

Sunfish: Enabling Predictive Analytics for Datacenters Through Digital Twinning

M. Kwiatkowski Ph.D. D. Niewenhuis¹ Prof. Dr. A. Iosup²

¹Daily Supervisor

²Main Supervisor

Vrije Universiteit Amsterdam

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Context

Heterogeneous datacenter architectures are common [8] due to the end of Dennard's scaling [5]. Today, computational needs of AI drive managers to diversify datacenters even more [1]. In result datacenters become extremely complex and hard to operate.

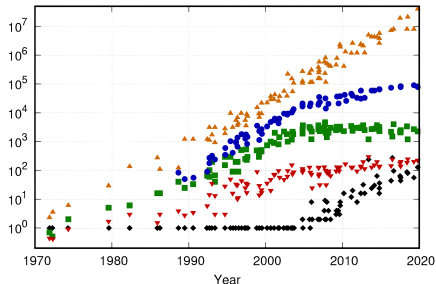


Figure 1.1: 48 years of microprocessor trend data. Legend: ▲ Transistors (thousands), ● Single Thread Performance (SpecINT 10^3), ■ Frequency (MHz), ▼ Typical Power (Watts), ◆ Number of Logical Cores [5].

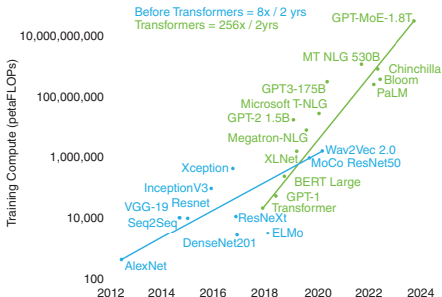


Figure 1.2: Explosive growth in AI computational requirements drives datacenter upgrades (source: NVIDIA Analysis: reproduction with NVIDIA permission by [1]).

We need effective tools to manage datacenters

To address the increasing datacenter complexity, Datacenter Digital Twins (DCDT) were proposed [1]. However, many DCDT's are not useful in practice, because they lack critical features (*e.g.*, predictive analytics) native to the generic Digital Twin definition [9].

Project	Simulation Technique	Focus	Stakeholders	Highlighted Features
ExaDigiT [2]	CFD/HT	Energy Loss Prediction		
SmartDC [13]	CFD/HT, BIM, AI	Heat Modelling		
DyTwin [10]	Gaussian Process Regression, ML	Anomaly Detection		
ChatTwin [7]	?	Configuration Automation		
Reducio [3]	POD	Heat and Airflow Prediction		
NetGraph [4]	Graphs	Network Management		
Kalibre [12]	ML, CFD	Heat Modelling		

Table 1.1: Comparison of selected datacenter digital twins. **Features:** 3D = 3D Visualizations; CH = Cooling/Heat, PE = Power/Energy Consumption, F = Failures, N = Network, FS = FaaS, SE = Scenario Exploration, VP = Virtual Prototyping, FD = Federation; **Tools:** AI = Artificial Intelligence, ML = Machine Learning, ODA = Operational Data Analysis; * = Predictive Analysis; ★ = Descriptive Analysis, ◆ = Prescriptive Analysis.

Main Research Question

How to enable predictive analytics for datacenters through digital twinning?

Research Question 1

How to assess the current state-of-the-art of digital twinning for datacenters?

Research Question 2

How to design a datacenter digital twin reference architecture using discrete-event simulation and predictive data analytics?

Research Question 3

How to evaluate and validate a datacenter digital twin architecture in relation to system requirements?



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Extra Slides: Societal Impact

Why is this research important today?

Over 3 million jobs in the Netherlands directly depend on cloud services, which are hosted in datacenters [6]. Already the rapid expansion of datacenters has increased the presence of service failures across all cloud services [11]. We need to act now.

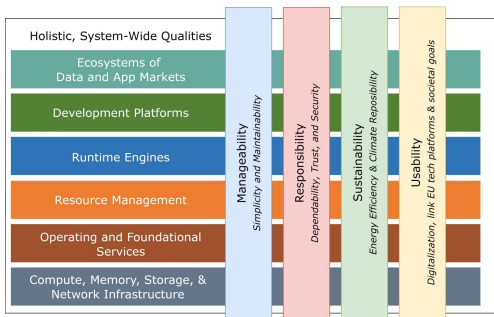


Figure E.1: Horizontally: the most important research areas in computer science in Netherlands. Vertically: qualities we should ensure across all research areas with the most outstanding impact on society. Datacenter manageability is a top-priority [6].

Extra Slides: Why Digital Twinning?