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Honours Programme, Problem Statement

Enhancing Datacenter Operations through Digital Twinning as a Service

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1 INTRODUCTION

Datacenter infrastructure is a fundamental building block of our society, undergoing a digitization process. Digital data has been the driving force behind many of the recent technological advancements. It is expected that by 2025, 463 exabytes of data will be generated daily. The impact of such growth is reflected in the economic sector, where every €1 invested in the ICT infrastructure generates a notably higher added value of €15 [1]. Stakeholders in detrimental areas of the world, such as government entities, educational institutions and economic organization rely on cloud services to maintain their operations. Even though cloud adoption rates are increasingly high, stakeholders are requiring performance and reliability guarantees from such systems, while also expecting cost-effective solutions.

Designing and operating a datacenter that is both performant and cost-efficient is a challenging task. On one hand, it is essential to manage the trade-off between performance and cost in a way that enables scalability and reliability. On the other hand, energy consumption and the environmental impact of datacenters need to be minimized to ensure sustainability.

The complex problem of designing and operating a datacenter has been proven to be effectively addressed through simulation [2]. Datacenter simulation tools have been created with the sole purpose of providing a reliable way to predict certain parameters of a datacenter's performance, that enable stakeholders to make informed decisions. However, as of right now, simulation tools have not reached a maturity level that would allow them to be used by non-experts in the field of datacenter design and operation. As the industry rapidly evolves, so do the requirements that have to be met by a reliable simulation tools. Therefore, most researchers and developers of such software prefer to focus on the core functionality of the tool, rather than on the user experience.

We have established that datacenter simulation is a necessary method in the process of enhancing the performance and efficiency of datacenters. We analyze through this work the potential of an ICT digital twin as a service, as well as the implications of designing and assessing the usability of such a service.

2 PROBLEM

In this report, we identify and aim to address three main problems in the field of datacenter simulation. Firstly, most datacenter architects do not currently adapt simulation tools in their practice. Thus, we identify **a lack of adaptability of simulation tools** in the field of datacenter design. Secondly, currently available datacenter simulation tools are still under development or have not reached a maturity level to enable them to be used *as a service*. We observe **the need for a reliable and accessible datacenter simulation service** that can be used by non-experts in the field of datacenter design and operation. Finally, operating a simulation service should be scalable for larger datacenter operators and novice users alike. Therefore, we identify **the need for a scalable service**, that can handle both complex operations at a reasonable cost and deliver fast and reliable results.

3 RESEARCH QUESTIONS

By evaluating the problem we conclude that it can be separated into three main research questions.

RQ1 **How to offer a datacenter simulation tool as *Software as a Service*, as well as *Platform as a Service*?**

There is a current lack of adaptability of datacenter simulation tools, mainly due to problems related to accessibility, reliability and scalability. The aim of this research question is to determine the functional and non-functional requirements of a datacenter simulation service. The trade-off between usability and functionality must be carefully analyzed to ensure a reliable and accessible service. We also aim to identify the best practices for offering such a service, as well as the potential challenges that may arise.

RQ2 **How to design the backend for a datacenter simulation service and under what policies?**

In order for a reliable and scalable simulation tool to function properly, a solid foundation must be established. We aim to determine the parameters that quantify the performance of the backend of a datacenter simulation service. Through these parameters, we can determine which policies are best suited for the backend of the tool.

RQ3 **How to evaluate experimentally, through a prototype, that the design of this system actually meets the goals?**

In order for any system to be deemed successful and complete, it must be first be evaluated by experts in its related field. We aim to deliver a prototype of the datacenter simulation service and evaluate it through a series of experiments. The purpose of this research question is to determine the best way to evaluate the system, to ensure that it meets the goals of its stakeholders, on both a functional and non-functional level. Furthermore, the system must deliver reliable results to both small and large-scale datacenter operators.

REFERENCES

[1] A. Iosup, F. Kuipers, A. L. Varbanescu, P. Grosso, A. Trivedi, J. Rellermeyer, L. Wang, A. Uta, and F. Regazzoni. Future computer systems and networking research in the netherlands: A manifesto, 2022.

[2] F. Mastenbroek, G. Andreadis, S. Jounaid, W. Lai, J. Burley, J. Bosch, E. van Eyk, L. Versluis, V. van Beek, and A. Iosup. OpenDC 2.0: Convenient modeling and simulation of emerging technologies in cloud datacenters. In *CCGRID*, 2021.