Very Large Scale Disintegration

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Cornell & Google

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computing’s carbon footprint

Carbon footprint papers at ASPLOS 2023

Ecovisor: A Virtual Energy System for Carbon-Efficient Applications

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ABSTRACT

Cloud platforms' rapid growth is raising significant concerns about their carbon emissions. To reduce carbon emissions, future cloud

for Carbon-Effi
tional Conferenc
Operating Syste
BC, Canada. ACM

Carbon Explorer: A Holistic Framework for Designing Carbon Aware Datacenters

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ACT

companies reduce their datacenters' carbon footprint
in renewable energy generation and receiving credits
purchase agreements. Annually, datacenters offset their
umption with generation credits (Net Zero). But hourly,
often consume carbon-intensive energy from the grid
n-free energy is scarce. Relying on intermittent renew-
n every hour (24/7) requires a mix of renewable energy
mentary sources

Support for Programming Languages and Operating Systems, Volume 2 (ASPLOS '23), March 25–29, 2023, Vancouver, BC, Canada. ACM, New York, NY, USA, 15 pages. https://doi.org/10.1145/3575693.3575754

1 INTRODUCTION

Carbon-free energy is essential f

Junkyard Computing: Repurposing Discarded Smartphones to Minimize Carbon

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ABSTRACT

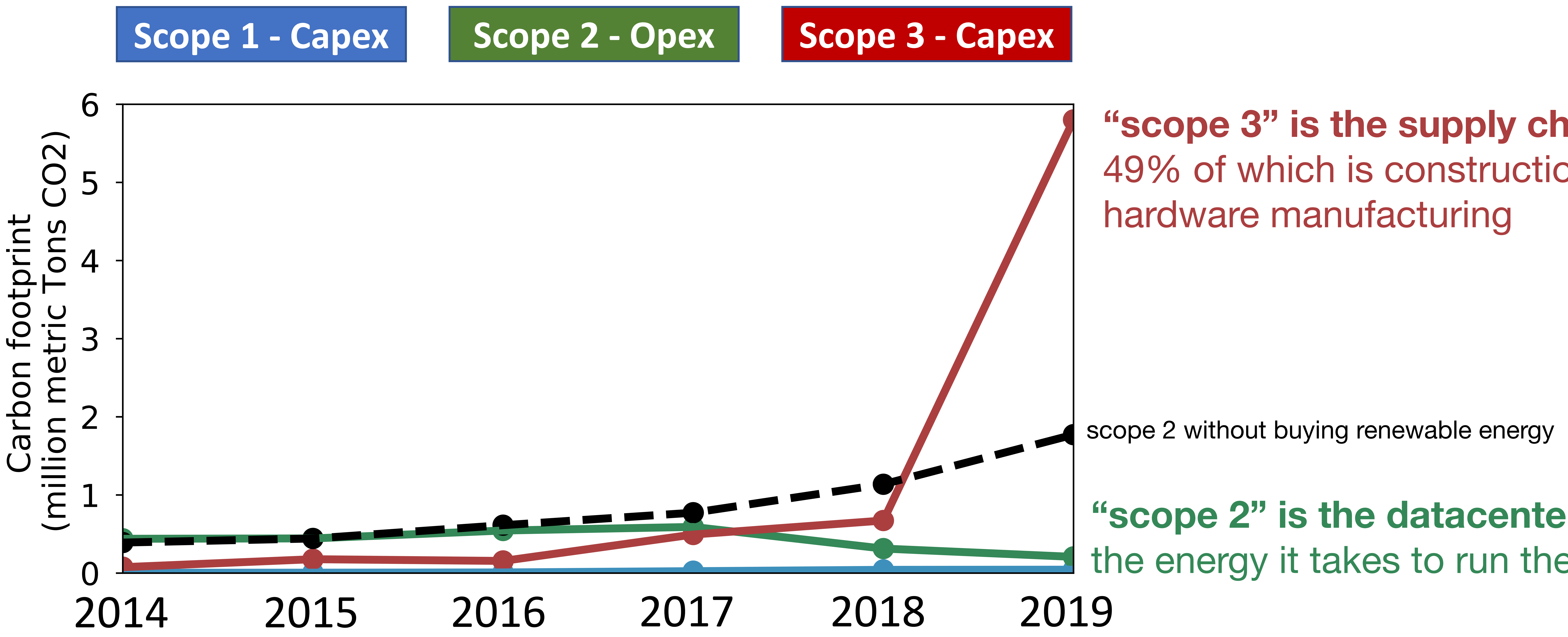
1.5 billion smartphones are sold annually, and most are decommissioned less than two years later. Most of these unwanted smartphones are neither discarded nor recycled but languish in junk drawers and storage units. This computational stockpile represents a substantial wasted potential: modern smartphones have increasingly performant and energy-efficient processors, extensive networking capabilities, and reliable built-in power supplies. This project studies the ability to repurpose these unwanted smartphones as "junkyard computers." Junkyard computers grow global compute capacity by extending device lifetimes, and save carbon by supplanting the manufacture of new devices. We show that the capabilities of even decade-old smartphones are within those demanded by modern cloud microservices, and discuss how to combine phones to perform increasingly complex tasks. We describe
... operation-focused metrics do not capture the actual ... address this, we propose Computa... balances the

1 INTRODUCTION

Manufacturing electronic devices is an energy-intensive proce
For devices with lower utilization, such as consumer-class el
tronics or over-provisioned servers, manufacturing dominates t
lifetime carbon footprint [17]. This is especially true in devices w
short use cycles. In the United States alone, 150 million smartpho
are discarded each year, amounting to one phone discarded per
son every two years [8]. As a result, manufacturing account
70 – 85% of the lifetime carbon footprint of a smartphone [17

Consumer electronics are also becoming increasingly powe
the performance of recent smartphones rivals or exceeds tha
Intel Core-i3 processor (Figure 1). Yet, phones are often disc
despite being completely (or partially) operational. Otherwis
tional electronic devices are retired prematurely due to te
style, or planned obsolescence [33]. Compare this to othe
priced devices with entire ecosystems of functional obsol
e.g., cars, which are resold until they are "driven into the
Of course, the performance of computing devices impro
faster than that of a modern automobile. What should th
? Should we also run every electron

Facebook's datacenter carbon footprint over time



"scope 3" is the supply chain, 49% of which is construction & hardware manufacturing

"scope 2" is the datacenter power, the energy it takes to run the machines

Figure from *Chasing Carbon,* Gupta, Kim, Lee, Tse, Lee, Wei, Brooks, and Wu; HPCA 2021

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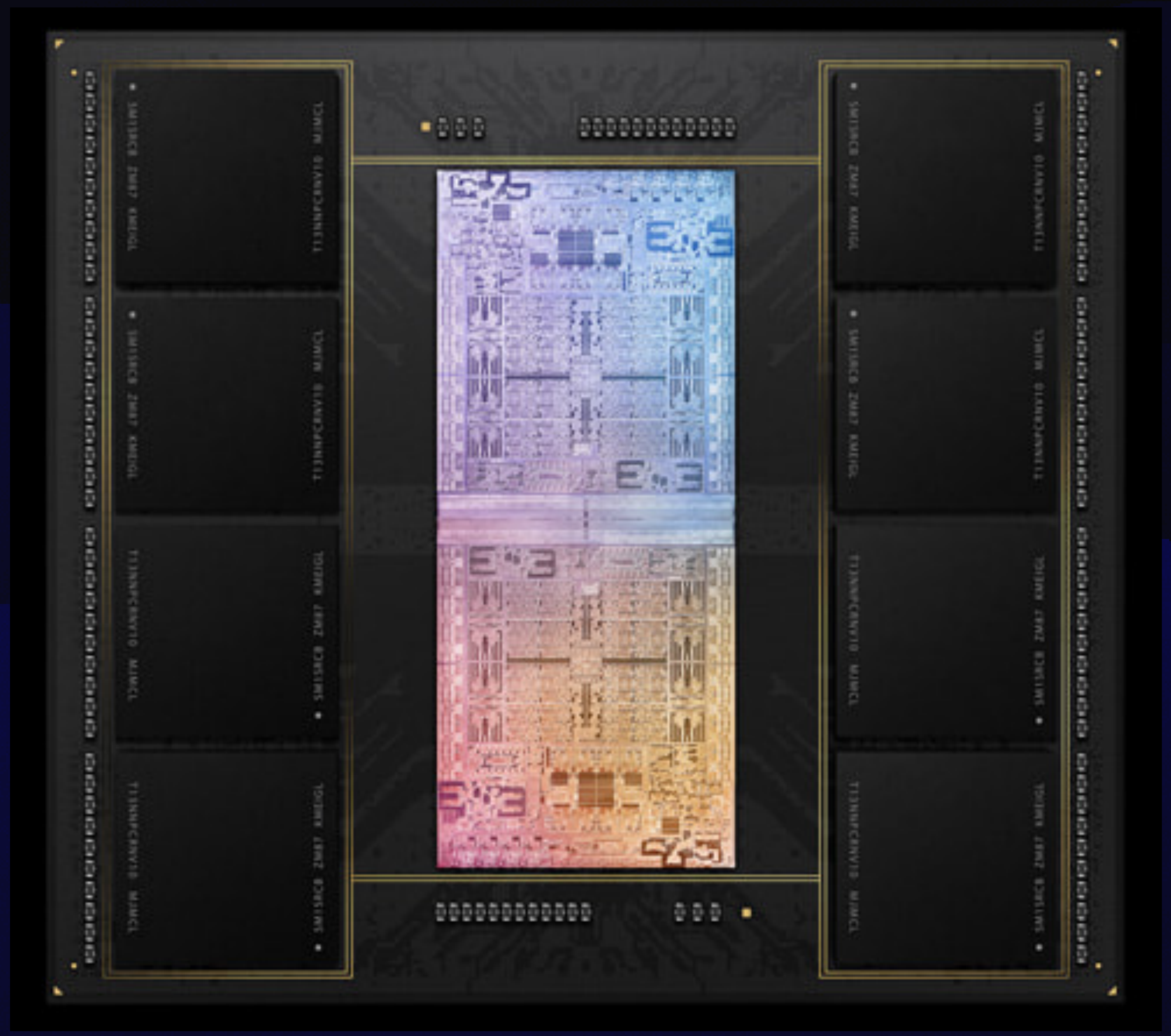
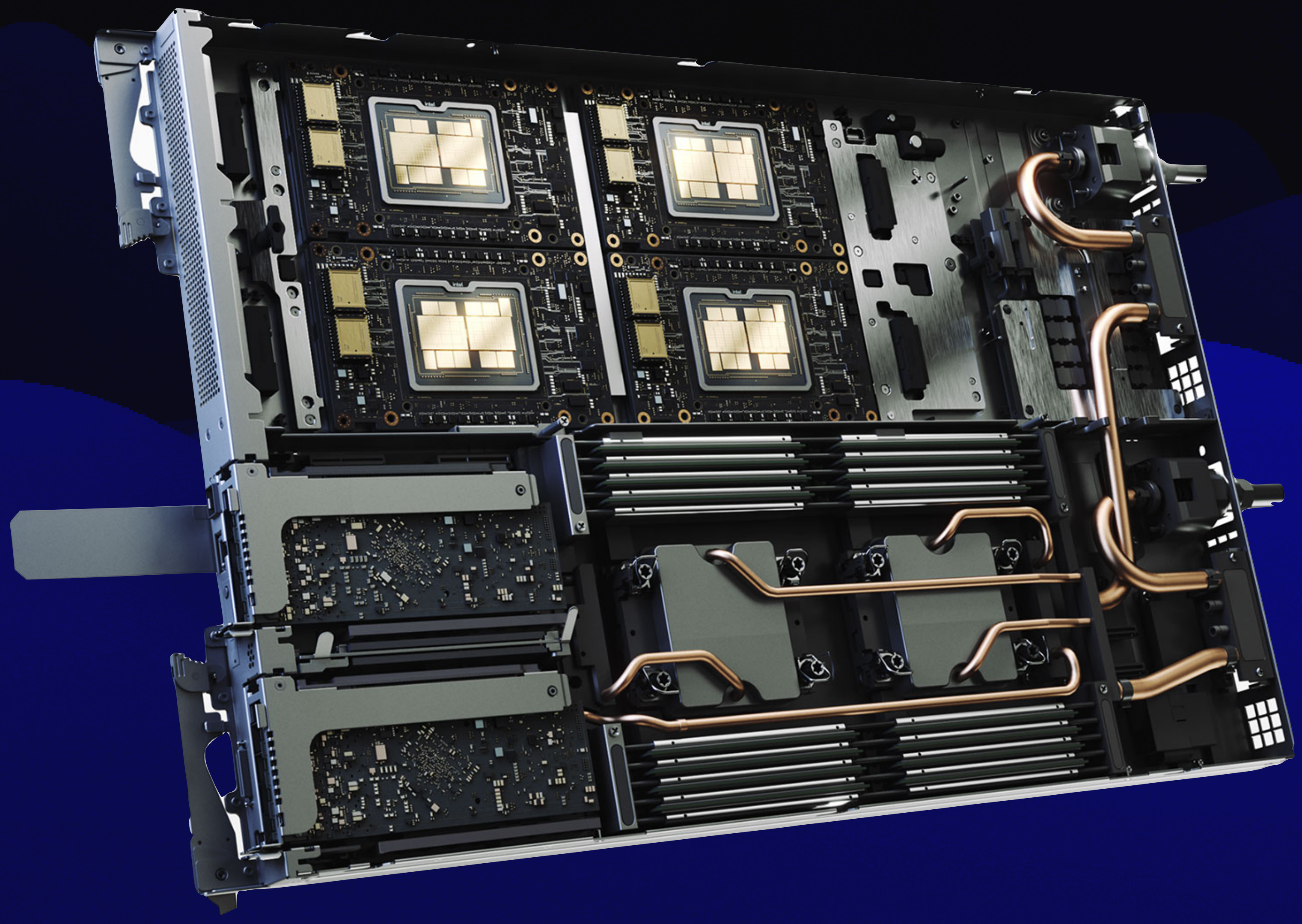
the chiplet revolution



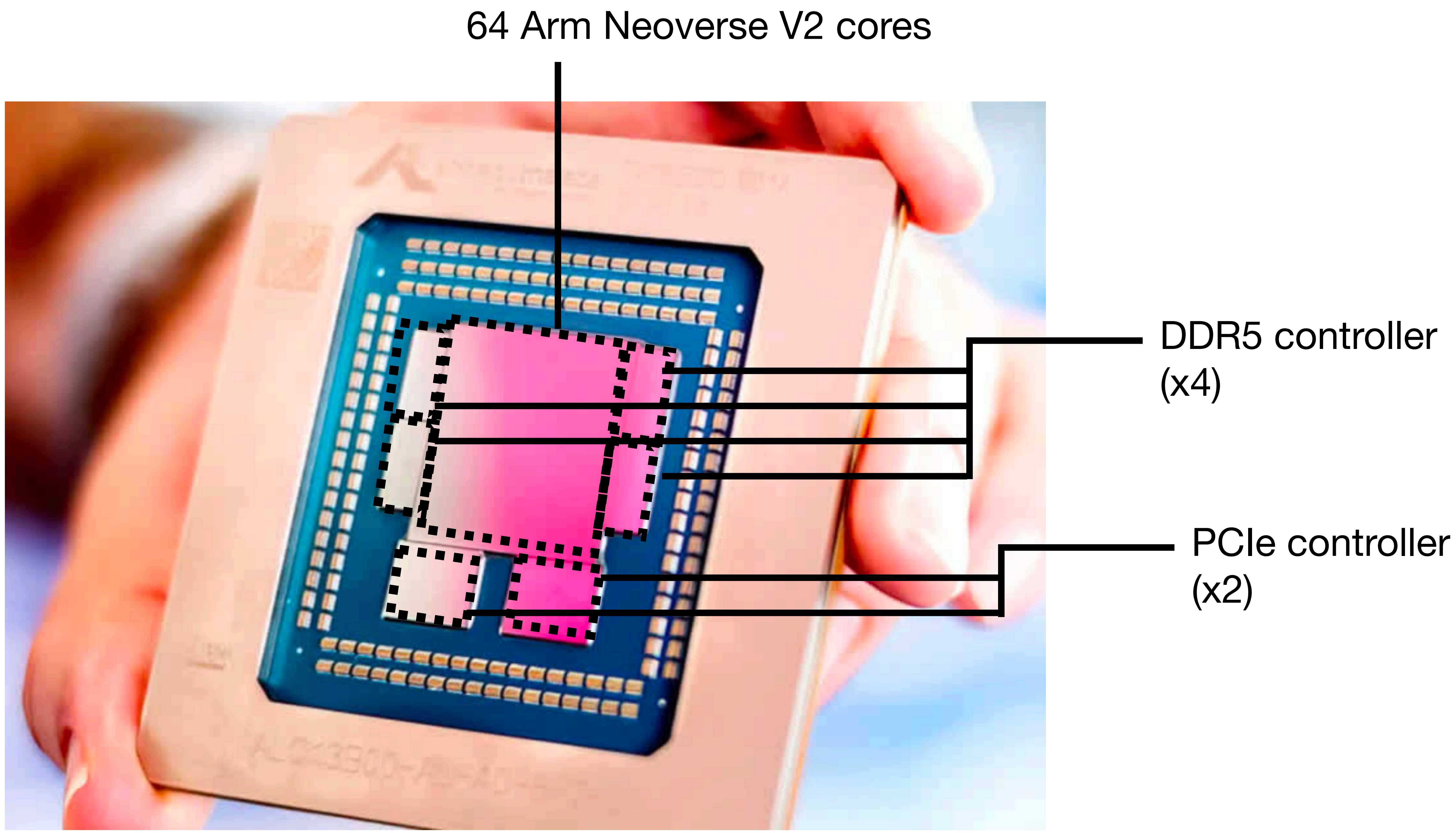
Apple M1 Ultra
2 dies

Ryzen Threadripper PRO 5995WX
9 dies



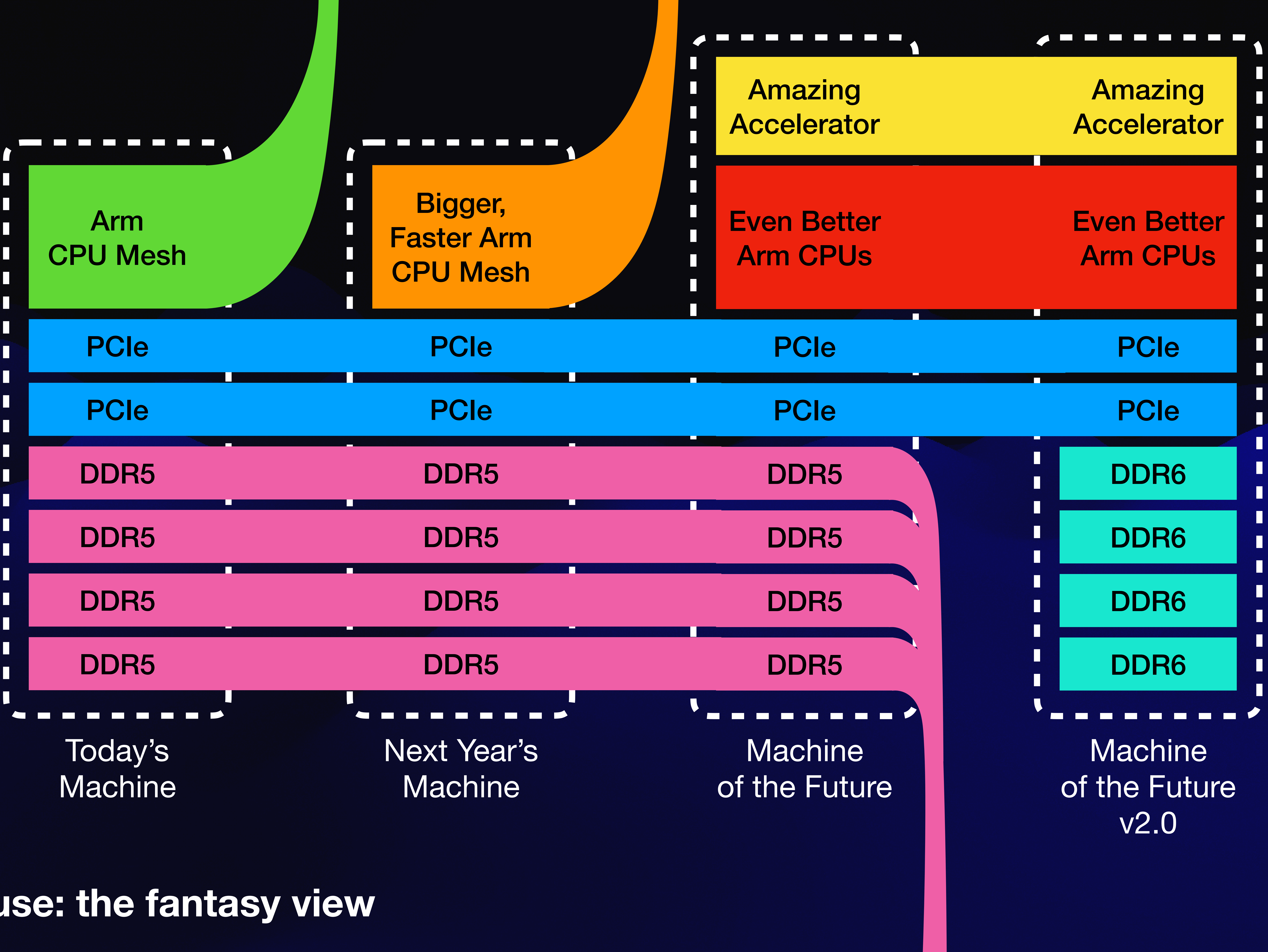
Intel Ponte Vecchio GPU
47 dies

Multi-chip modules are suddenly everywhere

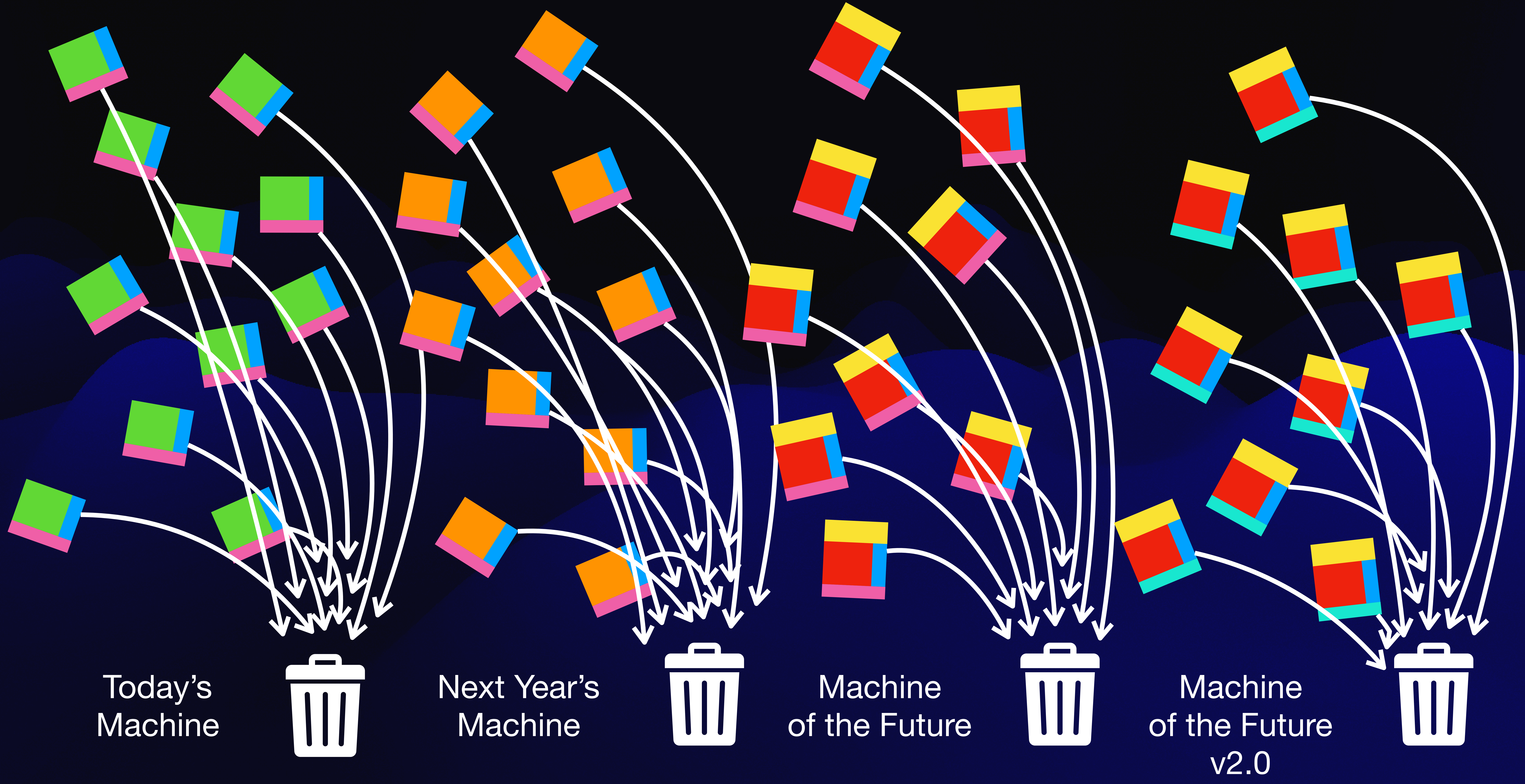


AWS Graviton3 Multi-Chip Module (2022)

DDR SDRAM standards tend to last for a good long while



Design reuse: the fantasy view



Design reuse: in the real world

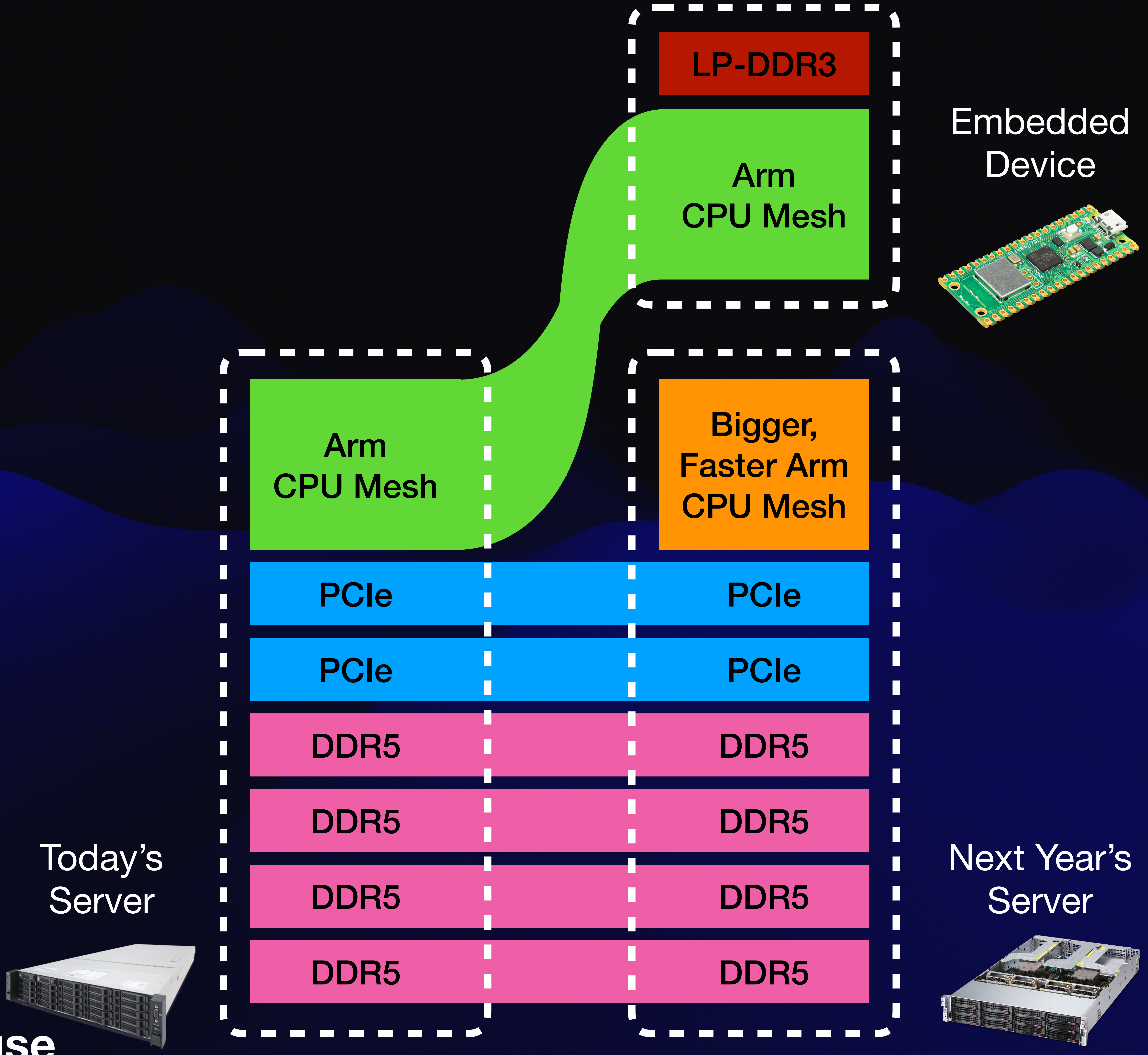
computing's carbon footprint

+

the chiplet revolution

=

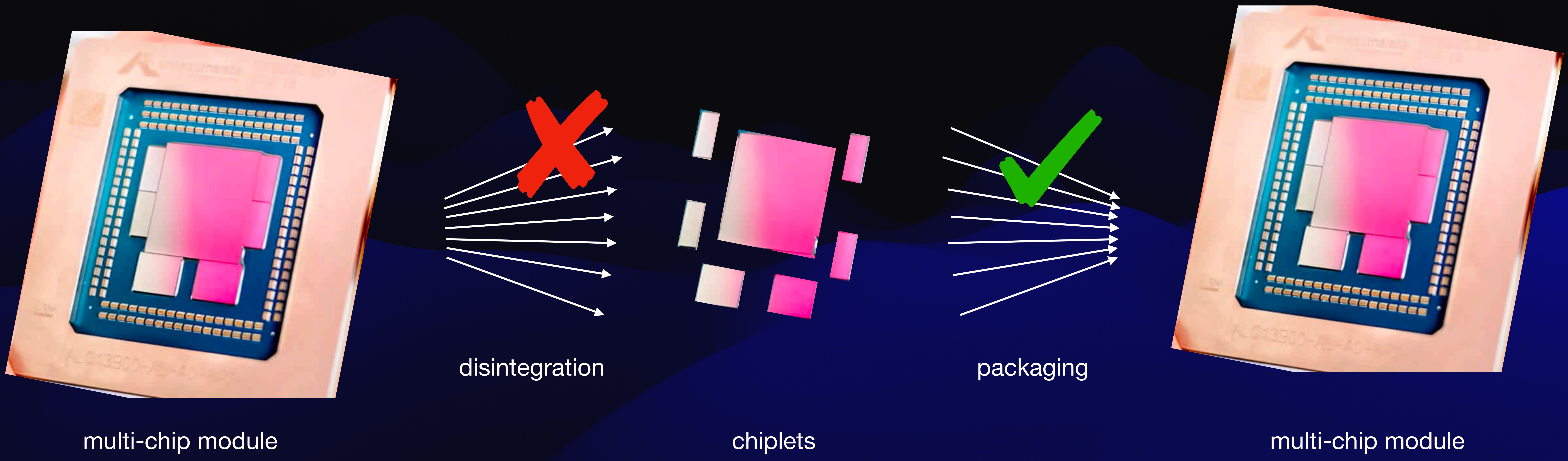
silicon recycling



Toward actual reuse


Disintegrate
Retire
silicon
recycling
Manufacture
Deploy
Package

Disintegrate



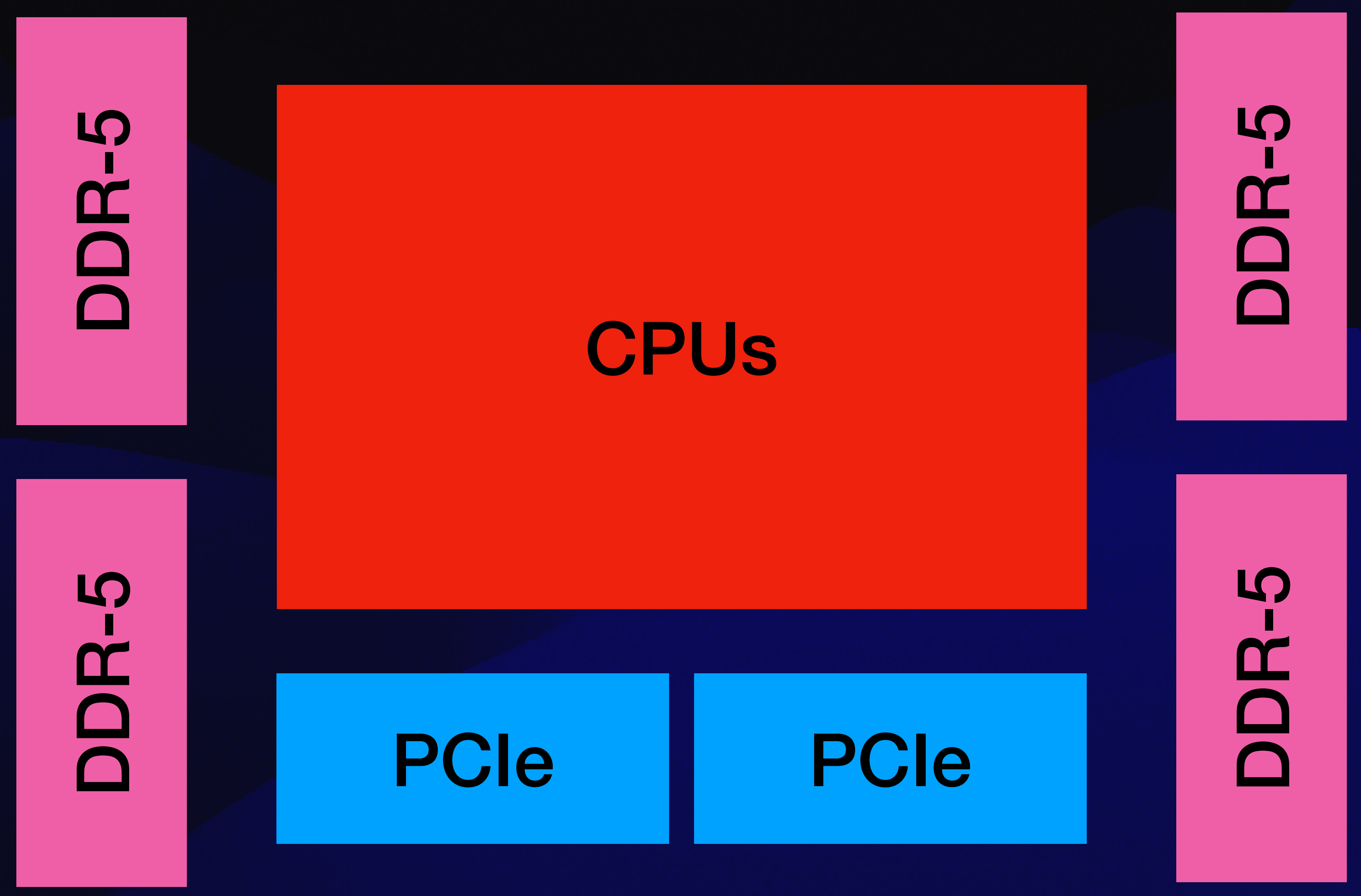
Chiplet disintegration

Make computers cheaper

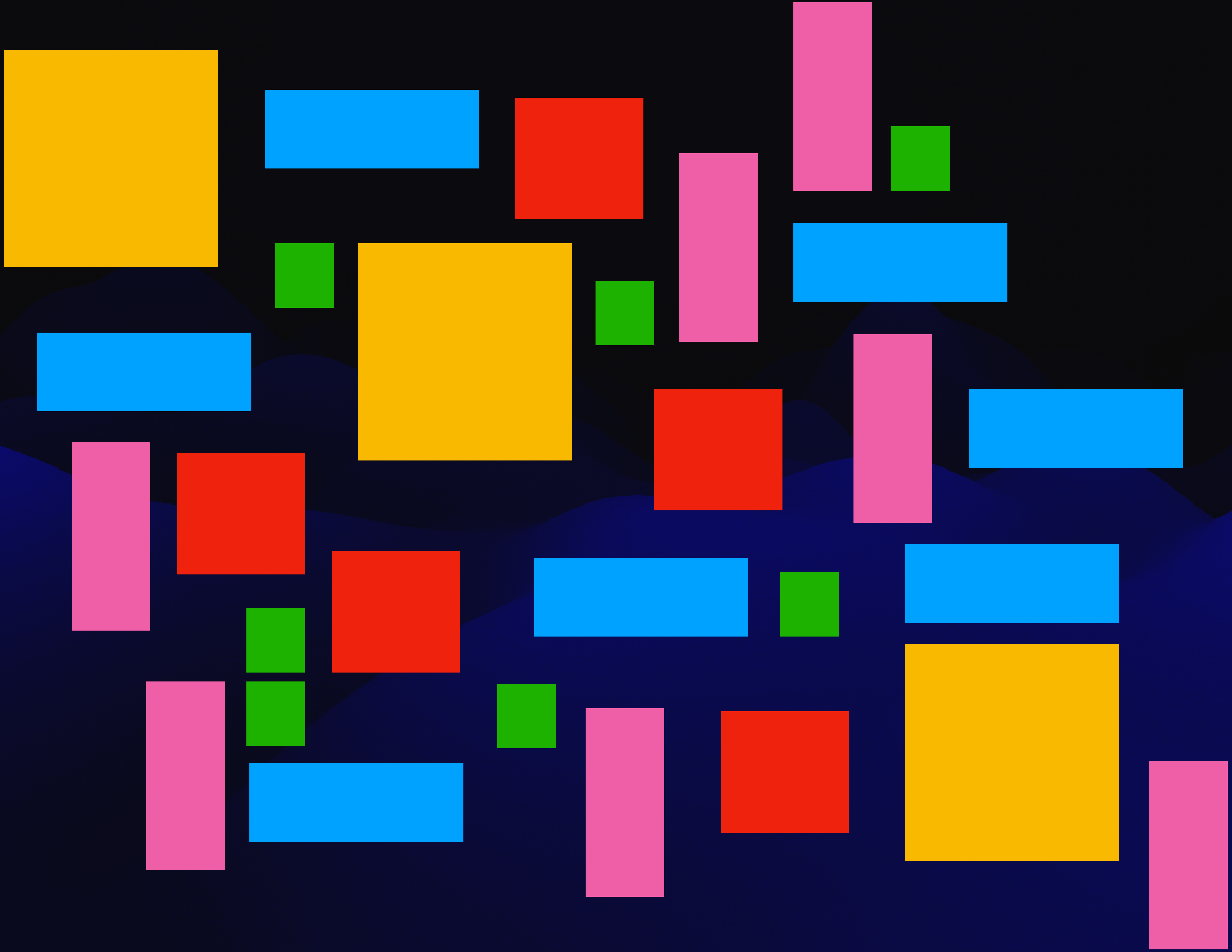
Reduce computing's embodied carbon footprint, thereby helping address the most urgent problem that humanity will grapple with in any of our lifetimes

Publish more ASPLOS papers

Reasons to be excited about silicon recycling



1: Carbon-aware architectural disaggregation



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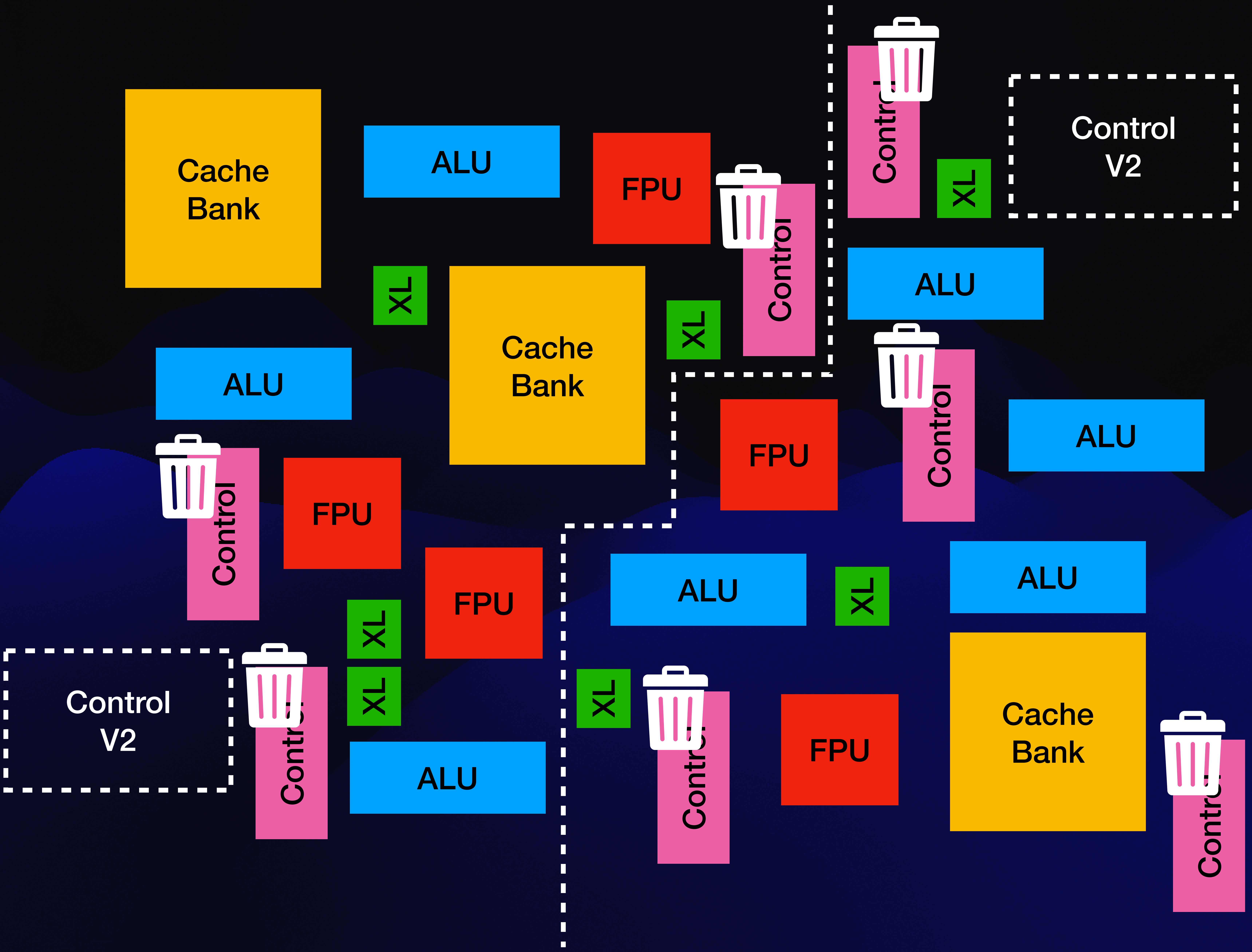
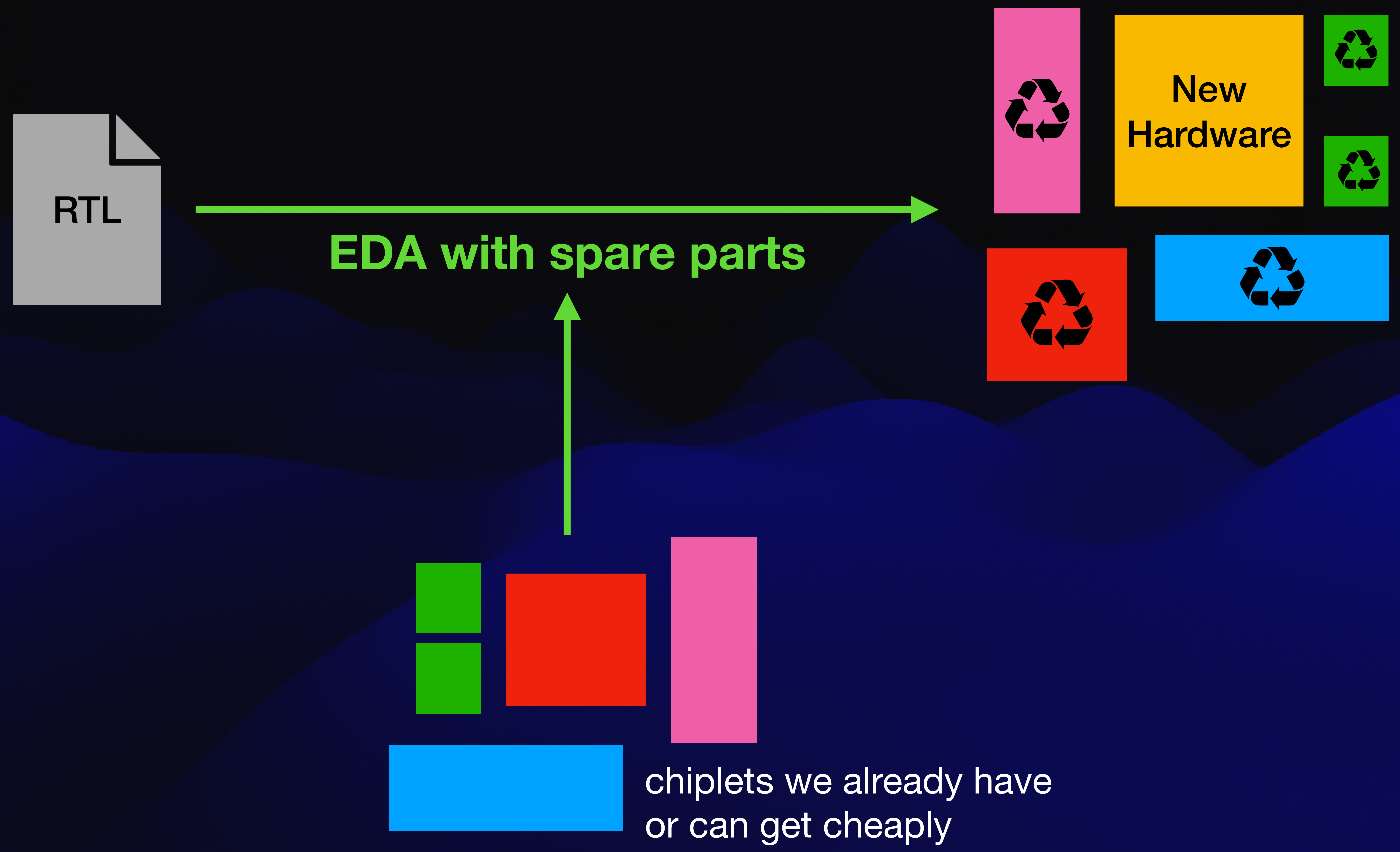
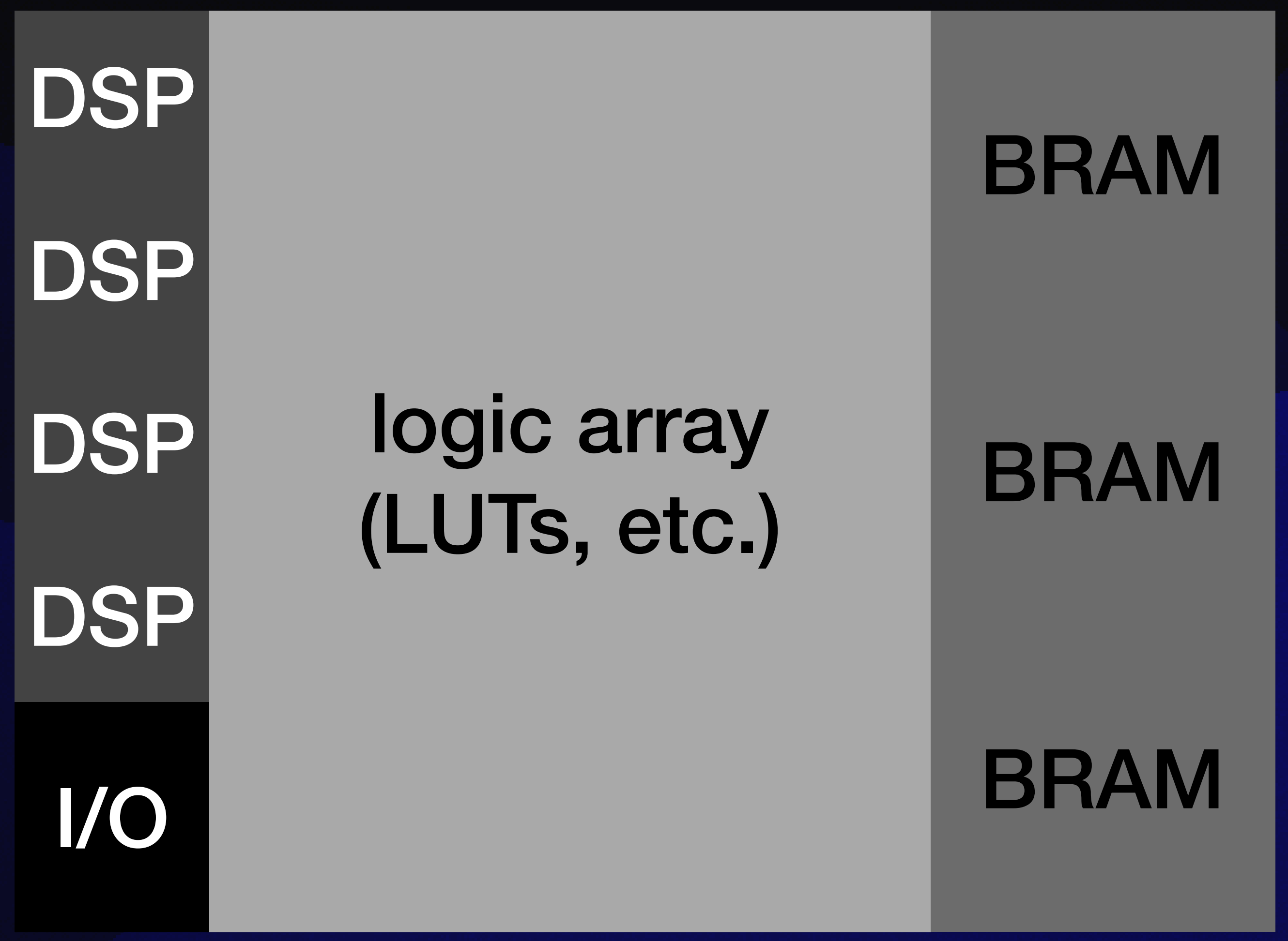


1: Carbon-aware architectural disaggregation

2: Design tools for spare-parts synthesis

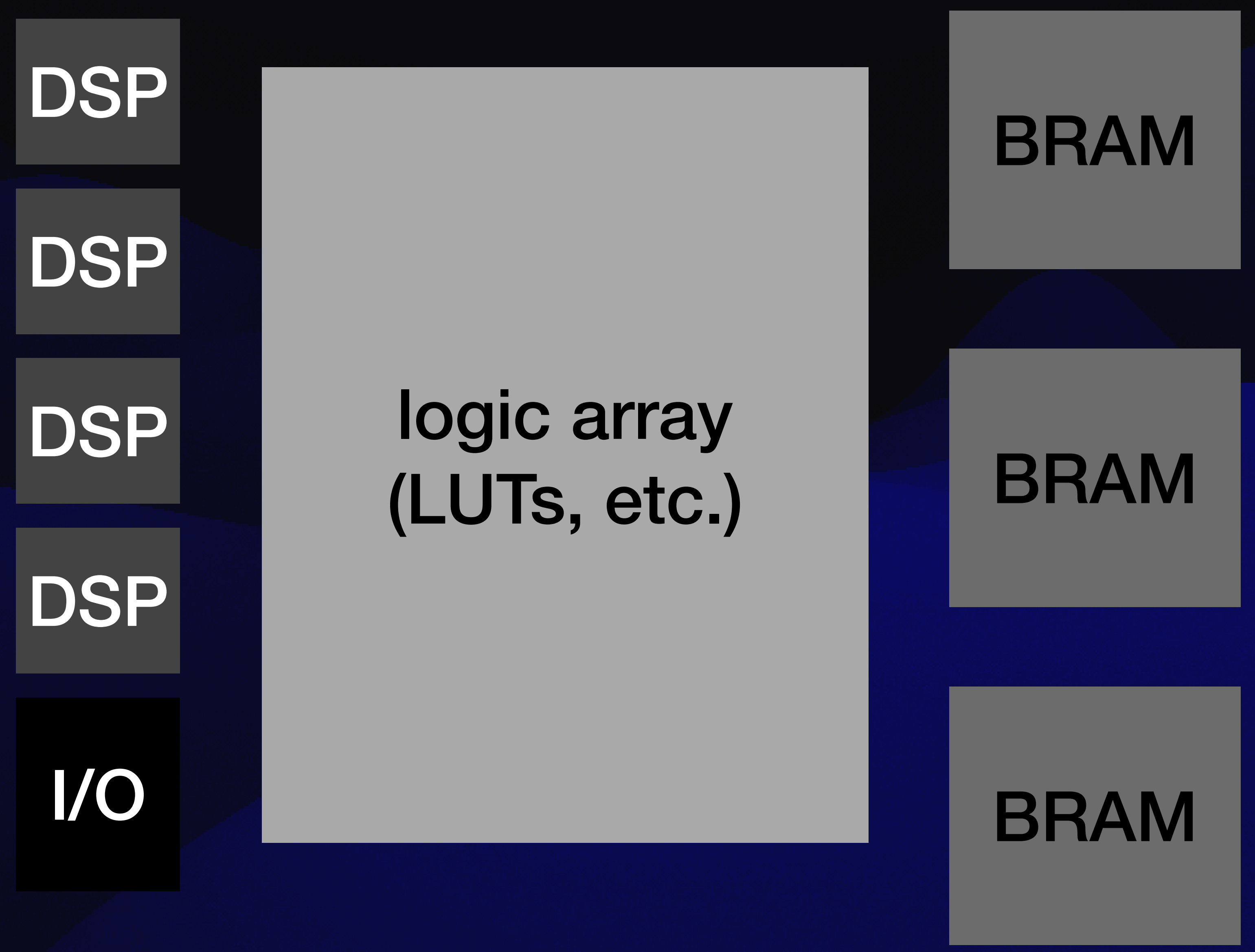


2: Design tools for spare-parts synthesis



a current FPGA
(hilariously oversimplified)

3: Physically reconfigurable fabrics



a physically reconfigurable FPGA

3: Physically reconfigurable fabrics

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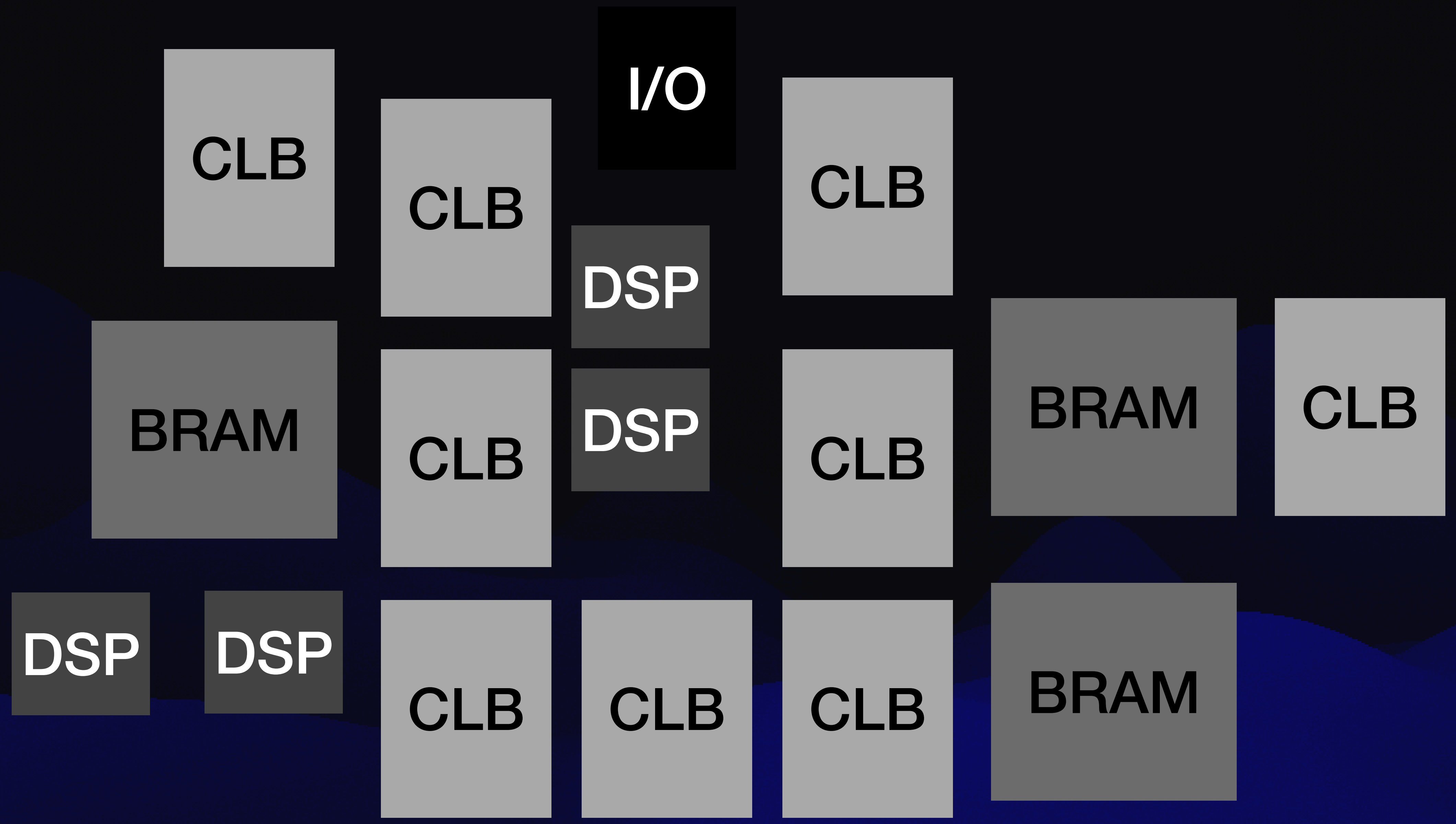

a physically reconfigurable FPGA

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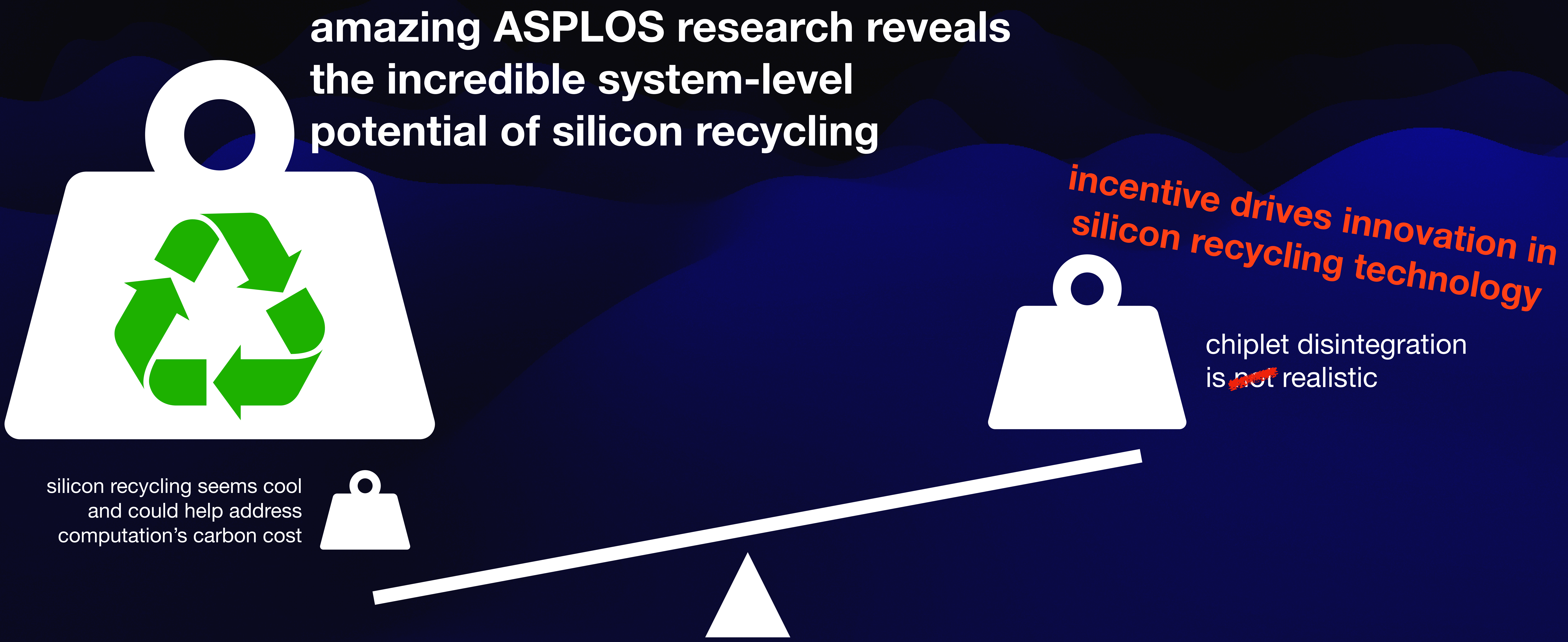
Disintegrate
Retire
silicon
recycling
Manufacture
Deploy
Package


amazing ASPLOS research reveals the incredible system-level potential of silicon recycling
silicon recycling seems cool and could help address computation’s carbon cost
chiplet disintegration is not realistic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incentive drives innovation in silicon recycling technology
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