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Prototyping an Open Digital Platform for Interdisciplinary Energy Research: Opportunities and Challenges

Abstract for the 1. NFDI4Energy Conference 2024

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1. Introduction

Energy systems are changing rapidly and energy research is of fundamental importance to enable and optimize this change with the involvement of scientists, practitioners, and the public. An open digital platform to share knowledge and experiences is crucial to support this interdisciplinary research area. Based on an intensive requirements' analysis [1], a concept for such a platform was developed including five service elements [2] (Figure 1). The *Competence* element enables researchers and developers to present their qualifications and to find suitable project partners. The element *Methods* provides ideas for structuring cooperative energy research and guidelines for platform use. The *Repository* element helps to find available data and frameworks for energy system simulation and optimization. Frameworks and models are coupled via the *Simulation* element. Finally, results and content from the energy community can be published and discussed in the *Transparency* element to reach various stakeholders. Based on this concept, a prototype was implemented for demonstration and validation purposes [3]. The project's team is committed to open science [4]. In this work, lessons learned from implementing the prototype are discussed in terms of opportunities and challenges encountered.

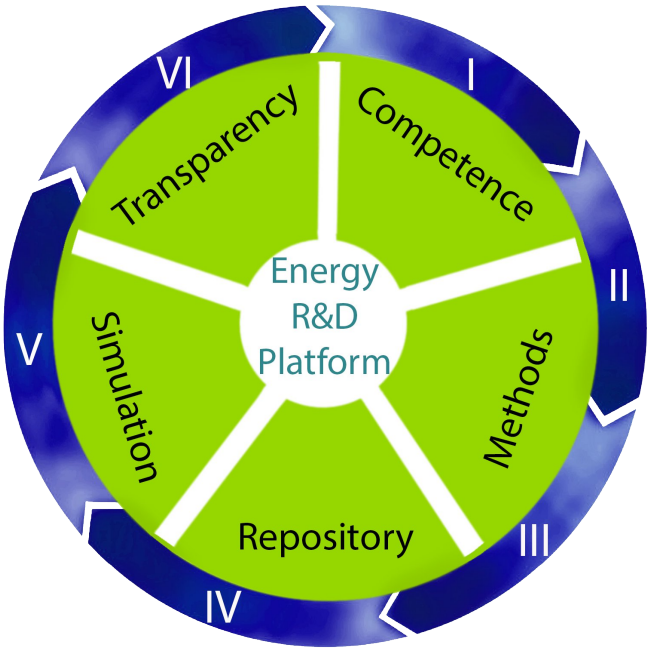

Figure 1. Platform concept overview.

2. Overview of the prototype implementation process

It was decided to use existing frameworks whenever possible. Therefore, *Methods* employs MediaWiki (mediawiki.org) and *Repository* ckan (ckan.org). The remaining elements were implemented using the web framework Django (djangoproject.com). *Competence*'s front end is additionally based on Angular (angular.io) while the others use Django's built-in rendering options. The server architecture in Figure 2 was implemented to coordinate the frameworks. Each element runs in at least one separate Docker container to avoid interferences. The coordination and forwarding of HTTPS requests to the individual containers is done with an NGINX web server. It was further decided that the elements should be hosted as sub-paths (e.g., zle.offis.de/methods) instead of sub-domains (e.g., methods.zle.offis.de). In the prototype phase, it was not possible to implement continuous integration and deployment (CI/CD) procedures. In turn, extensive documentation has been developed to guarantee maintainability and reproducibility [3].

A single user management across all elements was envisioned to enable a consistent user experience of the platform. As the development of the platform was only carried up to a prototype level, this is yet to be implemented. The user management will provide permissions to create, edit, and delete self-created content for registered users. For *Competence*, *Repository*, and the forum of *Transparency*, an identity validation is also beneficial. This could be achieved by using a social identity provider, such as ORCID, Google, or LinkedIn. A potential application that offers these functionalities is Keycloak (keycloak.org).

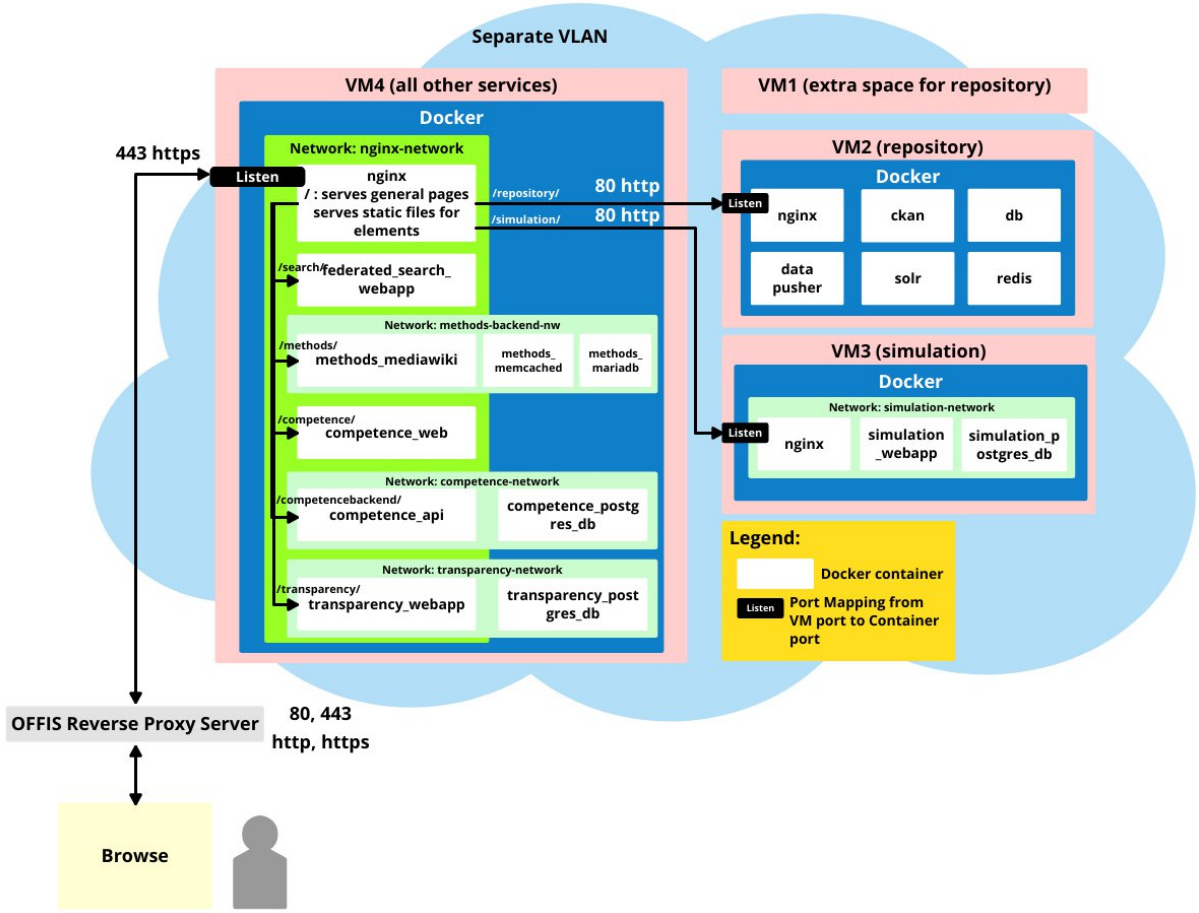

Figure 2. Server architecture of platform prototype.

3. Lessons learned: Opportunities and challenges

First, the implementation process of each element is reflected on, before drawing overall conclusions.

Regarding *Competence*, the use of Angular may have been exaggerated for the current requirements in prototype status. In turn, the creation or availability of a complete test data set greatly facilitated the platform development.

Regarding *Methods*, the set software requirements (free of charge and open source) limited the options of knowledge management tools significantly. Wiki engines were preferred, as they are familiar to use and provide easy interfaces for content creation. Mediawiki was chosen, as it allows to be hosted on a sub-path. Extensive documentation on installation and use with Docker was beneficial. However, the Docker version is not always corresponding to the latest software version. Mediawiki's skins allow an adjustment of the website design. This must be done manually and the changes stored separately, since a re-deployment of the containers requires repeating the adjustment.

Repository had similar issues to *Methods* regarding the differences of software versions available for Docker and as standalone. The Docker version of ckan moved to a completely new structure with little to no notice and the right documentation was not available yet. Additionally, the latest version of a framework might not have the best documentation or compatibility with extensions which hinders the implementation. On a positive note, open source frameworks and tools enable suggesting improvements to the developers and actively participating in the frameworks' improvement.

Implementing *Simulation*, difficulties were encountered due to dependencies on other platform elements, mostly on the models, data, and scenarios of *Repository*. In addition, it was necessary to ensure that the simulation components (models, data, tools) are compatible with each other in order to enable coupling for co-simulation. This involved a modular structure of the simulation models to allow re-usability. A concept to offer *Simulation as a Service* was developed which revealed the importance of defining a uniform application programming interface (API) and that the computing capacity of a standard server configuration is unfit for complex scenarios.

Transparency was structured in a way that allowed code re-usage as much as possible which enabled a fast implementation. *Transparency*'s sub-elements *Article Summaries, Project Summaries, Educational Content,* and *Forum* were all implemented similarly: A list view of all entries, a detail view for each entry, and a create and edit view. Before settling on a self-developed solution, Wordpress was evaluated for potential usage, but offered too little customization possibilities.

Overall, the decision to use differing frameworks for the elements' implementation came with the drawback of higher efforts to provide a continuous user experience. While feasible solutions to coordinate the back end were found (dockerization, forwarding with NGINX, single user management concept), aligning the graphical user interfaces of different frameworks remained challenging. It additionally limited the choice of compatible frameworks. The decision had long lasting effects on the implementation and should, therefore, be evaluated carefully. The initial decision to host elements on sub-paths of one URL instead of individual domains came with several drawbacks that did not outweigh the advantage of hosting only one domain. Therefore, it is recommended to weigh the alternatives carefully. Similarly, the user management concept has to be decided on early to prepare each element accordingly.

In conclusion, the prototype implementation proved to be valuable. The chosen frameworks, server architecture, and lessons learned can inform the development phase of further work. Due to the open science commitment [4], the prototype's source code is also available for further use.

Data availability statement

The source code and documentation are openly available at [3]. Basis of this abstract are the versions with tag "Deliverable_D2.3_Zukunftslabor_Energie_ ZN3488"

Author contributions

Sarah Eckhoff: Writing – original draft, Software. **Luca Manzek**: Writing – original draft, Software. **Annika Ofenloch**: Writing – original draft, Software. **Fernando Penaherrera V.**: Writing – original draft, Software. **Henrik Wagner**: Writing – original draft, Software. **Sarah K. Lier**: Writing – review & editing. **Michael H. Breitner**: Writing – review & editing, Supervision. **Bernd Engel**: Writing – review & editing, Supervision. **Sebastian Lehnhoff**: Writing – review & editing, Supervision. **Astrid Nieße**: Writing – review & editing, Supervision.

Competing interests

The authors declare that they have no competing interests.

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