# Shifting techniques and multi-platform services for carbon efficiency

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## Abstract

The impact of IT on climate change is growing rapidly. We aim to develop a data model that evaluates the carbon footprint of digital services, along with a visualization tool to inform users. Besides, we intend to propose new services to reduce carbon emissions when computing workload, adapting the moment, the location or with leaner processing.

## Introduction

The development of powerful, scalable, and accessible computing and storing resources increase significantly the number of companies using computing environments. At the same time, the development of new technologies and the penetration rate of mobile devices and wireless technology such as 4G/5G cause an explosion of data computed and stored by users all over the world. It leads to huge environmental problems as the Information and Communication Technology (IT) sector is increasing its Greenhouse Gases (GHG) emissions. It has been evaluated to contribute to the climate change by emitting 1.8-3.9% of the global carbon emissions [1].

The work done in the last decades to improve the efficiency is not sufficient to compensate the increase in the usage. It is called the rebound effect when the impact is raised instead of being reduced because the efficiency is countervail by new usages. We need also to include the user in the process, implying sufficiency techniques, which are every technique that directly or indirectly decreases the absolute level of resource and energy demand from the production of application of IT [3].

Nowadays, we have tools to calculate and estimate the cost of execution and the impact of using a service on a CPU, as well as the cost of storing and transferring data [2, 4]. We observe also that the demand for access to data is strongly correlated with the geographical origin of requests, their number and the storage locations. Techniques based on the migration of VMs, tasks or micro-services to the edge or via local consolidation offer the possibility of moving the processing and the services providing the data to other locations. Data management strategies can also be applied to save energy, bringing the data closer to the processing to reduce the latency when accessing the data and to increase privacy.

Our work tackles a relevant problem, concerns multiple fields (hardware, software, data management, energy, visualization, etc.) and will require tackling significant challenges. Beside, we see visualization as more "communication" oriented in order to help to involve people in general such as Information System decision-makers responsible to get, evaluate and communicate on the energy consumed/saved.

## Objectives

We aim to propose an answer for the 3 following research questions:

*RQ1*: How can we evaluate carbon emissions of digital services?

*RQ2*: How can shifting techniques been applied in order to reduce carbon emissions?

*RQ3*: How can we communicate about the carbon footprint of digital services and involve people?

We plan to obtain a prototype answering the *RQ1* that will be available to really enable data and service migration in order to reduce the carbon footprint. We will evaluate existing (and propose new) shifting techniques implementation for cloud providers for the *RQ2*. And, finally, for the *RQ3* we will propose a prototype implementing a visualization useful for decision-makers or communication services. Besides, an expected additional byproduct of our research could be the obtention of a dataset related to carbon emission.

## Methodology

To determine relevant software deployments, it is necessary on the one hand to collect data about the resources available on different platforms, but also to forecast usage and more energy-related metrics such as carbon intensity or electricity price using time series prediction.

The collected data are very heterogeneous. It can concern hardware, network usages, usage, locality, dynamicity, etc. In particular, the heterogeneity of devices today and their various hardware architectures make monitoring and collecting accurate energy data, and in real time, very challenging. Some data are more or less easily collected whereas others have to be computed, evaluated, or extrapolated. For instance, not all equipment provides sensors to collect energy data, or models to estimate their usage.

The data model will help us in collecting, storing and analyzing data correctly with some contextual additional information. It will also be a base for future works that need an important source of real data gathering.

For shifting techniques, we can already observe a lot of techniques in the literature, covering migration of workload or data in space, time or even finding alternatives that consume less energy or memory to compute a similar workload demand. They answer objectives depending on the use case. We are currently working on a prototype with a simulator to find which technique can be useful for a given scenario, and evaluate the impact of using that technique considering different metrics in order to obtain the best trade-offs to develop energy-efficient services while keeping a good Quality of Service.

## Conclusion

The carbon footprint of the IT sector is growing rapidly when we need a degrowth in every sector to mitigate climate change. Even with a lot of work done to improve the energy efficiency and to increase the knowledge of the impact of IT on the world, almost every IT department do not measure their GHG emissions, nor define goals to reach zero-carbon emissions in the next decades. Our work will propose a model to evaluate the footprint of digital services, and suggest some techniques for cloud providers and users to reduce the carbon footprint of the IT sector and reach net-zero emissions as soon as possible.

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