UNIVERSITÄT PADERBORN
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Model Based Experimentation on UI Prototypes

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Exposé/Proposal – October 11, 2022.
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1 Introduction

Motivation: Over the last decade, Software development had a tremendous impact with increasing customer demand and requirements [1]. So, the developers have come up with different techniques to meet this requirement criteria. Similarly, increasing product complexity and ambiguity have a significant impact on software development. Early user feedback from potential customers in the industry is crucial for creating successful software products because of the growing market uncertainties, and consumers' desire to receive integrated solutions to their issues rather than unique software developments [15]. With the increasing complexity of products, it becomes challenging to determine user requirements. Different people can have overlapping or contradicting opinions. And to reduce these risks, there has to be early detection of the user's needs and requirements. Giving users a "partially functioning" system is the most excellent method to determine their requirements [4]. This ensures that the developers with high uncertainties in the early product development can validate by testing the underlying assumptions [2]. Developers can use this feedback to validate the most critical assumptions about the software product. This validation can be used to decide whether to add, remove or update a feature [11]. This process is called `Continuous Experimentation (CE)`. There has been an increase in interest in the types of experimentation that can take place in product development. Fabijan et al. [5] have shown the benefits of continuous experiments in many use cases with incremental product improvement. In CE, the product owner designs different software variants (E.g., Different Subscription fees for registration) of the product, and the developer integrates these variants and assigns them to a distinct group of users. The variant with better results as per some evaluation criteria (more number of user registrations) is deployed for the entire set of users. So, an experiment can be valuable when it solves real-world problems. Hence, for experiments to be successful, they should offer one or more solutions that will benefit users.

Problem 1: The developers are responsible for creating the experiments, and the product owners give the ideas and feedback to the developers. The main problem is integrating the product owners and the non-developers into the development process to bridge the gap between the developers and non-developers.

Problem 2: The process of creating experiments and testing their variants is usually not systematically arranged, creating anomalies that give rise to unsuccessful experiments. (Use design principles)

Problem 3: In a small-scale company containing a few users, it is not easy to do experiments and get conclusive feedback on the "winner" variant. Because, with a small amount of data, it is impossible to prove one of the variants outperforms the others statistically.

Problem 4: Most often, the software application collects data from the experiments, and not all the data is used in the analysis phase reducing the software applications to improve based on customer feedback. (Use Data-driven development)

Research Approach: To solve the first problem, the developers focus more on automating the software code rather than coding everything stated in the product requirements [7]. This approach is formally known as a `Low-code` approach. So, this approach helps to have a UI interface for the non-developers to understand and develop the software products [9]. One approach to support the product owners in developing the variants is UI Prototyping. UI prototyping creates new UI variants using predefined UI elements (E.g., Drag and drop the UI elements into the screen). This helps product owners to be creative and innovative because it gives them visual feedback. So, if UI prototypes are developed in a low-code technique, they would be lightweight software that helps the product owner develop various prototypes and conduct experiments on the users. According to Cabot et al. [3], the low-code has become more accessible for Model-driven development. Similarly, while creating prototyping, the software should have connections between the screens (E.g., clicking on a button should go to the next screen), and this logic can be achieved using Models. Models are used broadly in prototyping because a model represents or describes the aspects of the systems that cannot be described adequately in a system of interest [12]. Moderately accurate models can be created using an iterative approach in software development by getting continuous feedback from the users.

To solve the `second` problem, a design science research (DSR) study should be conducted to obtain some Design Principles (DPs) defined for the whole process of experimentation [10]. Here, DPs capture and codify that knowledge by focussing on the implementer, the aim, the user, the context, the mechanism, the enactors, and the rationale [6]. The DPs explain the design information that develops features for software applications. We propose to use the variation of the cycle of Kuechler and Vaishnavi [10] consisting of five iteratively conducted steps. First, we identify the `(1) Awareness of the Problem based on a real-world problem` and provide a `(2) Suggestion of a possible solution`. Next, we work on the `(3) Development of the software artifact` and conduct an `(4) Evaluation` of it. Based on the evaluation results, another iteration is undertaken, and/or our research contributions as `(5) Conclusions` are provided [14].

To solve the `third` problem, we use supervised task-based usability testing [8]. The fundamental principle of usability testing is to have real users attempt to use the software application to do certain activities. These activities can be the tasks or scenarios (e.g., Locate a movie M1) for the users to complete and analyze (e.g., the time/clicks required to locate the Movie M1) [13].

To solve the `fourth` problem, the models should use data to measure the experiments' success for improvement. This process is called a Data-driven development approach. This approach uses meaningful, actionable consumer feedback regarding the effects of the product experiments by using the `Qualitative and Quantitative` data analysis. Using a combination of qualitative and quantitative data can improve an evaluation by ensuring that the strengths of another balance the limitations of one type of data confirming that the knowledge is enhanced by integrating different techniques.

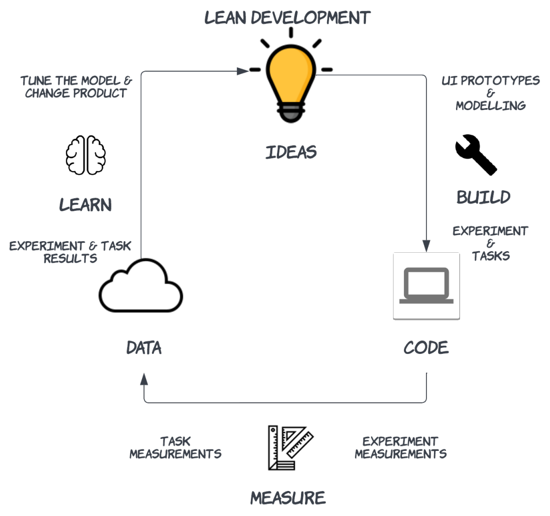


Figure 1.1: LEAN Development technique

Solution Approach: In our solution, we use the LEAN development technique (see figure 1.1) for development. LEAN development technique can be divided into 3 phases Build, Measure, and Learn. In the `(1) Build` phase, we plan to create the `UI Prototypes`, `Models`, create `Experiments`, and assign `Tasks` to the users. In the `(2) Measure` phase, we plan to measure the `Task and the Experiment measurements` and perform some analysis on the data received. And finally, in the `(3) Learn` phase, we display the `Experiment results`, `Tune` our models to decide the better variant among the others, and `Modify` our product. The solution approach is detailed in Chapter 3.

2 Related Work

This section considers some existing frameworks and compares them to our solution approach. We will only consider major features and neglect minor technical differences and implementation details. We will focus on the topics like `UI Prototyping`, `Crowdsourcing`, `Data-driven approaches`, `Continuous Experiments` and `Model-based approaches`.

For example, you could write about:

- Figma[1]
- Others[2]
- ...

Note: This template is just an example. You can of course combine Sections 1 and 2 into one section or use a different structure.

[1]https://www.figma.com/
[2]https://webflow.com/blog/prototyping-tools

3 Solution Idea

This section presents our plan for obtaining the objectives discussed in section 1. In our approach, we propose a Model-based and Data-driven development approach using the LEAN development approach. As mentioned earlier, LEAN contains three phases Build, Measure, and Learn.

In the Build phase, we plan to create the `(1) UI Prototyping` using the drag and drop approach, `(2) Model` these prototypes, and create `(3) Experiments and Tasks` from the models and assign them to the users. In the Measure phase, we plan to measure the `(4) Experiment and the Task measurements`. Finally, in the Learn phase, we would analyze the results from the `(5) Experiments and the Tasks`, `(6) Tune our model and modify the product`.

Consider an example of a “A video streaming service” called `VideoStreamer (VS)`. As shown in figure 3.1, this company has different stakeholders. We divide them into two groups the developers (e.g., programmers, designers, etc.) and the non-developers (e.g., product owners) to improve the product. Usually, the developers are responsible for developing various features required for the company. But, the problem is, in the beginning, knowing which design fits better for a UI is impossible. Therefore, we need to perform experiments on the UI using A/B testing. So, the developers develop different variants for experimenting with the UI and get feedback from the non-developers. This feedback process wastes a lot of time, so our solution is to give freedom to the product owners and reduce the gap between the product owners and the developers by allowing the product owners to create the UI using UI prototyping.

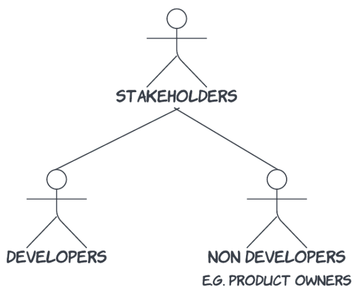


Figure 3.1: Different Stakeholders in the Company VS

3.1 Build

3.1.1 Visualising the Prototypes

We plan to implement the UI prototyping in a low-code technique for our solution because it needs negligible installation, setup, training, and implementation work. The low-code technique enables the rapid creation and deployment of business applications with the least amount of coding effort. We plan to create a system for non-developers to modify the UI elements in a canvas-like structure in an application. For this, the product owners first create a canvas screen and input the name for that screen. As shown in figure 3.2, they can add UI elements like buttons, input buttons, select buttons, etc., on the canvas screen. We propose to use angular[1] for developing the application. Various UI elements are available for the drag and drop of the UI elements, as shown in figure 3.2 (right side).

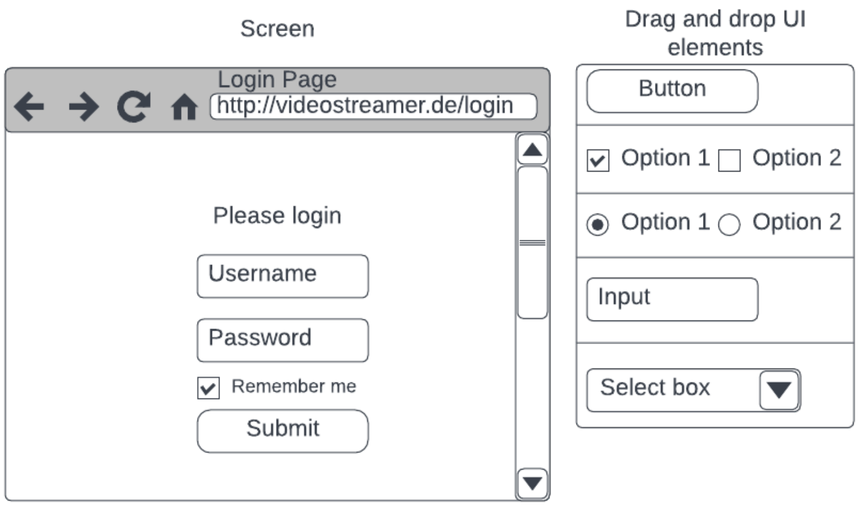


Figure 3.2: UI Prototyping using drag and drop of UI elements

Once the non-developers finalize the UI screen, they can move to the next screen by some logic (E.g., clicking on a button to go to the next screen). This way, the non-developers can design the entire application, having a sequence flow (i.e., the user will register, go to the Login page, next to the Dashboard page, etc.), using the canvas screen, and adjust the UI elements. This way, the non-developers can build the entire application quickly without any programming knowledge.

[1]Angular: `https://angular.io/`

3.1.2 Modelling the Prototypes

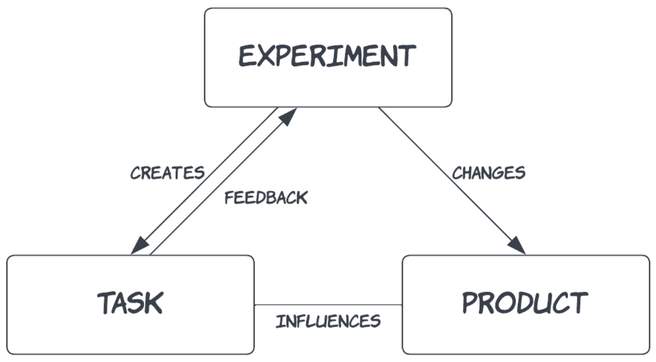


Figure 3.3: Triangle of Experiment, Task, and Product

In our application, we plan to convert the screens the non-developers develop into models. To do that, we need a modeling language that fits our requirements. Based on our domain, we need models for `Experiments`, `Tasks` and `Product`.

Experiment: In the `Experiment Model`, we store different properties of the UI elements along with the variant information.
E.g., from `Videostreamer app`: If the experiment is on a `Button` element, our model should have information about the position of the button, the style of the button (storing the color, font, etc.), the title of the button, etc. All this information would be stored in the model as its properties or attributes. The Model also stores information of different variants of a particular application screen. (E.g., see figure 3.5 the Grid and the List View) Moreover, the model can obtain this information from the UI prototyping done by non-developers using the drag-and-drop feature.

Product: In the `Product Model`, we store information about the product and all its components as independent parts. This model stores all the different screens available in a software application and links them.
E.g., from `Videostreamer app`: A video streamer would have different screens (see Fig 3.4 right side), a Home screen, a Video search screen, a Video display screen, etc. These screens are modeled to relate different screens and the elements within a specific screen. We plan to create Meta-models (see Fig 3.4 left side) and develop relationships between them. Moreover, the models should be able to accept measurements (e.g., `ClickRate` to measure the user clicks, `ViewTime`

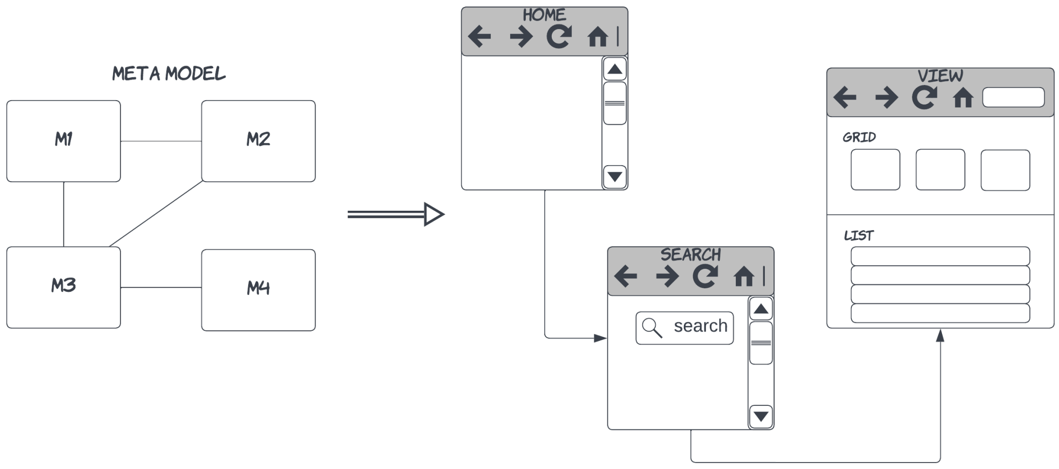


Figure 3.4: Example Meta Model

to measure the time spent by the user) to determine the best fit among the variants.

Task: In the `Task Model`, we store a sequence of activities that the user needs to perform and obtain feedback as measurements from the users for testing the software product.
E.g., from `Videostreamer app`: We would give a task to a user U1, saying "Navigate to the movie M1" and measure the number of steps/clicks and the time required for the user to perform this task.

There are some relationships between these models as depicted by the figure 3.3 `(1) Experiment-Task, (2) Experiment-Product, and (3) Task-Product` relationships.

Experiment-Task: An experiment can create various tasks for the users and get some feedback in the form of data from the Task model.

Experiment-Product: From an experiment, it can be decided which is the best variant for a product and can thus modify and improve the product in an iteratively continuous process.

Task-Product: A task should be created based on the current state of the product, and thus it creates a relationship between the task and the product.

3.1.3 Experimenting using A/B Testing

The product owners continuously investigate new features and product enhancement opportunities by conducting frequent experiments. The owners better understand their customers' experiences by creating that feedback loop with users. As a result, they can constantly give practical solutions. There are various types of experimenting[2] options available for the product owners. In our solution, we try to find which of these better fit our requirements and find an approach for conducting experiments with the UI elements. The product owner should be able to create various experiments by moving the UI elements and having multiple views for a particular screen.

E.g., from our `Videostreamer app`: As shown in figure 3.5, the experiment model can create different variants for the component `View`: the `Grid view` (on the left) and the `List view` (on the right). These experiments are conducted on the users by dividing the users into groups and assigning one of the variants to a group. This type of setup is called the "`Between-group`" design experiment. Then, the users would be given specific tasks per the `Task Model`, and the measurements will provide feedback to the `Experiment Model`. The data obtained are analyzed (explained in section 3.3.1), and finally, we find the best variant for a product's component.

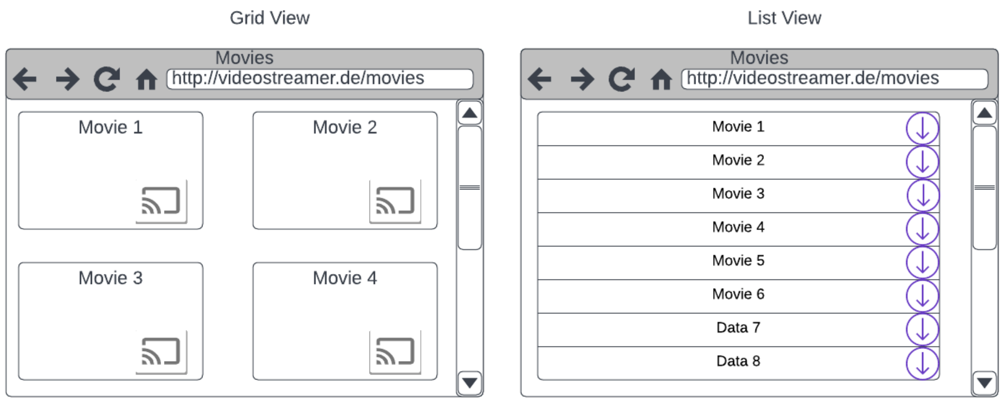


Figure 3.5: Example Experiment variants

[2] A/B Testing: `https://www.hotjar.com/conversion-rate-optimization/glossary/ab-testing/`

3.2 Measure

3.2.1 Prototypes for User Testing

3.2.2 Measuring the Experiment and Task results

3.3 Learn

3.3.1 Analysis

In our solution, we focus on data-driven development. To determine the "Winner" among the variants of a product's component, we perform data analytics on the feedback data we receive from the `Task Model` and the `Experiment Model`. We perform the `Quantitative` (presented in section 3.3.1), `Qualitative` (presented in section 3.3.1), and the `Task` (presented in section 3.3.1) analyses of the data.

Quantitative Analysis: Quantitative analysis uses mathematical and statistical methods to determine the behavior of the data. In quantitative research, various descriptive statistics methods like Means, Median, Variances, Standard Deviations, etc., are used to find some causal relationships in the data.

From the `Experiment Model`, we can calculate the measurements on various product components. (E.g., For the MoviesView component, the measurements could be "Watch time" to measure the duration of time spent by the user on that variant, "Click Rate" to count the clicks, etc.) Then, the experimenting server can calculate the measurements' mean (assume the mean is specified in the experiment). For validation, a significance test can be calculated to determine the probability of the event's occurrence, claim from the mean, and declare the winner variant.

Qualitative Analysis: To further improve, we need to perform qualitative analysis. Qualitative analysis is used to determine the users' behavior and semantics. Qualitative research data is usually unstructured, coming from open-ended surveys, interviews, etc. Our goal is to turn the unstructured data into a detailed description of the critical aspects of the problem. In our solution, we propose to perform a qualitative analysis of the data by asking some open-ended questions to the users (E.g., questions like "What do you think about the Look and feel of the software application?", "Are the items on the page easily locatable?", etc.). The users' responses can be studied using some tools using the inductive or deductive coding technique. So, in the end, we get feedback from this process on which variants are better for the users. This information is forwarded to the models for modifying the prototypes.

Task analysis: We also receive the data from the `Task Model`. Its data can be used to calculate the efficiency of the variant. A task model contains measurements for getting feedback from the users. (E.g., If the task is to locate a particular movie, we can calculate the number of clicks and time required as measurements for the users to reach their destination. This testing type is called “`Supervised testing`” [8]. So, we observe the users, and they know the result (i.e., the movie they need to locate). This process gives us more accurate feedback on which variant performs better, and we can then update the prototype as per our triangle relationship (see fig 3.3).

3.3.2 Improving the Prototype

4 Structure of the Thesis

Please give a general overview on how your thesis is divided into sections and chapters, for example, a table of contents.

Typical thesis could have the following structure:

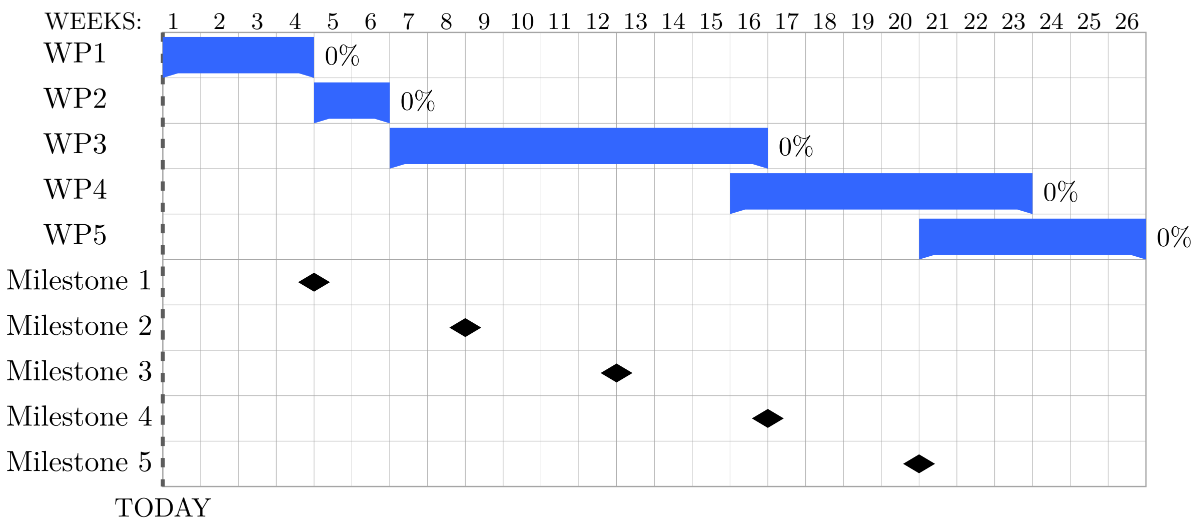
1. Introduction
2. Background
3. Design (design of your approach, it will contain some charts and architecture overview)
4. Implementation (detailed implementation description)
5. Evaluation (test environment, used tools and libraries, evaluation results)
6. Conclusion and Future Work

5 Work Packages and Timeline

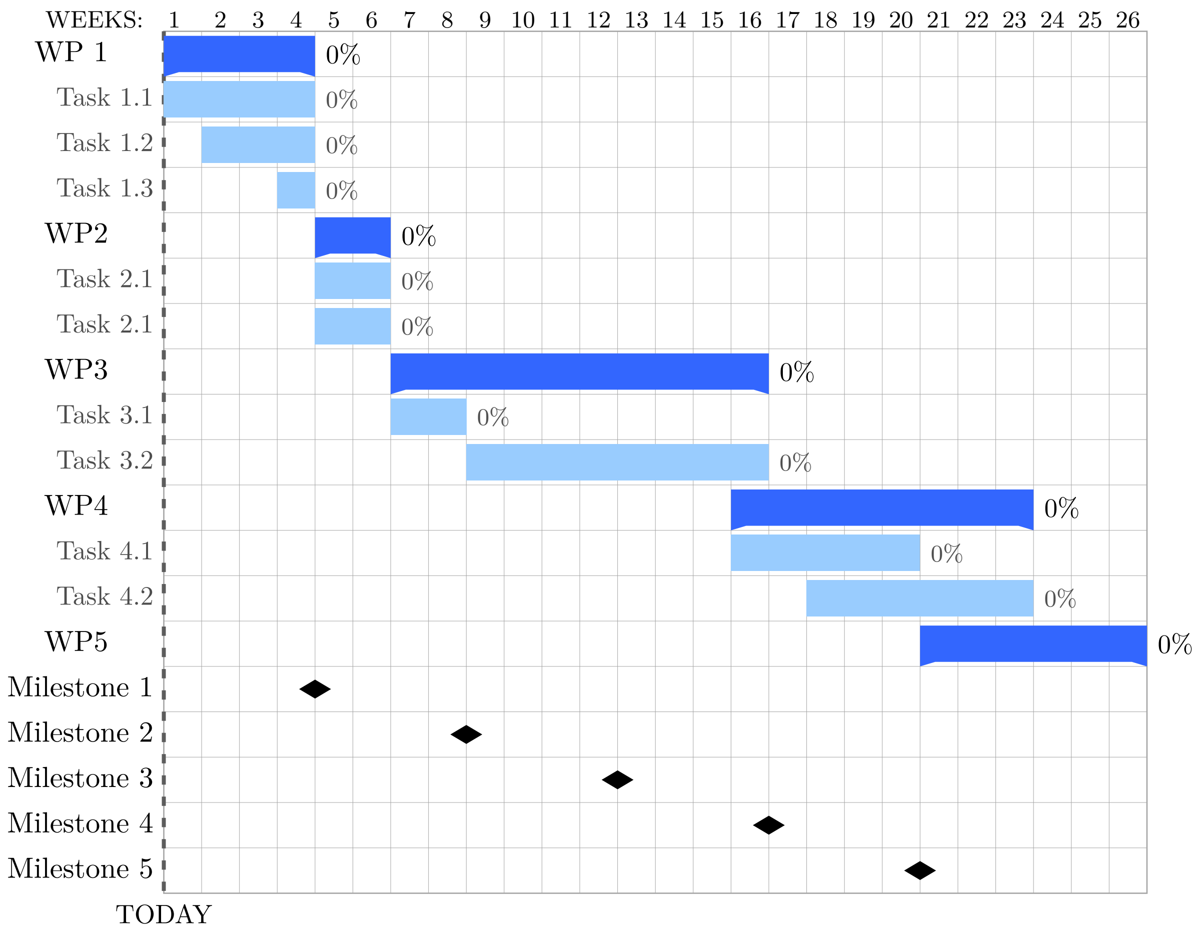
In this section, define work packages and milestones you are going to fulfill in the next months. Afterwards, create a timeline depicting the starting and ending date for each work package and milestone. You can use a nice Gantt chart (see examples below). Proper list of work packages and dates is also enough.

5.1 GanttChart Master Thesis

5.1.1 GanttChart Simple



5.1.2 GanttChart Detailed



Bibliography

[1] Faheem Ahmed, Luiz Fernando Capretz, and Piers Campbell. Evaluating the demand for soft skills in software development. IT Professional, 14(1):44–49, 2012. doi: 10.1109/MITP.2012.7.

[2] Steve Blank. Why the lean start-up changes everything. https://hbr.org/2013/05/why-the-lean-start-up-changes-everything, May 2013.

[3] Jordi Cabot. Positioning of the low-code movement within the field of model-driven engineering. In Proceedings of the 23rd ACM/IEEE International Conference on Model Driven Engineering Languages and Systems: Companion Proceedings, MODELS '20, New York, NY, USA, 2020. Association for Computing Machinery. ISBN 9781450381352. doi: 10.1145/3417990.3420210. URL `https://doi.org/10.1145/3417990.3420210`.

[4] Alan M. Davis. Software prototyping. volume 40 of Advances in Computers, pages 39–63. Elsevier, 1995. doi: https://doi.org/10.1016/S0065-2458(08)60544-6. URL `https://www.sciencedirect.com/science/article/pii/S0065245808605446`.

[5] Aleksander Fabijan, Pavel Dmitriev, Helena Holmström Olsson, and Jan Bosch. The benefits of controlled experimentation at scale. In 2017 43rd Euromicro Conference on Software Engineering and Advanced Applications (SEAA), pages 18–26, 2017. doi: 10.1109/SEAA.2017.47.

[6] Shirley Gregor, Leona Chandra Kruse, and Stefan Seidel. The anatomy of a design principle. 21(6).

[7] G. F. Hoffnagle and W. E. Beregi. Automating the software development process. IBM Systems Journal, 24(2):102–120, 1985. doi: 10.1147/sj.242.0102.

[8] Jasmin Jahić, Thomas Kuhn, Matthias Jung, and Norbert Wehn. Supervised testing of concurrent software in embedded systems. In 2017 International Conference on Embedded Computer Systems: Architectures, Modeling, and Simulation (SAMOS), pages 233–238, 2017. doi: 10.1109/SAMOS.2017.8344633.

[9] Faezeh Khorram, Jean-Marie Mottu, and Gerson Sunyé. Challenges and opportunities in low-code testing. In Proceedings of the 23rd ACM/IEEE International Conference on Model Driven Engineering Languages and Systems: Companion Proceedings, MODELS '20, New York, NY, USA, 2020. Association for

Computing Machinery. ISBN 9781450381352. doi: 10.1145/3417990.3420204. URL `https://doi.org/10.1145/3417990.3420204`.

[10] William L. Kuechler and Vijay K. Vaishnavi. On theory development in design science research: anatomy of a research project. European Journal of Information Systems, 17:489–504, 2008.

[11] Eveliina Lindgren and Jürgen Münch. Raising the odds of success: the current state of experimentation in product development. Information and Software Technology, 77:80–91, September 2016. ISSN 0950-5849. doi: 10.1016/j.infsof.2016.04.008.

[12] L. Luqi and R. Steigerwald. Rapid software prototyping. In Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, volume ii, pages 470–479 vol.2, 1992. doi: 10.1109/HICSS.1992.183261.

[13] Marieke McCloskey. Turn user goals into task scenarios for usability testing. https://www.nngroup.com/articles/task-scenarios-usability-testing/, 2014.

[14] Enes Yigitbas Sebastian Gottschalk, Suffyan Aziz and Gregor Engels. Design principles for a crowd-based prototype validation platform. 2021. doi: 10.1007/978-3-030-91983-2_16.

[15] David J. Teece. Business models, business strategy and innovation. https://asset-pdf.scinapse.io/prod/2140699752/2140699752.pdf.