized and implemented within the constraints of an exisiting ecosystem?

Matthias Kind

Matrikelnummer: <IhreMatrikelnummer>

matthias.kind@fu-berlin.de

Betreuer: Florian Berger

Erstgutachterin: Prof. Dr. Claudia Müller-Birn

Zweitgutachter: Prof. Dr. Lutz Prechelt

Berlin, TODO

Eidesstattliche Erklärung

Ich versichere hiermit an Eides Statt, dass diese Arbeit von niemand anderem als meiner Person verfasst worden ist. Alle verwendeten Hilfsmittel wie Berichte, Bücher, Internetseiten oder ähnliches sind im Literaturverzeichnis angegeben, Zitate aus fremden Arbeiten sind als solche kenntlich gemacht. Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungskommission vorgelegt und auch nicht veröffentlicht.

Berlin, den TODO Datum

Matthias Kind

1 Abstract

In recent years, the shift from print to digital publishing channels has increased the need for tools that allow publishers to quickly build and configure apps and websites.

The goal of this bachelor thesis is to conceptualize, plan and implement an User Interface (UI) editor for apps and websites used by magazine and news publishers, particularly in Germany and the UK. The editor was built for a proprietary web framework called "Purple Experience" and was developed within the constraints of an existing software ecosystem, which posed challenges and limitations on the design and implementation of the tool.
To gain insights into the needs and workflows of the groups of users who will be using the editor, a variety of Human Computer Interaction (HCI) methods were applied during the user research phase, including moderated observations and interviews.

The outcome of this research is useful as guidance for future software development projects for internal tools at companies. It can also be useful in environments where constraints exist, but a user base is already in place to provide valuable input and feedback. As a result of the user research phase, an interactive prototype was built using modern web technologies. In the next step it was deployed to a controlled group of test users. This approach combined with methods of agile software development allowed me to iterate fast and collect direct feedback until it was rolled out for production use.
TODO reformulate
Learned: - if existing user base (manageable number): qualitative research methods seem to provide more value / deeper feedback than quantitative
- if existing products: use tracking etc. to figure out who already uses tools how, as a base line for comparison
- use vizualizations and other methods to sort ideas by multiple dimensions (user value, impl. effort) -> easier to reason what to do next & to convince other stakeholders

2 Zusammenfassung

TODO: translate english abstract when finalized <Hier sollten Sie eine kurze, aussagekräftige Zusammenfassung (ca. eine Seite) Ihrer Arbeit geben, welche das Thema der Arbeit, die wichtigsten Inhalte, die Arbeitsergebnisse und die Bewertung der Ergebnisse umfasst.>

List of Figures

List of Tables

3 Introduction

3.1 Topic and context

In the ever-growing world of software development, many companies are now in the situation to maintain a large software ecosystem with complex dependencies. Still, there is need for continuous improvement and development to stay competitive. This poses the challenge of improving the software from aspects like user experience, scalability and maintainability while being restricted by the ecosystem.
From my point of view, Greenfield development[1] is implicitly assumed in the majority of books about HCI. This approach is not applicable to the situation many software companies are in today.
TODO: rewrite that HCI methods might need different weight / get a bit adapted for brownfield development However, applying HCI methods for user research and user experience-focused design in brownfield development, where many choices are already made, must be approached differently.

In addition, the three major factors in HCI (Usability, Accessibility and Time-on-task, [2, pp. 38-40]) are often neglected due to tight deadlines and limited resources which usually leads to premature releases and unstable software.

3.2 Goals of this thesis

My goal was to demonstrate how HCI principles and methods can be applied in a brownfield project, using a real world case study at the company Sprylab as an example. Sprylab is a company which is engaged in the digital publishing industry, providing SaaS[2] to publishing houses for editing and distributing content. The case study consists of the redevelopment of a UI Editor which I will describe more in detail in chapter 4 in order to improve user expeirence and usability.

[1] Greenfield- and brownfield development refer to software development concepts, where Greenfield projects start in a new environment and don't have legacy code, while brownfield projects are about upgrading or redeveloping software in an existing environment. [4]

[2] Software as a Service, TODO definition

3.3 Process for research, prototyping and implementation

While writing the software and thesis, I followed the software design process described in [2, p. 104]. There, the process is divided into the three phases "Design Thinking", "Lean UX" and "Agile".

For this case study, the abstract plan for the process looks as following:

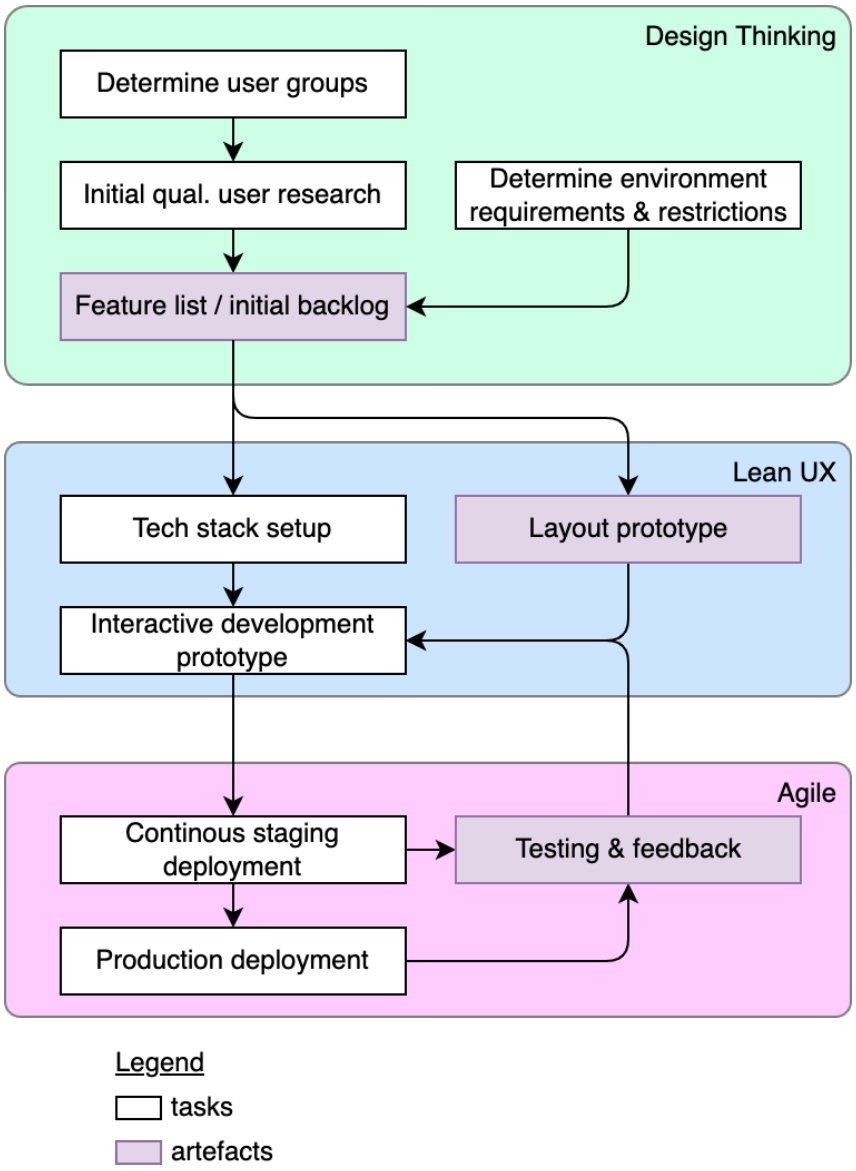


Figure 3.1: Software design process for the UI Editor.

TODO write what Agile lean UX and design thinking are

4 Theoretical background

Before discussing the design and implementation of the UI editor, it is necessary to provide a brief overview of the applied parts of HCI and the specific context, challenges and Opportunities in which the UI editor was developed.

4.1 Applied human-computer interaction methods

Let me start by concretizing the HCI aspects of this work and why this I approached the subject from a not so common point of view. HCI is a complex topic with a long list of available methods and even more ways to adapt them to a concrete project, so it is impossible to cover all aspects. As a brownfield software project [1], the development of the UI editor faced the challenge of integrating with an existing ecosystem and adhering to pre-existing technical requirements. In my opinion, these technical requirements face only limited coverage in HCI literature, which is why I set some special focus on them during this case study.
To determine the initial functional requirements, I chose to apply qualitative user research methods like moderated observations (6.2.1) and interviews (6.2.2). While I also use quantitative research methods to get insights during the testing phase, I decided against using them during the inital functional requirements phase. The available user base was small enough to get meaningful and representative statements only from qualitative research and a questionnaire would either be too long or not provide enough helpful insights.
Furthermore, two concepts were used as foundation and guidelines during the process:

SMART goals <todo>

3 major factors of HCI <todo>

4.2 Project specific background

4.2.1 Functional

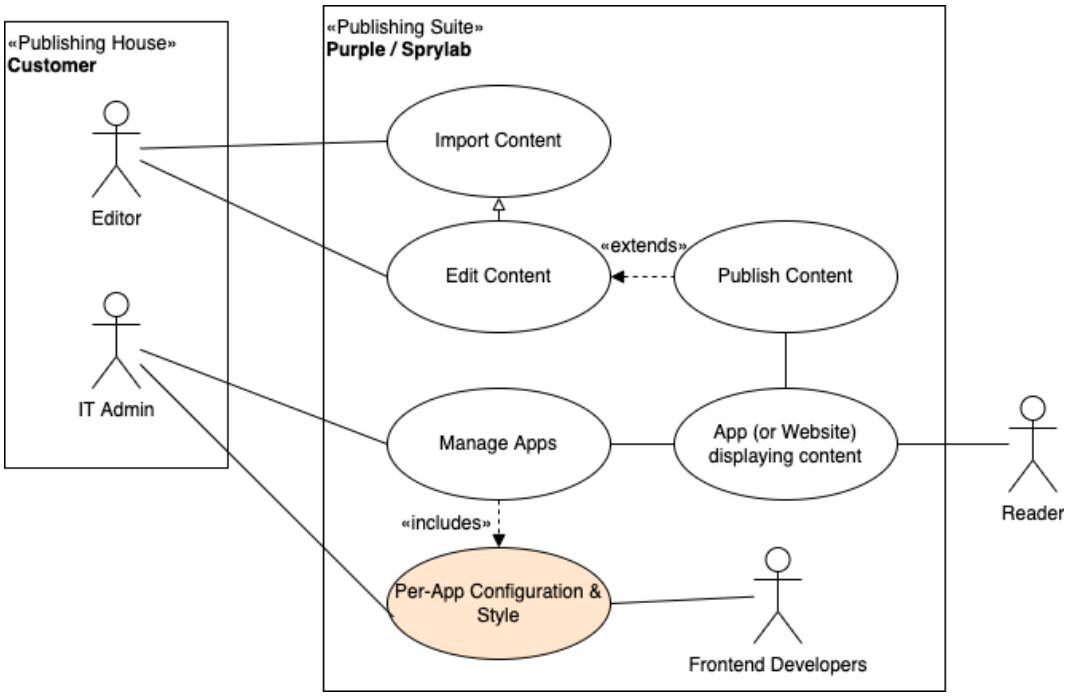
TODO: use this?
The UI Editor, which I will describe more in detail in 4, is a tool relying on may external systems and is limited by the file system structure and configuration

[1] Brownfield development is the opposite of greenfield development, brownfield refers to adding "new capabilities on an existing product or product platform, using existing technology" [1].

schemas imposed by the Purple Experience Franework. The editor was developed for magazine and news publishers in Germany (DACH) and the UK, and is intended to facilitate the editing of dynamic resources by users with variying leves of expertise.

To understand the usecase and value of the UI Editor, we first have to declare the fundamentals of the environment the editor will be embedded in. The publishing houses resp. their digital departments (in the following *customer*) purchase the license for an app or website (in the following just *app*, as there is not much difference besides the end medium). Then, they can import content via multiple ways into the system, or the editors write the content directly inside the tools provided as an Software-As-A-Service (SaaS).

Figure 4.1: Use Case diagram showing interactions from publishers, readers and frontend developers with the system



The UI editor fits into the Use case ”Per App configuration & style” (see fig. 4.1), with wich mostly Frontend Developers and Project Managers from Sprylab as well as some external customer’s IT admins will interact. The goal is to lower the editing burden as much as possible, so that more of the configuration can be handed off to external customers while also improving usability for the developers of the company.

4.2.2 Technical

Now that we have established a rough understanding of the environment and use case the UI editor will be placed in, I want to explain more about the configuration and styling itself. For that, it is important to understand the Frontend framework Sprylab uses for the delivery to apps and websites. It is called Purple Experience and is a Meta framework build ontop of Angular. The benefit is, that it is completely configurable via JSON files describing the routing, rendering of diffrent components, connecting data sources (an API abstraction) with those components, loading assets like images and ads, and styling the whole page with CSS.
These configs and assets are stored on an file system called *dynamic resources*.

Dynamic resources are individually managed and loaded for every app. This way, on mobile phones the endusers download an native core app, which in turn just downloads the dynamic resources and executes the angular app with the configs provided from the resources. Similar, when a end user requests a website, the backend server just looks up the dynamic resources matching this app's Domain and renders the website using that config. This way, all customers can share the same server instance(s) in case of websites, or at least don't require extra native sourcecode changes per app.
In addition, there are preview and live resources for every app, so that changes can be tested before they are released to the end users.
If you have worked with larger, deeply nested JSON files before, you may recall that they get convoluted quite fast. Also, manually handling ZIP files, changing assets and config files, packing everything back in a zip file and hoping one didn't introduce a typo anywhere is an inefficient an at times quite dangerous workflow.
As a base for making editing of these configuration JSON files easier, the Purple Experience generates JSON schema files directly from the Interfaces in the source code for every released version. JSON Schema is a specification and a declarative language "that allows you to annotate and validate JSON documents." (Retrieved 11th January 2023, from `https://json-schema.org/`). With these schemas, it's possible to validate the users input directly and even generate UI Elements so that is impossible for the user to enter invalid JSON or JSON that doesn't match the types declared in the source code.

At Sprylab, there exists an tool called "Storefront Editor", which is used as the foundation for this new editor. It uses a open source software called *Json Editor* (`https://github.com/json-editor/json-editor`), which takes a JSON schema and a matching JSON config as input and generates such a mentioned UI to manipulate the JSON in a safe way. As part of the chapter 6 about User Research and Analysis, I evaluate the state of the JSON editor for that usecase and in general outline the positive aspects and approaches which I reused for the new editor, as well show the missing features and features the interview candidates noted as confusing, not working or which slowed down

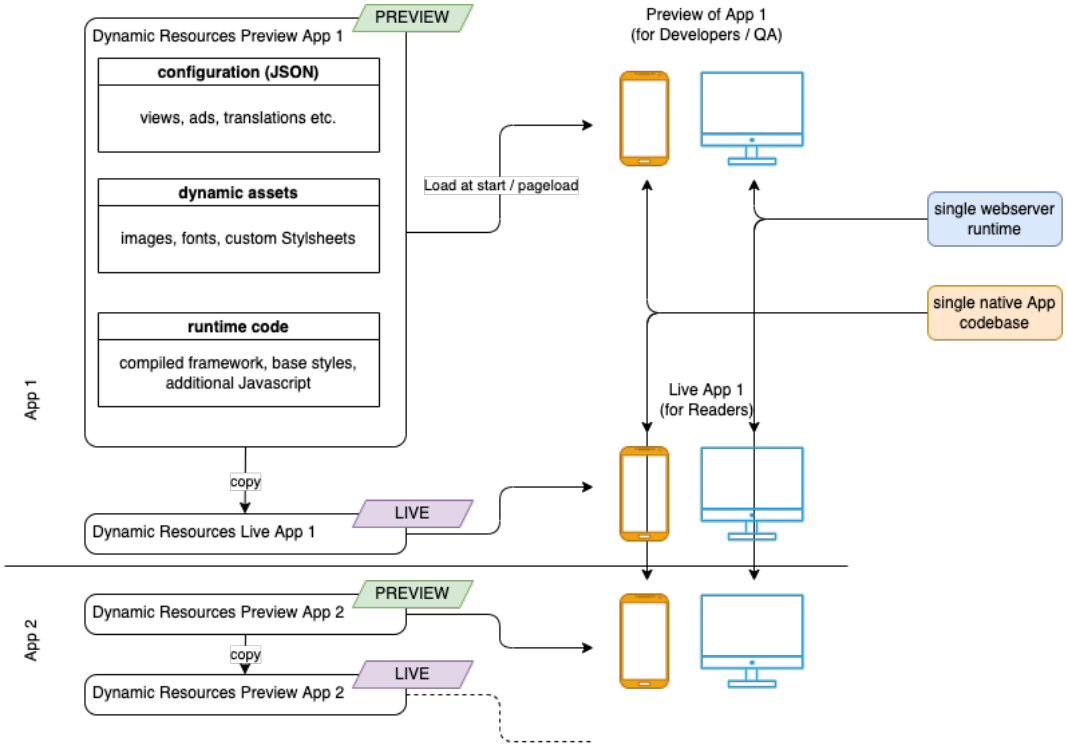


Figure 4.2: Sprylab preview and live dynamic resources for two imaginary apps 1 and 2

their work.

```
{
  "type": "view",
  "path": "/newsstand",
  "content": [
    {
      "type": "list",
      "content": {
        "type": "issue"
      },
      "dataSource": {
        "type": "issue",
        "filter": {
          "purchasable": {
            "value": true
          }
        }
      }
    }
  ]
}
```

Figure 4.3: Simplified example of an view configuration showing purchasable issues

5 Related work

TODO

6 User research and analysis

TODO maybe use this reference?:

- [7] why companies dont conduct user research

Over ten years after the publication of Tomer Sharon's book "It's our Research", the listing of qoutes in the introduction about user research in software companies still feel as relevant as ever.
"Yeah, but this study will delay our launch date.", "Yeah, but we can't learn much from only five participants.", "Yeah, but research sounds so academic." [8, p. 4] are only some of the statements that according to Sharon are often heard in software companies when discussing if UX research should be conducted.
The common pressure from different stakeholders often leads to quick implementation of features and workflows without first investing time to figure the user's needs out, which may be faster in the beginning, but can badly impact the user's acceptance of the product due to cumbersome and slow workflows, in the worst case leading to the user not using the product anymore.

To counteract this, it is crucial to conduct and evaluate user research methods, which is what I did for the development of the UI builder.

A starting point for qualitative user research is to define the goals through the help of the SMART criteria, which provide guidelines and formulated goals during research.

For the project, I defined the SMART criteria as following:

- **specfic** - improve the workflow of users modifying dynamic resources for the Purple Experience.
- **measurable** - interviews after testing period concerning working speed, confidence and joy when editing resources, automated user tracking
- **assignable** - research and implementation will mostly be conducted by me, with input from CTO & product owner, connections to external users through customer service team
- **realistic** - new software platform which reacts quicker, prvides more safety regarding errors and is scalable and extensible in the future. Limiting factors are time (as I only have three months for the first phase, including writinh this thesis)
- **time-related** - the new software should have at least the same feature set and be usable by company-internal users until the end of 2022

TODO: flow first and second concept The second one are "three major factors that an HCI designer should consider" [2, pp. 37-41] according to Becker, which are

Usability Factor describes the spectrum from "usable" to "unusable" software. This is determined through the software design features implemented and how they help the user archieve their tasks in the environment provided.

Accessibility Factor is high when as many users from different backgrounds can use the software in different enviornments. It includes, but is not limited to access for people with physical and other disabilites, as well as the entry hurdle a new user must overcome. While it might look like this factor is not as important as the other two for specialized software mostly used internally, it should not be left out when designing and implementing. For example, even if currently no user with visual impairment is working with the software, it can always happen that an exisitng or new colleague suddenly has to rely on screen readers to continue his work.

Time-On-Task Factor refers to "[...] solutions that use up the appropriate of time to solve a problem." [2, p. 40]. Obviously, to save users as much time as possible, a fast system is required. But it is inevidable that the system, network delay and complexity of computation all have some minimal required time, and users understand that some operations might take time. More important is to reduce the perceived lag of interactions and give users feedback if a task takes longer to complete.

6.1 Identifying and categorizing users and user groups

In order to effectively design and implement the UI editor, it is crucial to understand the needs and preferences of the various users and user groups who will be using the tool. Therefore, the first step in the user research process was to identify and categorize the different users and user groups who will be using the editor.

In a later chapter (6.5), I'll build concrete Personas for the different user groups utilizing the information gained from the interviews.
Because we already have existing users that work with the previous editors and other tools from the ecosystem, it was relatively easy to collect a list of internal and extneral users, which either I personally knew or I could write a short message asking about if and how they use existing tools and modify dynamic resources. I see that this won't be as easy when dealing with a larger user base or primary external customers, when this first step probably requires more effort to collect a user overview upfront.
With a list of many of the users, I started grouping them to understand the characteristics and needs of each user group, through which can ensure that

the UI editor is tailored to their specific requirements and can be used effectively by all users[1].
I derived the follwoing common factors from the users, which made the communication and categorization a lot easier.

- **quantitative usage** There were users who relied on the tools for most of their work, while others like the external customers accessed the tool a few times a year.

- **common tasks** I roughly categorized the common tasks into three groups:

  Heavy configuration Mostly internal devs used the tools to build new apps and websites from scratch (or derived from exisiting apps), making many modifications, from structural changes to the seperate views, menus, data sources and more, over styling and translating messages to diffrent languages.

  Moderate configuration Project devs and customer support people copy resources from existing apps and adapt them for new brands, which often includes changing colors and logos, adapting texts or switching authentification flows.

  Small changes External customers often only use the tools to exchange some ads, translations or logos, which affects a small set of files.

- **expertise**

  Technical Depending on the area of education and working time in the web development industry, the expertise about web technologies, languages like CSS and JSON and often also intuition differs between users.

  Domain- and Platform Specific There is a lot of vocabulary, functionality of the Purple Experience and other systems as well as permutations of configurations that users learn with time.

6.2 Qualitative user resarch

The existing user base enabled me easy access to subjects for qualitative user research methods. Using one or multiple ways of Triangulation [5, p. 264] can strengthen the significance of the research outcome. Limitations of a method or source can be removed by variation of those, resulting in a less distorted picture. Therefore I used metholodical triangulation (using multiple data gathering techniques) as well as triangulation of data (collecting data from different

[1] When I refer to ”all users”, I mean the group of users that are expected to work with the tool. There is an expected technical and domain specific base knowledge that the Editor won't cover

people and different sources). Moderated observations combined with interviews proofed to be a good fit for this case study, as they are interaction driven and the observer can react directly on behaviours / emerging topics and steer the process. This stands is contrast to more passive methods I found like passive observations or user recording and tracking analysis, where the outcome only depends on the prepared question / task and the users behaviour and which can't adapt to changed circuumstances etc. during the application.

The chosen structure for the observations and interviews looks as following:

Introduction (~5min) used to explain the circuumstances and the goal of the session, how we proceed, which data I will collect and how I will evaluate the data afterwards.

Moderated Observation (10-15min) have the observed perform specific tasks in a prepared environment

Semistructured Interview (~15min) ask prepared questions as well as open ones and discuss observation situation

The reason for Interview following the Observation is, that the observer and observed can discuss the situations or issues occured during the Moderated Observation before, which was a good point of entry into the open dialog after the mandatory prepared questions were asked. The other way around, I'd have no way to react to workflow and potential problems the observed encountered during the tasks.
As I had no prior experience conducting these methods with an scientific approach, it was important to me to test the whole process before scheduling all the other meetings. One of our working students agreed to be a test candidate and we went through the tasks and questions I planned, after which he gave me feedback. Testing the methods and specific questions before conducting them on a broader audience helped finding questiones that were ambiguous or lead to a lot of repetition of already known facts. For the moderated observation tasks it gave me feedback on the difficulty and time they would take for others on average, which tasks needed clearer formulations and which were already good.
In total, I performed the user research on six persons, from which one was an core Purple Experience developer, two were working students from our project department, one was an developer from an different department who had worked with the software some time prior, one Customer Support Manager from our company and one external user from an publisher.

6.2.1 Moderated observation

I prepared a list of six tasks, with the last two beeing optional depending on the time left and the confidence of the user with the platform I perceived

during the beginning. That way I could present the same first tasks to every interviewee regardless of their level of knowledge, and present the last two tasks if we had enough time left. Also, it was important that the tasks did not build on each other to prevent the observed person getting stuck because of an earlier mistake. To me, it was more important to see a variety of tasks getting performed than one task beeing executed without errors.
In practice, I prepared an example app on our staging system, noted the link down and downloaded the initial state so that I could easily reset the enviornment after each observation. The six tasks were

- Change english app menu entry "Newsstand" to "Home" on all platforms (Web, Android and iOS)
- Change the Advertisement banner target on top of the home page to https://google.com
- Change the exnglish text "Latest Issues" on the home page to "Read new Issues"
- Change color of "Read new Issues" and "Latest Articles" headers on the home page to the app's primary color.
- *(Optional)* Add an dropdown on the home between "Read new Issues" and "Latest Articles"

  It should show all publications connected to the app

  It should set an URL parameter "publication" to the id when selected

  Define the reset message as "All publications"

- *(Optional)* Configure the filter of the "Latest Articles" list to only show articles from that publication

These were constructed in a way that I anticipated some errors so I could see how users tried to figure out what went wrong and fix them. These cases then also occurred, for example the first task was often only done for one of the three platforms, the "Latest Issues" text was not found in the translation files or the wrong CSS selector was used to recolor the header elements on the home page, leading to more elements beeing recolored.

The optional tasks were presented to four people, of which three solved them at least one of them successfully, only the core developer solved all six tasks completely. With the consent of the interviewees I recorded their screens during the observation to rewatch specific actions or flows if required.
TODO: noticed workflow patterns that can be improved? like file opening, switching files (quick links & file tabs)

6.2.2 Interview

For the interview, I chose a semistructured interview as the appropriate tool. The interviewer has a list of open and closed questions, through which he can ensure that important topics are coveredw hile also allowing for flexibility to delve deeper into specific issues and ideas that may arise during the interview. My prepared questions consisted of some closed questions, like how often they interact with the tools, how confident they feel implementing changes or fixing errors, as well as some open questions like to describe step by step what the most recent task was they performed with dynamic resources, how they were onboarded etc. Then, if I had notices points during the observation, I addressed these points directly, else I directly introduced the open question "If you dream of the UI builder, <>, how would it look like, which features would you expect and what workflows are most important to you?".
The semistructured interviews proved to be valuable in providing insight into the experiences and needs of the users. Through the interviews, I was able to gather a lot of new ideas and saw how different features were massively valued differently by the users. Two of the interviewees even provided written lists of their ideas and suggestions which they sent me afterwards. After every interview (wich I also recorded), I filled out a Word document noting basic questions about the person and it's usage of the dynamic resources, important situations from the observation, input from the interview and linked to the recordings in case I needed to rewatch parts of it.

Some of the outcomes were:

- The way users validate their changes differs widely, some use a preview window in the old editor, some merge changes into the resources and view it on the website or inspect the app's javascript context, some prefer seperate windows, some embedded frames to see code and preview at the same time.
- Rearranging or adapting the layout of the tools / editor to match the current screen and browser window size is important, e.g. hide unecessary panes if not used, make the window the user currently works in larger to see more content at once.
- Editing multiple files at once (in the old editor one could only edit one file at a time, had to close the current and open the next one).
- Colaborative working: Seeing the current state of the resources, e.g. if a live or preview resource is processing, if other users are working in the same app parallel, and having git-like line-by-line diffs of the changes made.

Some of these points and their implementations will be covered in chapter 7 8.

6.3 Quantitaive user research

In the beginning, I thought about also distributing questionaires to the exisitng and potential users, but as the outcome of the qualitative research was already very productive, it felt hard to design a questionaire that provided additional information while still adhering to the common design rules for questionaires concerning length and amount of questions as well as the type of them.
Some prototype questionaires exist in Microsoft Forms, but they were either too long, the questions difficult to understand or didn't contain anything of interest for the development of prototypes. Thus, we decided against questionaires and to stick to qualitative research results for the prototyping, as well as for the feedback, mixed with some automatic tracking implementation.
TODO: ref squeaky.ai section

6.4 Process and vizualize the outcomes of the initial user research phase

Besides the already mentioned Word document which contained semi-structured notes from the interviews, and Jira tickets I created for the necessary base tasks for setting up the new software project, I experimented with some alternative methods to explore and vizualize the data.

6.4.1 2x2 Opportunity Matrix

This two-dimensional vizualization of a set of proposed features prooved helpful when prioritizing tasks with other stakeholders, as it shows the (approximated) cost of implementation as well as the value the feature can have for users.

The matrix I used is a slightly modified adaption from [2, p. 181], replaced the term "idea originality" on the x-axis with "Value".

6.5 Building Personas

Personas are descriptions of fictional users of the product, incorporating assumptions and optinally data for a user group. They aim to give developers and designers more context and depict real potential users, which makes it easier for a developer to empathize with the user. The following three Role-based Personas are derived from 6.1 and the outcomes of the interviews, based on the description of Personas in [5, pp. 403-405]

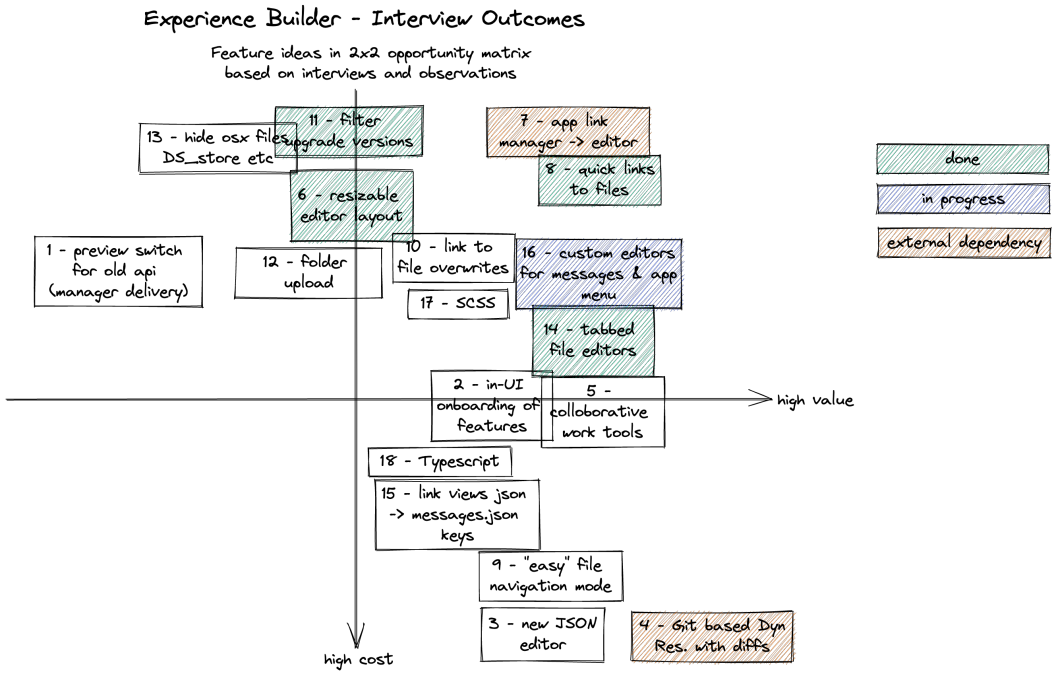


Figure 6.1: 2x2 Opportunity Matrix during the early phases of development

6.5.1 John - Purple Expeirence Product Developer

Background and Skills

John (34) is a senior Angular Web Developer at Sprylab, working there for two years. He was born in Berlin and lives in Lichterfelde with his wife and mostly works from home. He is passionate about Angular, Typescript and Developer Experience in general, studied Computer Science at the Beuth Hochschule and hosts Angular conferences.

Goals and work with the Editor

- Test newly developed features and the related configurations
- Configure test apps for development and QA purposes
- Support in case Project Developers like <TODO> encounter problems
- John works with the editor multiple times a week

6.5.2 Steffi - Project Developer

Background and Skills

Steffi (23) studies media informatics and works as a working student at Sprylab since a year. This is her first job in the industry and she is learning new

things every day. Her skills include writing CSS and understanding modern web technologies, but she still struggles using native and custom debugging tools if something goes wrong.

Goals and work with the Editor

- Configure new apps based on existing templates and adapt them to customer's requirements
- Add new components or change data sources for existing apps
- Add custom HTML pages or Javascript snippets to intergrate external services
- Change styles, color schemas or icons when a customer has a rebranding
- Steffi uses the editor as a primary tool for her work

6.5.3 Karsten - IT department at a publishing house

Background and Skills

Karsten (46) worked in the publishing industry for 20 years, but only during the last years his company, aga magazine publisher, tries to catch up with the digital development and trends. He is still struggling with his role and is thankful for every trick or tool that makes his life managing the digital products easier.

Goals and work with the Editor

- Exchange logos and colors when the magazines he supervies get a redesign
- Add new ads to different views when a new campaign starts
- Manage URLs to external sites when they change
- Karsten uses the Editor once a month on average

7 Prototyping

After collecting the inital user feedback, I started drawing minimal digital "paper" prototypes using Figma to gather vizualizations of the proposed UI layouts. Two ideas emerged from the interviews: a (file-)editor-centric layout and a preview-centric layout.

7.1 Editor centric vs preview centric layout

The editor-centric layout is inspired by modern text editors / IDEs like VS Code (`https://code.visualstudio.com/`), which was mentioned as reference during the interviews multiple times. There, the central pane is the editor for the currently open file, while on the sides additional panes for file management, preview and more can be shown. The familarity, especially to developers who are used to IDE layouts, could help new users adopt patterns to work with the UI they use in other tools as well.

The idea for a preview-centric layout was inspired by popular generic website builders like `https://wix.com` or `https://wordpress.com`, where the user can see the page in an interactive mode, move, configure or place elements, and then has on the side additional panels like one with information & options about the currently selected element. There are also framework-agnostic tools like `https://vwo.com/why-us/technology/visual-editor/`, but they either focused more on only editing the style and not the structure of the page or were not compatible with the Experience's framework and data fromat.
Ultimately our choice fell to the editor centric layout, the following are some of the reasons for it over the preview-centric one:

- The configuration structure of the Experience framework was not built with preview-based editing in mind. A lot of functionality is hidden inside the components and invisible for the user, often components only appear under specific conditions that are not easily reproducable in the editor environment. Thus, editing in a preview-centric mode could in many situations lead to more confusion by the editors than speed the process up. As the configuration schemata are mostly fixed and I can't prevent

- After evaluation of some avaialble libraries and examples, we concluded that building a reliable and usable preview-centric editor is more complicated, and even without the time restricition of my bachelor thesis, I proposed to not go this way, as it was unclear if it even could result

in a viable product in reasonable time. For editor-centric UIs, many thirdparty libraries exist, that can be integrated into the UI. Some relevant are Monaco Editor (the VS Code Open source text editor part) for editing generic web related files like CSS and JS with automatic syntax highlighting and error detection, and an JSON Editor for work with json configs where we could provide a schema.

- The userbase consists mostly of tech-affine people who are used to layouts of IDEs, and the old tool also had a similar editor centric layout. As Jakob's Law of the Internet User Experience states (cf. [6] and [9, p. 2]), the user's understanding of a website is directly tied to his/hers mental model of that system. Introducing a unconventional workflow comes with the danger that the user gets confused, makes mistakes or in the worst case doesn't like working with the tool anymore.

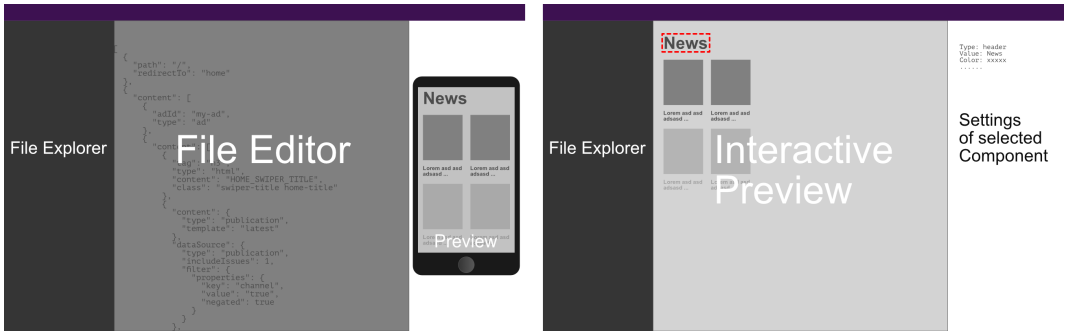


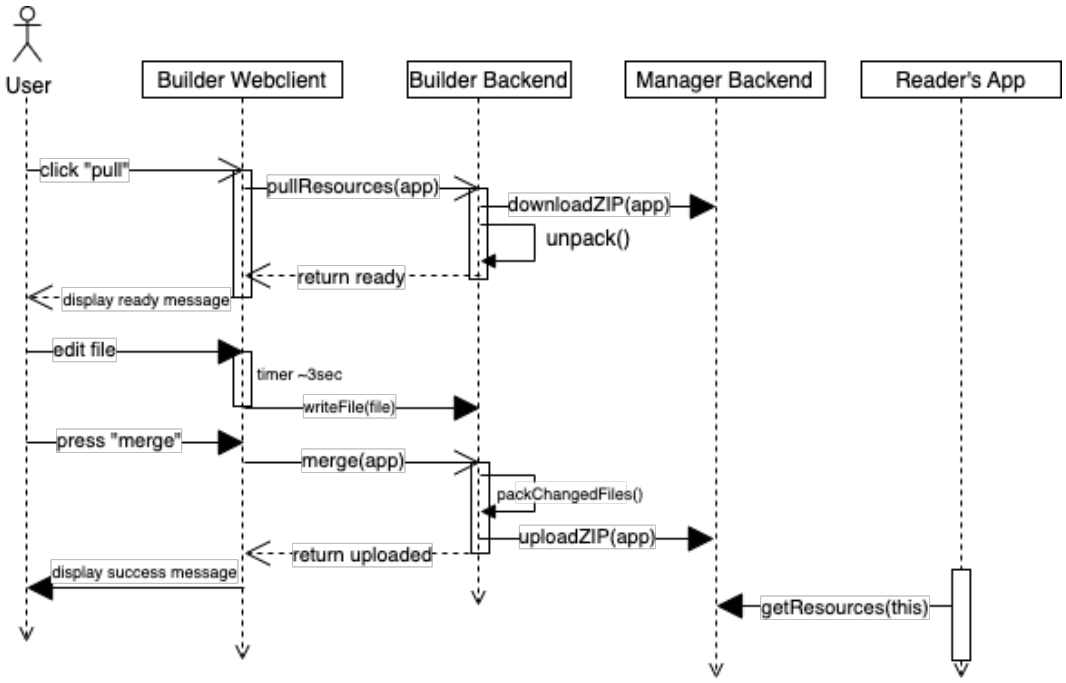
Figure 7.1: Mockups: Editor centric vs preview centric editor layout

8 Implementation and deployment

The phase of implementation and deployment followed an agile development process, where I could deploy changes easily to get fast feedback from users.

8.1 Architecture

Let's start with an overview about the architecture and high level user flows. We have three software components relevant for a basic interaction with the system: the UI editor frontend, the UI editor backend and the "Manager" backend, which is responsible for authentification, app management and providing the dynamic resources in an ZIP format.
At the beginning of a user journey, the user visits the root domain (e.g. `https://builder.purplemanager.com` for production apps) and logs himself in with username and password. These credentials are validated in the manager backend, returning an session token which grant's the user access to specific apps he is entitled to see and edit. Then, he can select one of the available apps he wants to edit. The following UML sequence diagram displays a typical interaction of a user with the editor frontend after he selected an app; pulling the latest dynamic resourses, editing a file and merging the changes.



8.2 Software stack

From the company's point of view, it is advantageous to keep the technology stack as narrow as possible. Without restrictions one may chose the latest and greatest language or framework for a new project, but maintainability and availability of persons to review and collaborate are not guaranteed. For this case study, the most important point was the availability of additional persons with knowledge about the frameworks and languages used. Additional constraints from DevOps' [1] side were only vague, since the code gets deployed in Kubernetes, a containerized environment, so the only baisc requirement is that the application must be able to run inside a Docker container.

For this project I decided to use Typescript language (`https://www.typescriptlang.org`) on both back- and frontend. The advantages are wide availability of persons in the company who also work with it, a mature ecosystem, and shared type declarations between server and client, reducing the risk of working with incompatabile data types by accident.
The rest of the stack is fairly common in the web developemnt industry too, the frontend uses React JS as a rendering and reactivity framework, with additional libraries for state management, UI Components and API query management on top.
For the backend, I used Node as a Javascript runtime, combined with the most used HTTP server framework for Node, Express JS [3]. On top of express, a framework called TSOA (`https://github.com/lukeautry/tsoa`) is used to improve the developer expeirence. It provides a class based architecture similar to the well known Spring platform for java, including dependency injection, type validation of the http parameters at runtime and automatic API documentation in the OpenAPI specifications.

Frontend, backend and shared libraries are stored in a monorepo to speed up development and deployments and make refactorings more consistent while maintaining clear APIs and reducing accidental tight coupling.

8.3 Feature examples

In the following section, I'll present a selection of the features that were implemented during the UI editor case study. These features are chosen as examples to how the HCI methods and outcomes from the user research phase influenced their design and how they can improve the user's experience with the tool.

(connect to HCI research)
Files:

[1] DevOps, short for developer operations, refers to methods or in this case responsible persons to manage the combination of software developemnt and IT operations, e.g. how the code get's deployed, how services get provided and resolved and more.

- multiple tabs as files -> switch between files more fluent, no wait times, discovered during mod. observation

- quick links -> shortcut to often used files, input from interview

Editing

- messages.json custom editor (feedback Anja) -> demo for custom editors per file,

- changed files -> current implementation, plans to use git as source of truth

- editor abstraction? (more techincal for prechelt for example)

Post processing pipelines

8.4 CI/CD

CI/CD, short for Continous Integration and Continous Deployment, is a core practice of agile software development and provides a log of value to HCI projects. The first part, Continous Integration, means "[...] developers add to a shared repository frequently that integrates their code." [2, p. 81] The integration consists of automatic builds and tests (cf. 8.5) to improve quality of the code and confidence of the developers to publish changes more frequently.

As Sprylab uses and private gitlab, for the Expeirence Builder I set up a Gitlab CICD Pipeline. The stages may change when additional build steps or tests are added, but currently it consists of the following stages: *Build*, *Package* and *Deploy*.
Deploy is only active on the develop and master Branches and contains the code to upload the docker image to the company's staging and production clusters and update the kubernetes deployment to run the latest build. The other two stages are run for every Commit of an Merge request. This has the benefit that as soon as a developer pushes his code to a branch that has a Merge Request open, he and all others can see if the latest commit could be merged safely or if there is more work to do. The *Build* stage installs the dependencies, builds all packages in the monorepo and executes unit- and e2e-tests afterwards. If any of these steps fail, the Merge request can't be merged until this issue is resolved.

Of course the benefit of CI/CD depends on the setup of the build chain, amount, coverage and quality of tests and other factors. To further improve code quality, we integrated Sonarqube into the repository on gitlab (`https://www.sonarqube.org`), which is a service that automatically scans the code and reports code quality, security issues and technical debt added in a commit.

Having a fast and reliable CI/CD process early on during prototyping and development prooved very valuable, as I could quickly react to user's input on new features or bugs, implement and deploy them quickly on a staging system and get feedback on the new behaviour in less than 15 minutes. Through the seperation of staging and production system, I could deploy quick fixes with more confidence even when beta testers were working on the production system, as I could verify that my changes worked in a production-like environment

without interrupting users.

8.5 Automated Testing

As already elaborated, the quality and quantity of automated tests plays a huge role when using CI/CD, as it drastically reduces the time required by Quailty Assurance testers to go through all the edge cases on every change. For the Experience Builder I stuck to two of the most common testing levels: unit tests and End-to-End tests (also known as E2E or System tests).

Unit tests are mostly used to test one "component" in an sandboxed environment. For the server, this meant testing Services and classes or even finer grained; single functions. On the client, we distinguished between UI testing of single react components, and business logic code that is encapsulated in classes or Javascript modules.

They also are helpful during development to test software patterns before dogin large refactorings and to do test-driven development (TDD), where the specifications and constraints can be laid out as code with invariants, pre- and postconditions, and then the implementation is performed while continously running the tests again until the don't fail anymore.
Espeically for TDD, but also for the CI/CD Pipelines, the speed of the tests is important. If a single test run takes multiple minutes, the developer is blocked during that time and can't progress on the task, but the duration is also not long enough to start working on another task in the meantime. That's why I tried to integrate a fast test runtime comatible with UI- / browser testing as well as node runtimes for the server code. After evaluating diffrent commonly used frameworks, I settled for Vitest (`https://vitest.dev/`), which fullfills all the requirements, runs tests in parallel, thus reducing the time between saving the change and seeing the test result to often less than a second, and has easy integration mechanisms into our build tools.

While unit tests are a good way to verify encapsulated behaviours, when many components interact with each other, new errors can emerge often as it is quite unrealistic to have all intenral and extenral APIs behaving exactly as expected for every input, and Web based UI applications have unmanagable number of factors that influence the behaviour of UI, network and timings.
E2E tests are supposed to cover a typical user interaction with the service to vaildate the interaction between business logic components, UI and the user itself. I started with using a custom setup of a headless browser[2] (`https://pptr.dev/`) in combination with vitest, but writing and especially debugging the tests prooved slow and error prone.
At an internal training day some colleagues introduced a new E2E test frame-

[2]Headless browsers are browser instances that don't render the actual content to a user's screen, but run as a CLI application and still execute all Javascript, CSS and HTML.

work called Playwright (`https://playwright.dev/`), which allows recording a test case in a "normal" browser window, it then generates the base code for the test automatically and only needs to be adapted in a few places. After looking through some examples and seeing how it can get integrated into our pipelines, I started porting the exisitng tests to playwright, and after a few hours the tests run on the new framework, now with much better debugging tools and the ability to add new tests much faster.
This can be an example for others, that investing time to investigate new tools and port code to them if they bring value, can improve developer expeirence and thus also speed and confidence.

8.6 Scalability

- REDIS pubsub + observables - code example

8.7 User Testing, Feedback, Beta and Monitoring

- deployments to staging - small test group at start - internal beta - problem: people didn't want to adapt new platform?? - beta flags

8.8 Communication and Documentation

- teams - jira - documentation in tool & external

9 Conclusion and outlook

- Die Zusammenfassung sollte das Ziel der Arbeit und die zentralen Ergebnisse beschreiben. Des Weiteren sollten auch bestehende Probleme bei der Arbeit aufgezählt werden und Vorschläge herausgearbeitet werden, die helfen, diese Probleme zukünftig zu umgehen. Mögliche Erweiterungen für die umgesetzte Anwendung sollten hier auch beschrieben werden.

TODO: formulate in sentences

- User research with existing groups of users (small-medium size, easy access for interviews) : qualitative more value than quantitative
- processing of reserach data: personas, 2x2 matrix, jira tickets, feedback rounds
- implementation: Monorepository
- unit & e2e tests for more confidence
- abstract external systems so that other parts of system can change APIs without strong coupeling
- Problems appeared:

  quantitative feedback difficult, not much feedback

  limited by other systems (e.g. Git based dynamic resources)

  hard to prioritize when many people want different things -> use data viz to figure out impact of features on "average user"

  Architecture: good abstractio n of server state with multiple instances (prevent inconsistencies)

  code review process slowing down development

Bibliography

[1] Johanna Wallén Axehill et al. "From Brownfield to Greenfield Development – Understanding and Managing the Transition". eng. In: *INCOSE International Symposium* 31.1 (2021), pp. 832–847. ISSN: 2334-5837.

[2] Christopher Reid Becker. *Learn Human-Computer-Interaction*. 2020. ISBN: 978-1-83882-032-9.

[3] Vano Devium. *Top Node.js Web Frameworks*. URL: `https://github.com/vanodevium/node-framework-stars` (visited on 12/13/2022).

[4] *Greenfield vs Brownfield: Understanding the Software Development Differences*. URL: `https://www.johnadamsit.com/software-development-greenfield-vs-brownfield/` (visited on 01/02/2023).

[5] Jennifer Preece Helen Sharp Yvonne Rogers. *Interaction design - beyond human-computer interaction, 5th Edition*. Wiley, 2019. ISBN: 978-1-119-54725-9.

[6] Jakob Nielsen. "End of Web Design". In: (2000).

[7] Jim Ross. "Excuses, Excuses! Why Companies Don't Conduct User Research". In: (2016). URL: `https://www.uxmatters.com/mt/archives/2016/03/excuses-excuses-why-companies-dont-conduct-user-research.php` (visited on 01/02/2023).

[8] Tomer Sharon. *It's our reserach: Getting Stakeholder Buy-in for User Experience Research Projects*. Elsevier Inc., 2012. ISBN: 978-0-12-385130-7.

[9] Yon Yablonski. *Laws of UX*. O'Reilly, 2020. ISBN: 978-3-96009-156-1.

Appendix

9.1 Erster Teil Appendix

9.2 Zweiter Teil Appendix