Energy-efficient Hardware Reuse for Sustainable Data Centres

Ismael Samaye, Paul Leloup, Gilles Sassatelli, Abdoulaye Gamatié

Energy-efficient Hardware Reuse for Sustainable Data Centres (Extended Abstract)

Ismael Samaye, Paul Leloup, Gilles Sassatelli, Abdoulaye Gamatié
LIRMM, University of Montpellier - CNRS, Montpellier, France
first.last@lirmm.fr

ABSTRACT

As technologies progress in data centres, older-generation servers are often replaced by more energy-efficient ones. As a result of this trend, the problem of electronic waste is exacerbated. This extended abstract discusses a few recent insights about sustainable data centres. Then, it presents an on-going approach to extend the lifetime of old-generation servers in data centres and reducing the amount of brown energy and water needed for cooling.

CCS CONCEPTS

• **Computer systems organization** → **Architectures**; *Other architectures*; Heterogeneous (hybrid) systems.

KEYWORDS

Sustainability, data centre, system reuse, renewable energy

1 INTRODUCTION

Recent advancements have been made in the field of information technology, particularly in the areas of cloud services that make life more convenient (e.g. the Internet of Things, streaming) and data centres that provide these services. However, this progress is not without consequences, especially for the environment, including an increase in CO_2 emissions as a result of the production of electricity to fill the demand for data centres, which constitute approximately 1 percent of total global energy consumption, as indicated in [7]. In order to meet this energy demand, data centres commonly utilize non-green energy sources that contribute to significant carbon dioxide emissions [8]. The emissions of carbon dioxide from data centres account for 0.3% of the total emissions of CO_2 on the planet.

Additionally, in [6], authors point out that data centre hardware and infrastructure also contribute significantly to the amount of CO_2 released. Besides the emission of CO_2, data centres are also concerned about water stress problems in some regions where they are located [9]. Electronic waste is another issue that contributes to pollution. As a matter of fact, toxic elements can be found in the metals and electronic components extracted from data centre equipment and deposited in the environment. There are two types of equipment included in this category: the data centre infrastructure, which consists of mechanical and electrical components (e.g. transformers, generators, air conditioners, racks, cables), and computing components (e.g. servers). The equipment is periodically replaced to maintain and improve its performance. Generally, infrastructure components are replaced every 10 or 15 years. In contrast, computing components are more frequently changed. A white paper from the SuperMicro Company [2] examines the server renewal cycle in data centres. Various approaches to the management of electronic waste are also discussed. The paper argues that green IT is driven by the replacement of older systems with newer ones that can handle more intensive workloads. In 2020, only 68% of surveyed respondents renewed their servers annually or every 2 to 3 years compared to only 37% in the 2019 survey. For those who keep their servers for six years or more, only 8% reported doing so in 2020, compared to 23% in the 2019 survey. For organizations that refresh very frequently, about every year, 7% did so in the 2019 survey, but this number increased significantly to 26% in the 2020 survey. This enthusiasm for new, more energy- and workload-efficient systems is a trap. As people will want to use such a system, this will lead to an increase in the frequency of replacement, which means an increase in the amount of e-waste and also in the pollution caused by mineral extraction and manufacturing of servers.

Regarding the e-waste issue, various approaches are surveyed in [2], as shown in Figure 1. One can observe an increase in the efforts to mitigate the e-waste issue in 2020 compared to 2019.

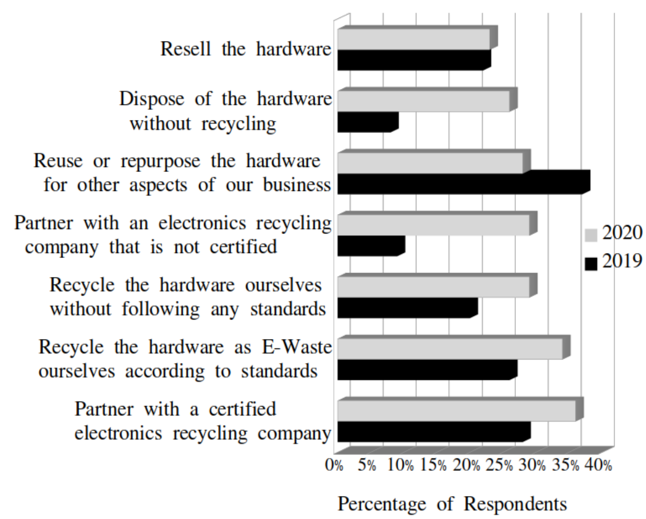

Figure 1: E-waste plans 2019 and 2020 surveys [2]

To build green data centres, authors in [10] suggest the reduction of CO_2 emission during the data centre construction and operational phases while taking into account server lifetime. In a recent study [1], the authors addressed the issue of electronic waste issue from a different perspective. Instead of replacing the whole servers for upgrading the compute infrastructure, they advocate renewing only some components within servers, thus reducing the electronic waste. Then, they also propose an approach to renewing servers in data centres by upgrading servers that have been in use for five to six years, thereby extending the life of the servers and reducing the amount of electronic waste dumped in nature. Despite the fact that this approach reduces the amount of electronic waste, some electronic waste is still emitted due to the replacement of certain components. We also have to take into account the possibility of errors in the calculations due to the fact that some of the server components are old.

Similarly to [1], we aim at reducing electronic waste due to data centres. In our approach, it is strongly advised that old-generation servers be moved to companion data centre infrastructures using mostly renewable energy, thereby mitigating the energy efficiency penalty caused by their age.

2 OUR PROPOSAL FOR HARDWARE REUSE

Different strategies can be used to increase energy efficiency in data centres: one is to increase the computing performance of the data centre while maintaining (or, even better, decreasing) its power consumption; another is to maintain the data centre's computing performance while reducing its energy consumption.

Here, to achieve energy efficiency, we advocate a novel computing concept, referred to as Genesis, recently implemented in a demonstrator [3] [4] [5]. As illustrated in Figure 2, Genesis is a companion mini data centre typically deployed on the roof of the building that hosts servers and energy harvesting and storage facilities. Genesis is composed of modules or nodes that are interconnected. The nodes can exchange energy and computational data (e.g. virtual machines). A node is comprised of a solar panel, a battery, a server, and a local control system. In the event that a node lacks enough energy in its battery to execute a workload, it can request energy from another node. Or, it can send the workload to a node with sufficient energy. Local controllers are responsible for this energy exchange.

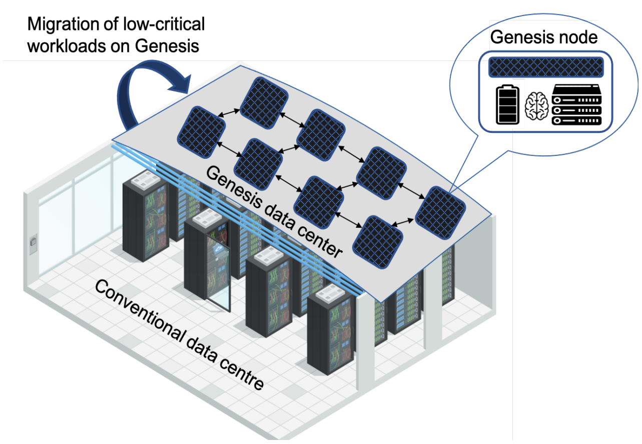

Figure 2: Integration of Genesis with conventional data centre for sustainable compute infrastructure (illustration partly based on macrovector / Freepik –https://fr.freepik.com/vecteurs-libre/composition-interieure-isometrique-du-cloud-computing-server-datacenter_4027518.htm)

The essence of our solution is to migrate non-urgent or non-critical workloads (e.g. workloads with low quality of service requirements) from indoor data centres to an outdoor Genesis data centre. The migrated workloads are therefore executed on servers that have been repurposed by Genesis and powered by free solar energy.

By extending the use of old-generation servers, the approach directly reduces e-waste. Moreover, the energy efficiency issue related to old-generation servers is mitigated by only leveraging clean renewable energy. In particular, it eliminates the amount of energy required for cooling indoor servers since Genesis is deployed outdoors to benefit from ambient cooling. As a result, this reduces the carbon footprint and water stress on the environment associated with conventional data centres.

We evaluated the potential of our proposed approach by integrating two typical old-generation servers into the Genesis prototype: a server fitted with an Intel Xeon processor E5-1620 v2 with 10M cache and operating at 3.70 GHz, and a less powerful Dell PowerEdge T20 server. The former server was used six years ago in the world-class supercomputer hosted by CINES in Montpellier, France (https://www.cines.fr/en). The latter belongs to an old generation of Dell servers. The benchmarked configuration of Genesis comprises a 2 KWh battery and 300 W solar panel per node.

Given the above configurations, a node integrating the most powerful server can run for 10h and 6.5h at 50% and 100% CPU stress levels respectively, by only using its associated battery budget. When considering the less powerful Dell server option, a node can run for 27 h and 19 h at 50% and 100% stress levels respectively. Note that under favorable solar irradiation conditions, an empty node battery can be completely filled with energy within about 18 h, using a single solar panel.

Based on the above compute capacity, Genesis should be able to perform some workloads in conventional data centres while providing better sustainability.

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