General-Purpose Long-Lasting Computing Platform

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***Abstract*—This paper presents the Olonys computing platform. With its robust nested architecture design, it provides stability throughout implementations to open up longevity in software. This core technology is embedded within Micr'Olonys, a solution that makes long-term passive digital archiving possible on durable optical media such as paper and film. The approach introduces the concept of "potential computing" that improves the longevity and sustainability of software and digital data retention.**

***Keywords*—behavior change, low-power electronics, sustainable digital infrastructure, permacomputing, software-on-paper**

I. Introduction

Longevity in computing, and particularly in the software realm, is an oxymoron. Indeed, software execution typically depends on a complex environment, whose nature is itself software (e.g. operating system, libraries, firmware, networked services) and ultimately hardware (e.g. processor, memory, peripheral devices, network infrastructure). Computing environments are usually rapidly evolving, as new and improved features are implemented and bugs are corrected, with very few exceptions such as the 60-year-old System/360 architecture and its successors to this day, at the cost of uninterrupted support from IBM.

The Eupalia company based in Hyères, France, has undertaken for over two decades to tackle the challenge of designing long-lasting computing technologies, to address software and file format obsolescence, with its technology called Olonys. The goal is to achieve passive longevity, i.e., one that does not require any active maintenance, be it of software or hardware.

II. The Olonys Platform

Olonys is a computing platform designed for both hardware and virtual implementations, and to expose the least possible adherence to external particular features. Its fundamental approach is to decouple software from hardware by turning as much computing hardware complexity as possible into software, and to provide adaptive mechanisms to access peripheral devices. It is in line with the concept of permacomputing [1].

Olonys features a nested processor architecture, comprising 5 sub-processor layers of increasing complexity and efficiency, all with register-based Instruction Set Architectures (ISAs), from a processor operating with only two instruction types (namely "subtract with borrow" and "store"), up to a full-featured, extensible ISA similar to that of the RISC-V or ARM processors, and that may possibly be replaced altogether with a different ISA as the evolutions of computing make necessary. Implementation of the latter layer may rely on the implementation of any of the 5 layers, offering a variety of trade-offs between execution speed and the effort required for its development, or its robustness to harsh conditions (including limited available energy) as a hardware implementation. In particular, the ISAs of the three more complex layers are optimized for dynamic recompilation. Conversely, user software may directly target any of the simpler layers to operate in a more lightweight computing environment, better suited to the most constrained embedded applications.

The basic Olonys layer (called $^{Lin'}$Olonys^{URisc}) is so simple that introducing a non-obvious bug in its implementation is next to impossible, thus providing utmost stability. This guarantees that the execution environment supporting the whole software stack is extremely robust to variations in the underlying environment, especially over extended periods of time when knowledge fades away. I.e., all software running within the Olonys environment will continue to work in exactly the same way over platforms and through time. This basic layer, comprising virtual processor and minimal peripheral device abstraction, can be implemented in typically half a kilobyte of native code. Such minimal computer architectures have been researched since the 1950s [2], although with limited application.

With the three simpler layers already fully specified and implemented, work is ongoing to complete the specifications of the two more complex ones, and to evaluate which compiler and operating system would be most suitable for feature-rich user applications, with support from the EC through the LEVIATAD Euroclusters project[1].

One important aspect pursued for the most complex layer is specification completeness, i.e., excluding any unspecified state that could cause variations in software behavior across implementations. More generally along this principle, the stability that the Olonys architecture offers is meant in particular as a bedrock foundation for software (or computational) reproducibility.

III. The Micr'Olonys Solution and Discussion

A partial implementation of the Olonys technology is already integrated within a century-scale digital archiving solution on durable optical carriers (namely paper and film) that was tested extensively since 2020 by Andra [3] [4], the French national radioactive waste management agency. This solution, called Micr'Olonys, includes a self-contained primer that bootstraps the Olonys environment to run software that decodes custom 2D barcodes containing user data, complete with decompression and Reed-Solomon error correction.

Compared to analog information, documents become increasingly complex in digital form (e.g. 3D models, linked data, interactive content), making their long-term preservation a challenging endeavor in digital environments whose only constant is quick obsolescence of hardware, software and storage media.

On storage media with proven multi-century durability guaranteed by international standards, namely permanent paper defined by ISO 9706 and LE-500 rated microfilm that conforms to a set of ANSI and ISO standards, the Micr'Olonys primer acts as a "Rosetta Stone" to decipher the digital content stored passively on these media. Similar approaches typically rely on a much more complex virtual environment, e.g. the Immortal Virtual Machine [5].

The integral "passive digital archiving" strategy that stems from the combination of durable media and Micr'Olonys contrasts with the currently mainstream "active digital preservation" strategy that implies permanent monitoring and maintenance of the digital content and storage, a strategy governed by the OAIS international standard (Open Archival Information System – ISO 14721). While OAIS-based digital preservation systems rely on computer systems in operation able to deliver continued online or nearline access, the primer embedded into Micr'Olonys archival documents only contains a "potential computing" system that must be actually implemented prior to performing as a key to access the archived digital material. By eliminating the need for active computing components during long-term digital information retention, potential computing and passive digital archiving contribute to reducing the ecological footprint of digital preservation, only consuming marginal energy, even if higher than usual, at access time.

For the time being, the Micr'Olonys firmware does not support the conversion of any specific file format to a form any future user may readily interpret, beyond the built-in compression whose performance lies between that of Zip and 7-Zip. This currently limits applicability of the solution to simple data formats such as UTF-8 text, plain bitmap graphics and waveform audio files. Formats based on international standards such as PDF/A or JPEG XL may also be considered. Built-in conversion from complex formats to easily-interpretable plain digital representation is planned for future developments.

IV. Conclusion

The Olonys platform, and its application Micr'Olonys for passive digital archiving, contribute to durable computing, in the sense of both longevity and more sustainable use of resources. Indeed, deferring physical implementation until when the system is actually needed, if it ever is, effectively reduces resource-hungry computing system production and operation. This potential computing approach (similarly to potential energy in physics) makes software and digital content immune from obsolescence and enables computational reproducibility.

References

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