SlowTech LIFE project: second-hand computing devices under intermittent energy supply

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1 Introduction

At present, parts of natural sciences (e.g. climate science) that help us understand the planetary limits and act inside them are computational sciences (e.g. climate science uses climate models which are computationally demanding). Those computations are done by micro-electronic devices (computers). However, these devices have an ecological impact, at manufacturing [2], use [7], and disposal [3] phases. While reducing the use phase impacts mostly amounts to energy efficiency, reducing the manufacturing and disposal impacts (water consumption, land use, pollution, mineral resources) is a much more complex challenge.

At the same time, due to different obsolescence mechanisms, a non-negligible proportion of computing devices (most notably end-of-life devices) are either trashed or stored without any use even if they are in perfect working condition. For example, the working place of the authors (university Paris-Est Créteil) is an urban mine [8] [1] of computing devices (switching from Microsoft's Windows 10 to Windows 11 on a fleet of 1,500 machines will mean having to dispose of around 10% of the fleet, i.e. 150 machines).

2 Cluster LIFE

In this context, we propose the LIFE [2] approach, which consists in building a cluster. This cluster is made up of end-of-life (from the user's point of view for personal devices and in terms of financial amortization for the university's devices) heterogeneous devices (personal computers, smartphones, network devices, rack-mounted servers...) recovered from the university's IT services, staff and students, to be used for scientific computing tasks. The cluster will be powered by an intermittent energy source, in this case solar panels, with energy storage elements. As a result, the LIFE cluster will operate itself intermittently, depending on the energy available in storage.

Previous work on computing clusters with smartphones focus either on a homogeneous set of machines [5], or on software solutions with a high level of abstraction [1], resulting in unsatisfactory memory consumption and computing performance. Moreover, practical experiments at this stage are limited to a dozen or so machines [5].

For the sake of efficiency, we are not using a virtualized architecture for the entire cluster, especially on smartphones with limited memory resources. The cluster's middleware has to meet a number of constraints, all of which, to the best of our knowledge, are unprecedented.

1. We will address our view of urban mining and its application to universities in a future work. Indeed, current work on this concept only considers the recycling aspect of collected resources. We believe that the concept should be extended to electronic devices, whose parts can be collected and used either as is or as high-grade parts for computer repair. In the case of electronic equipment, material recycling does not recover enough rare and precious metals to make it worthwhile [6].

2. LIFE stands as a french acronym for *Longévité Informatique et Frugalité Énergétique* meaning roughly *Computer Longevity and Energy Frugality.*

The machines in the cluster have different hardware architectures, and in particular different instruction sets. While the rack-mounted servers and personal computers all have x86_64 CPUs, the recovered smartphones have either armv7 (32-bit ARM) or AARCH64 (64-bit ARM) CPUs. Managing these different instruction sets, as well as different individual performances, under energy constraints that may involve not running some calculations or switching off some nodes requires the development of specific middleware for task scheduling as well as computing node management and orchestrating task distribution and snapshots to anticipate nearly drained batteries.

3 Perspectives

Beyond questions of computational and environmental performance measurement, the LIFE cluster paves the way for social science work on governance issues. Like Wikipedia and OpenStreetMap, which constitute informational *commons*, the LIFE cluster will be considered as a university's computational common. Like all commons [4], the questions of who can access the cluster, the management of limited computational resources, and the governance of the cluster, are present. Also, from the viewpoint of maintaining the cluster's usability, some user self-organizing maintenance, rather than going through a specialized support service, is an open avenue that deserves further exploration.

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