

Computer scientists tackle annual waste of 1.5 billion junked smartphones

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Credit: Pixabay/CC0 Public Domain

From a pristinely packaged device on a box-store shelf to a beat-up and

abandoned phone stripped of its SIM card, a smartphone's journey from indispensable to deactivated is remarkably brief.

In a peer-reviewed paper presented at the 28th ACM International Conference on Architectural Support for Programming Languages and Operating Systems in March, computer scientists from the University of California San Diego Jacobs School of Engineering say that most smartphones are decommissioned 2.5 years after purchase. That's the average length of time consumers keep their phones before depleted [battery life](#), a broken screen, obsolete software or the release of a new model motivates them to shop for a replacement.

With 1.5 billion [smart phones](#) sold annually, it's estimated that nearly as many are deactivated within that same time frame. The end-of-the-line for many of these outmoded smartphones is a junk drawer or a storage box in the garage.

But while these devices languish out-of-sight, out-of-mind, their processors could run faultlessly for more than 10 years. That means smartphones are routinely retired after expending just 25% of their functional lifespan.

This truncated lifespan begs the question: can smartphones be given a second life? If so, a second and more perplexing question must be considered, too: how can smartphones be repurposed without doing more [environmental harm](#) than good?

These are the issues researchers from UC San Diego's Department of Computer Science and Engineering (CSE) are tackling. Ph.D. student and first author Jennifer Switzer, along with her co-authors CSE professors Ryan Kastner and Pat Pannuto and Ph.D. student Gabriel Marcano, has proposed a promising strategy to target [smartphone](#) waste in the paper [Junkyard Computing: Repurposing Discarded Smartphones](#)

[to Minimize Carbon.](#)

"It takes a spectacular amount of energy to manufacture modern, high-performance computer technology. The paper explores how to make computing more sustainable by finding new uses for devices society has already paid the carbon cost to manufacture," said Pannuto.

The high carbon cost of recycling phones

For many years, the Environmental Protection Agency (EPA) has encouraged consumers to recycle their deactivated smartphones. Their data suggests that for every million smartphones recycled, more than 35,000 pounds of copper can be recovered along with smaller amounts of silver, gold and palladium. These and other raw materials can be used to produce new consumer goods such as automotive parts, jewelry, garden furniture and batteries.

The challenge is that one pocket-sized smartphone has already left a sizable carbon footprint. Recycling the phone leaves another. The process involves extracting [raw materials](#) from the [phone](#), manufacturing new products and transporting them to consumers. Collectively, these steps burn fossil fuels and run the risk of harming air and water quality as well as sensitive ecosystems.

In contrast to the EPA's e-waste recycling plan, Switzer and her co-authors hope to resurrect billions of discarded smartphones and redeploy them as working processors. Their approach avoids a carbon intensive manufacturing process while conceivably harnessing the unspent 75% of a smartphone processor's lifespan.

Maximizing the lifespan of smartphone processors

Switzer's innovative study considers the practicality and environmental benefits of reusing processors (even from decade-old devices) for non-consumer applications, specifically as cloudlets for microservices for social media websites and as wildlife monitoring sensors. It also explores how to combine phones to perform increasingly complex tasks.

Along with these technical considerations, the paper addresses how to make computing more sustainable, offering a metric, Computational Carbon Intensity (CCI), to enable quantified comparison of the true lifetime impact of computing. The research suggests that junkyard computers can grow global computing capacity while simultaneously supplanting the manufacture of new devices.

The team applied CCI to old servers, laptops and smartphones and found that smartphones offer the best potential for carbon impact. Not only are there a remarkably large number of discarded phones available, but they come with a wide array of valuable components, including a robust power supply, networking hardware and, of course, powerful processors with plenty of utility remaining.

"For devices with shorter lifespans, such as smartphones, 80% or more of the lifetime carbon footprint comes from the energy expended to make the device, not the energy it used while it ran," said Pannuto. "How many old phones, laptops, and desktops are gathering dust? Let's see if we can find a useful [second life](#) for them!"

Earlier this year, Switzer and her co-authors earned a Distinguished Paper Award at the 2023 Architectural Support for Programming Languages and Operating Systems (ASPLOS) conference, the premier forum for interdisciplinary systems research. Since then, their paper has had over 50,000 downloads, a record in the conference's 28-year history.

More information: Jennifer Switzer et al, Junkyard Computing:

Repurposing Discarded Smartphones to Minimize Carbon, *Proceedings of the 28th ACM International Conference on Architectural Support for Programming Languages and Operating Systems, Volume 2* (2023). [DOI: 10.1145/3575693.3575710](https://doi.org/10.1145/3575693.3575710)

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