Towards Deploying Decommissioned Mobile Devices as Cheap Energy-Efficient Compute Nodes

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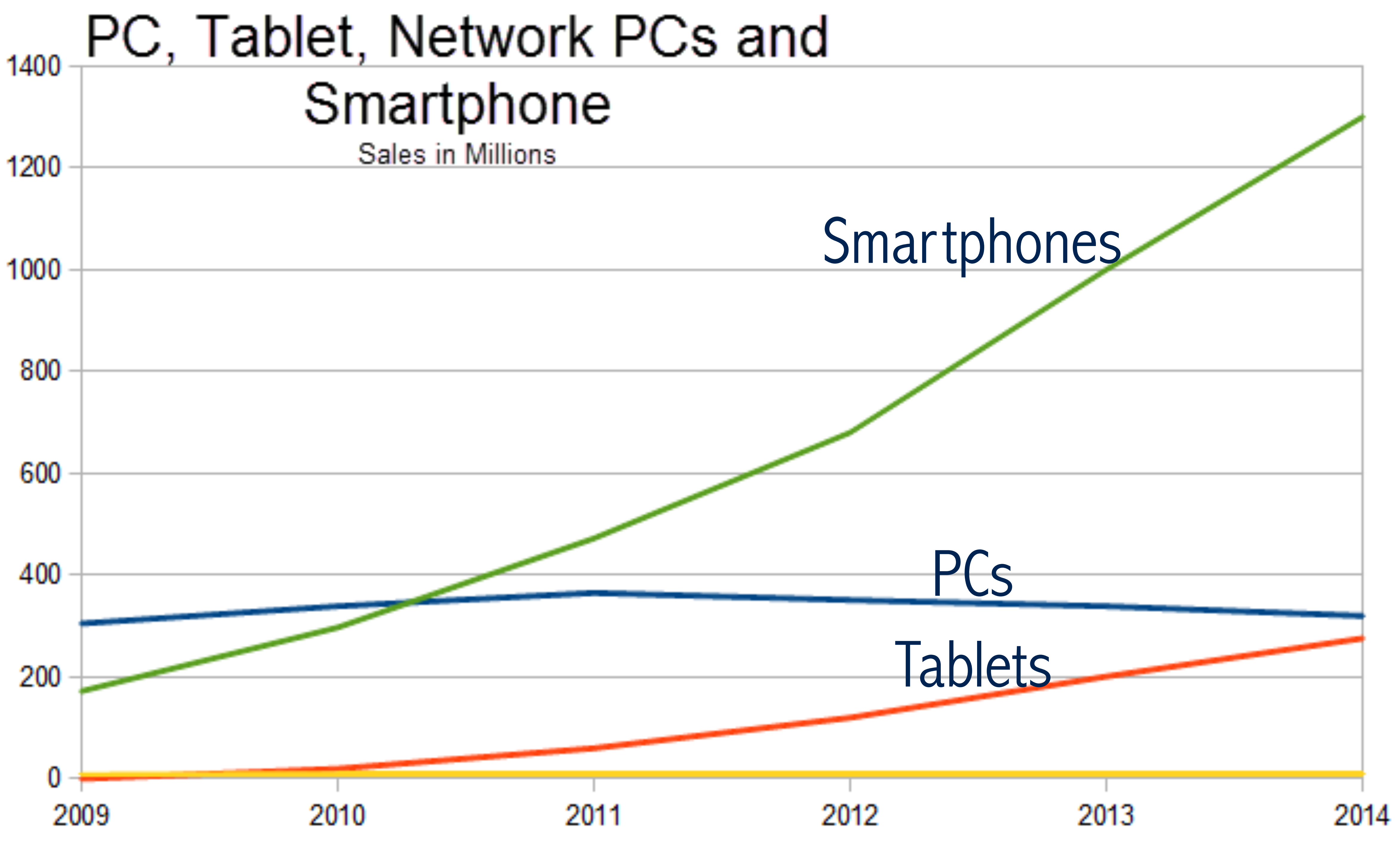
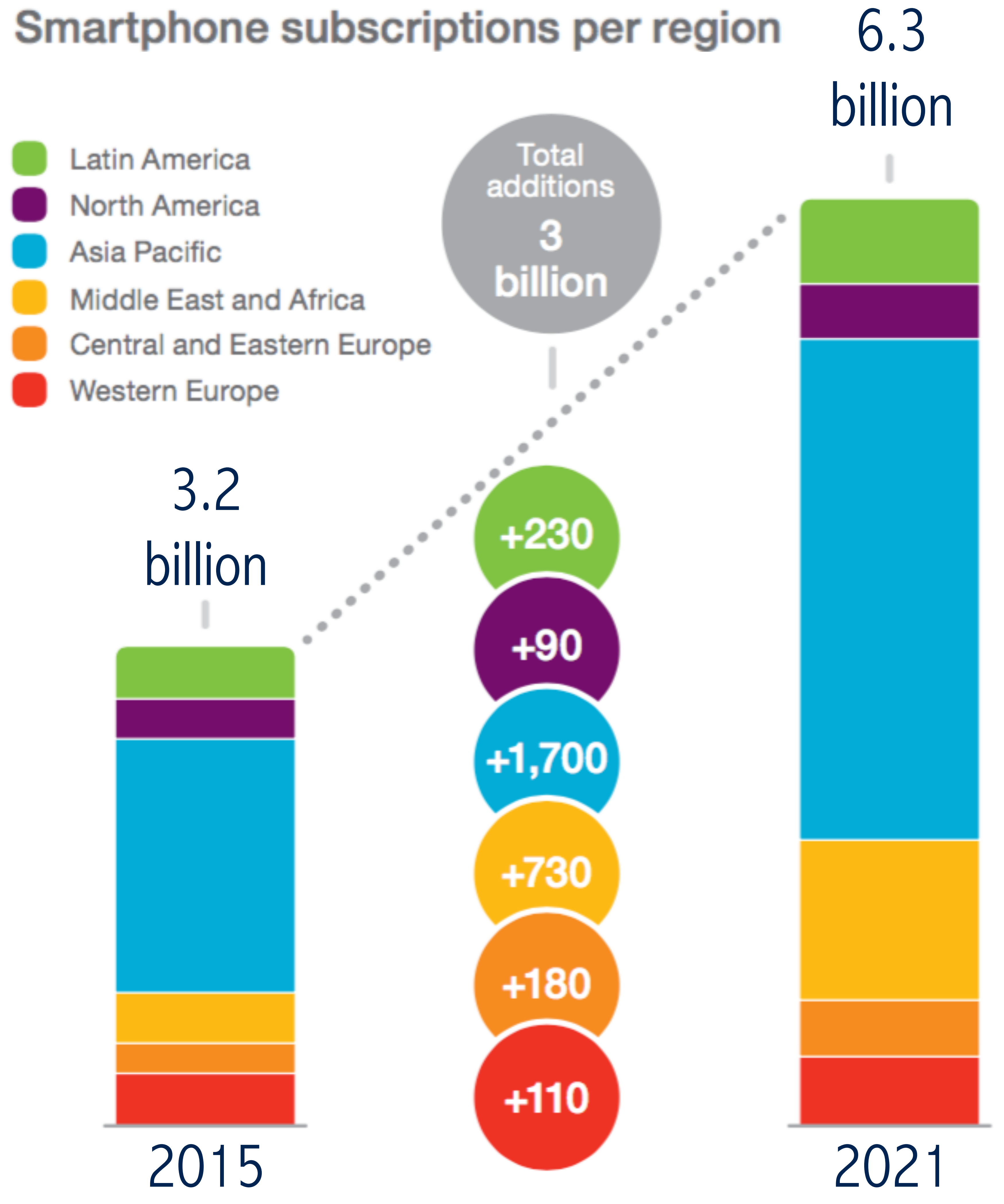
PRINCETON UNIVERSITY

HotCloud '17

Growing Dominance of Smartphones

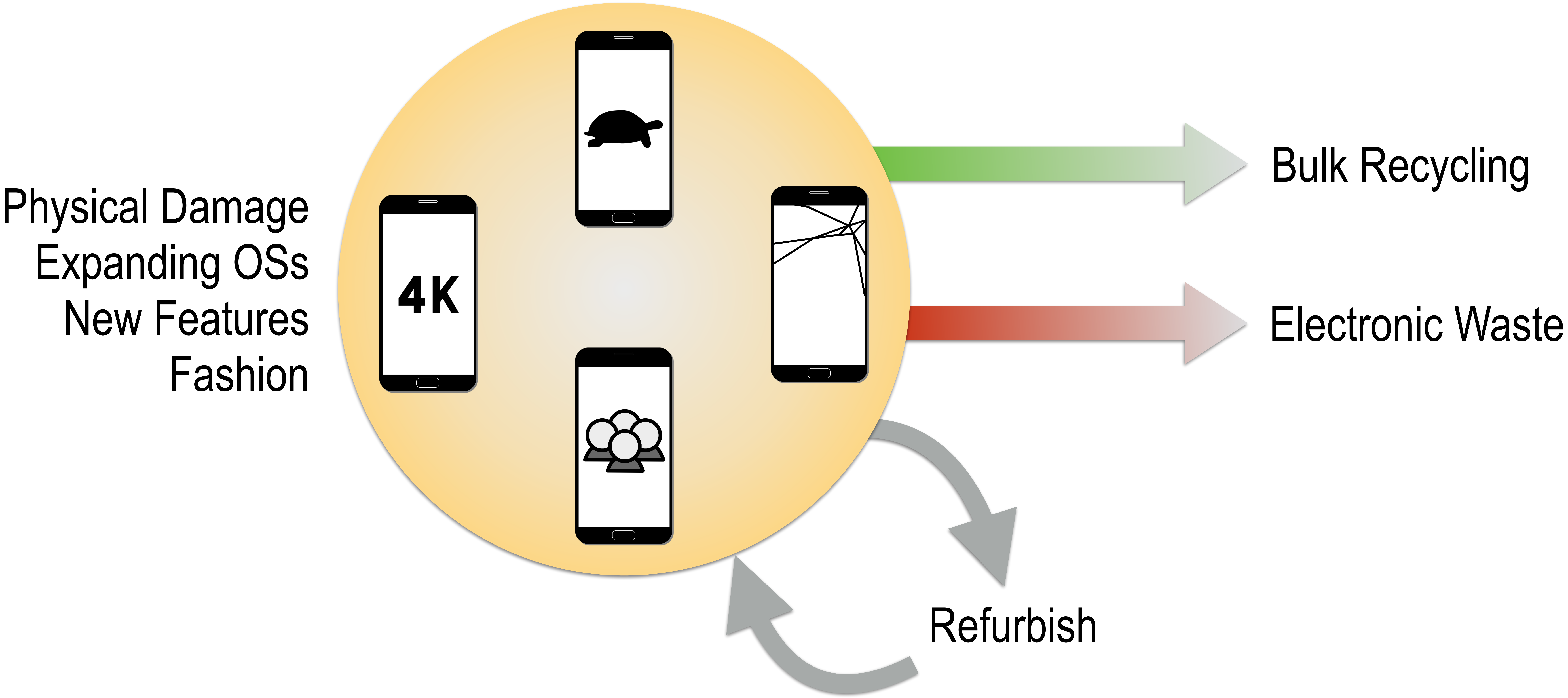


[Gartner, IDC, Zuberbühler Associates AG]



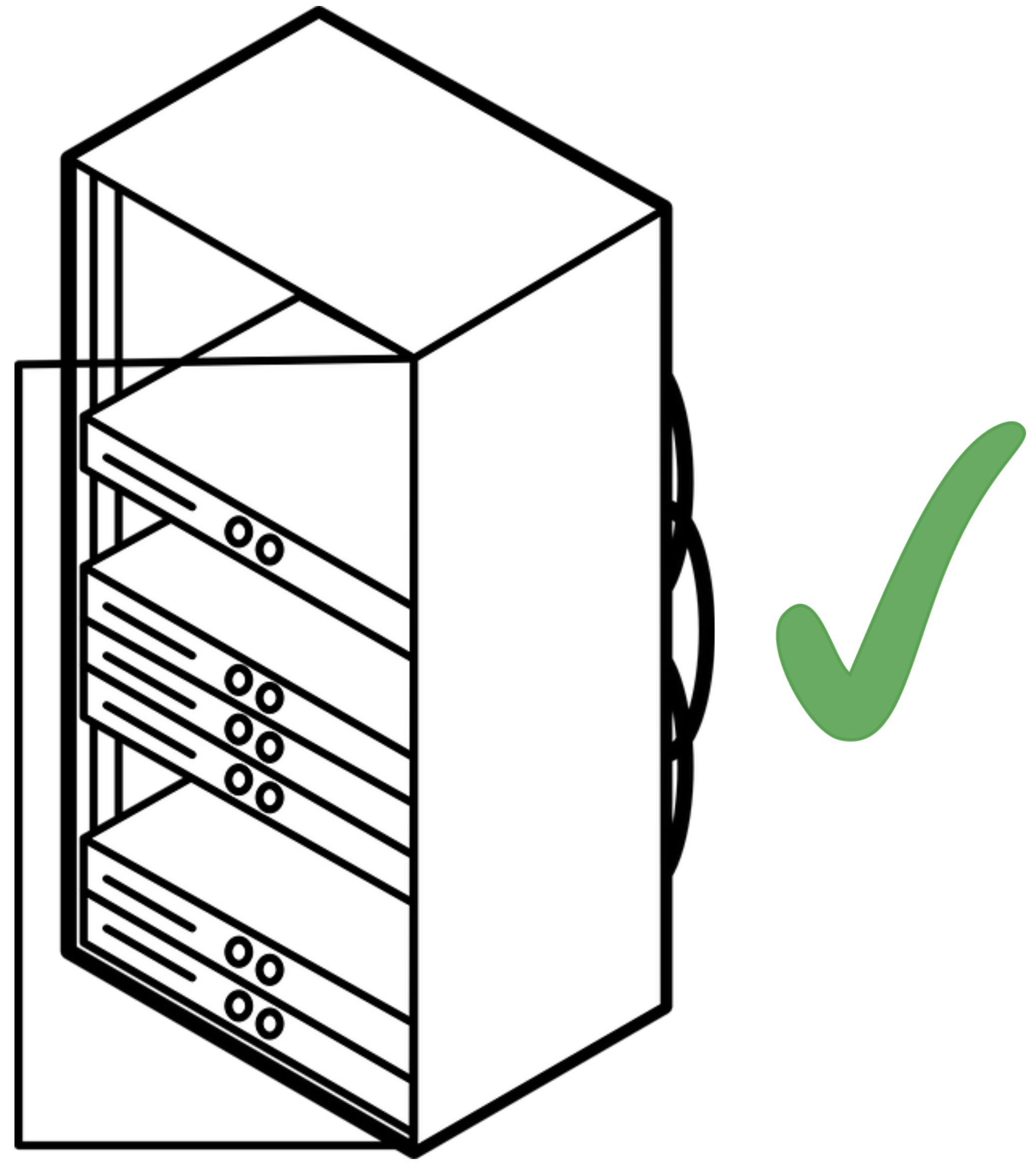
[Ericsson Mobility Report 2016]

Decommissioned Smartphones



Using the computational capacity of decommissioned devices

Reusing smartphones as compute nodes?



Outline

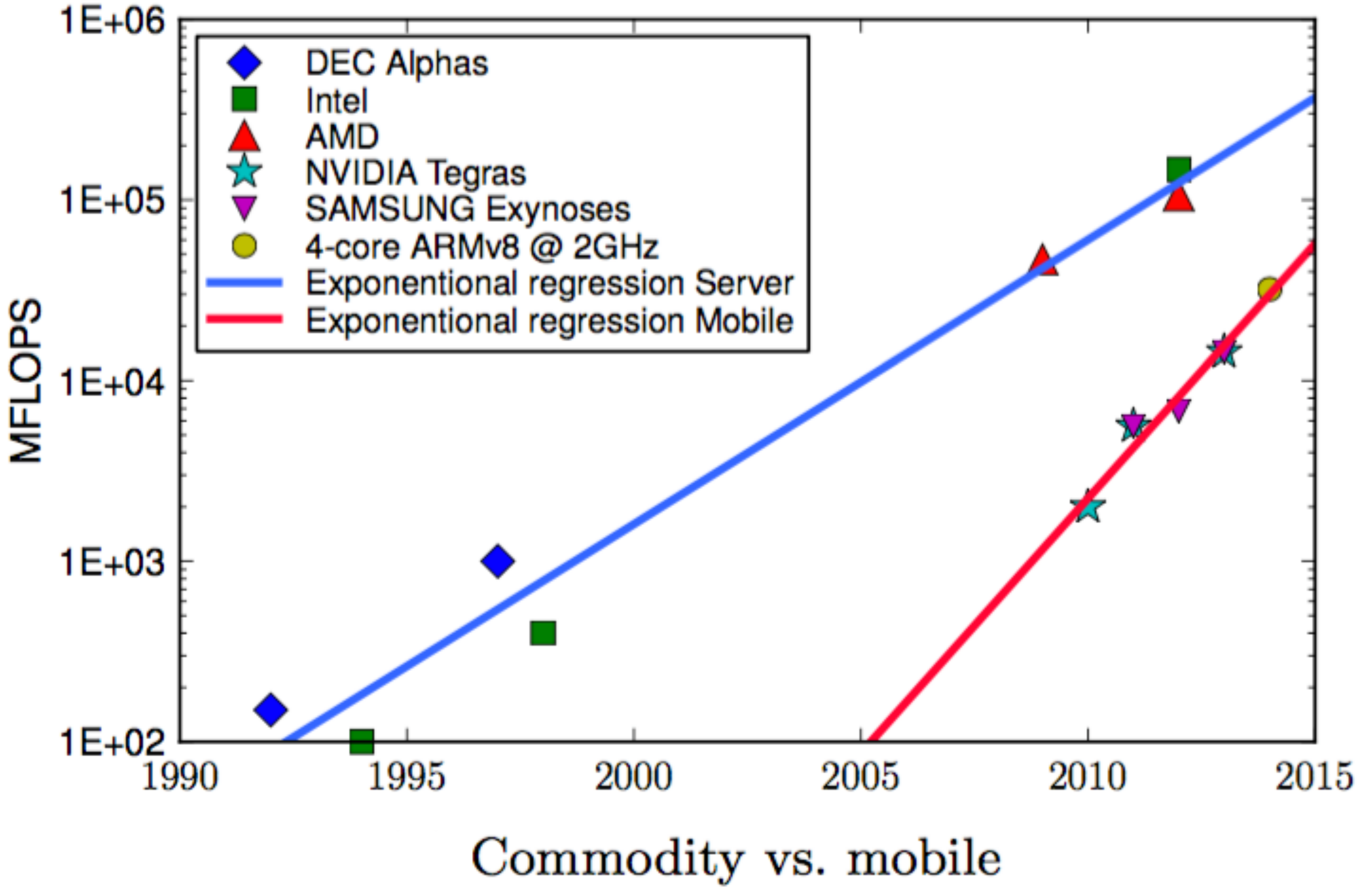
Why using mobile SoCs now?

How to integrate mobile devices into data center fabric?

What to do with such mobile devices in data centers?

Does such deployment make economic sense?

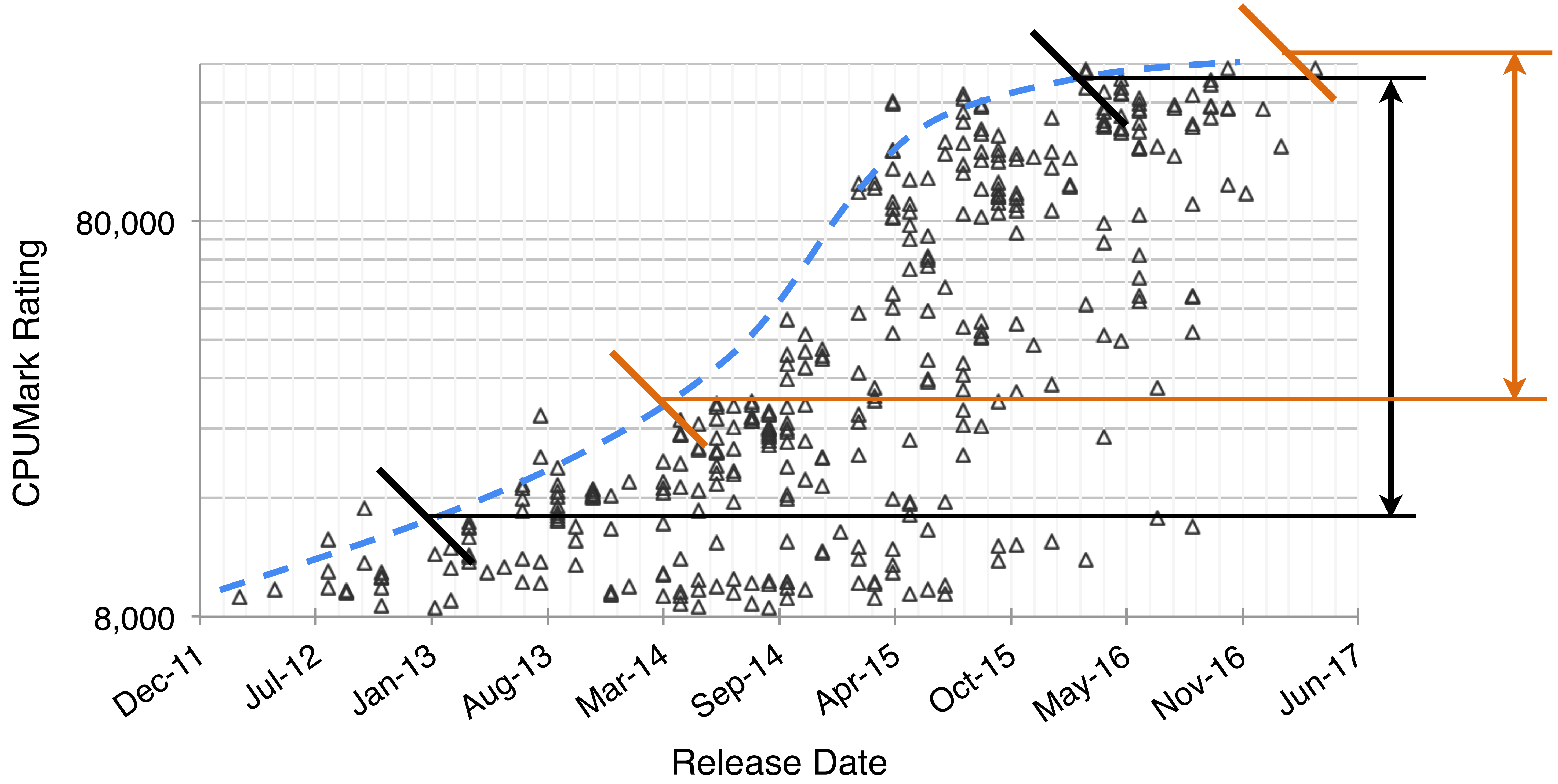
Trend 1: Commodity vs. Mobile Performance



[Rajovic et al., Supercomputing with commodity CPUs: Are mobile SoCs ready for HPC?, SC '13]

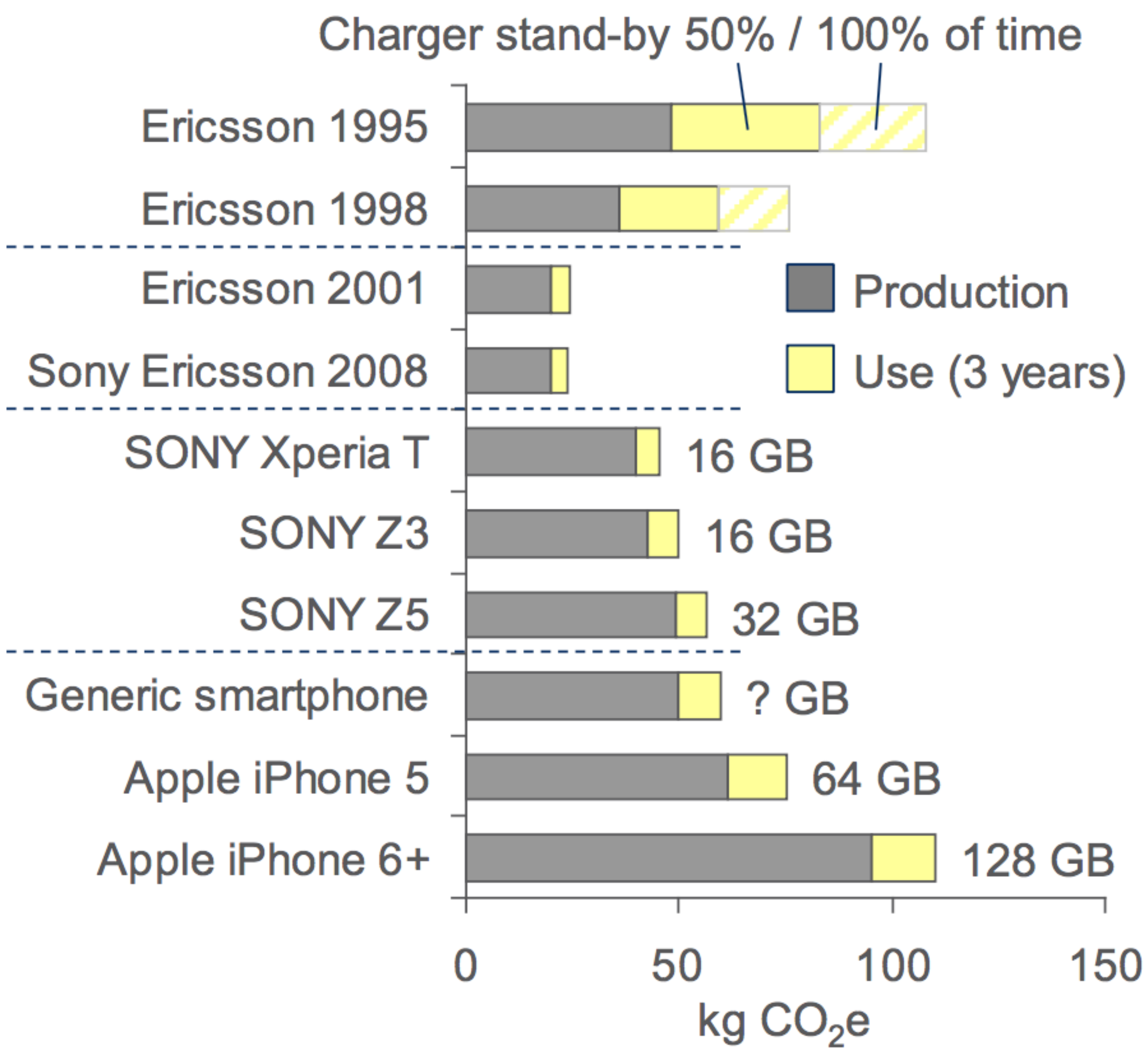
HP Moonshot

Trend 2: Diminishing Performance Growth



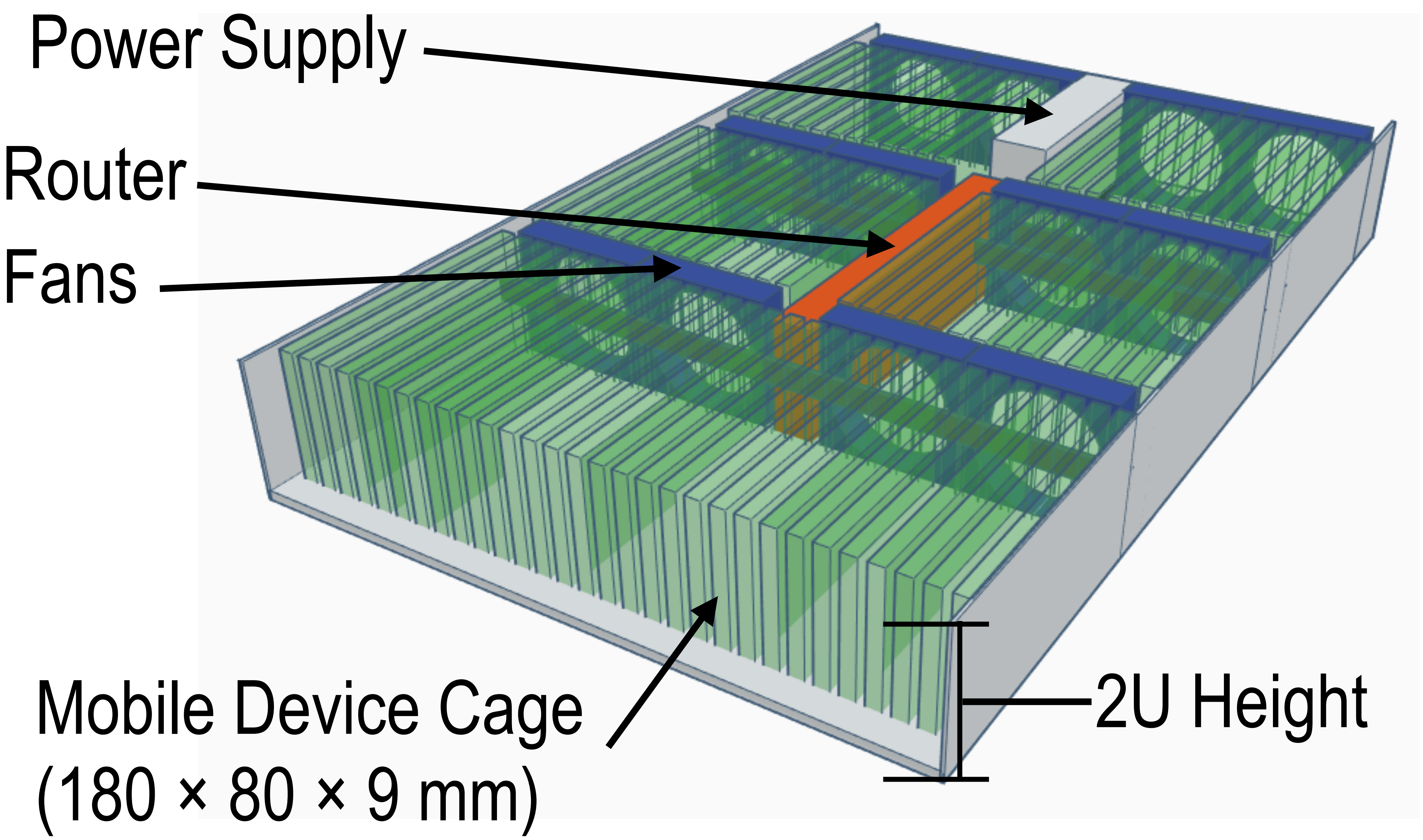
End of Moore's Law is starting to kick in for mobile SoCs. → The performance gap between a new vs. a 3-year old phone is decreasing.

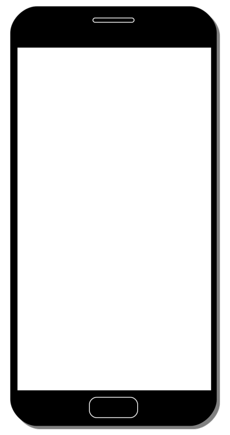
Extending Effective Lifetime to Improve Carbon Footprint



[Ercan et al., Life cycle assessment of a smartphone, ICT4S '16]

Proposed Integration Fabric

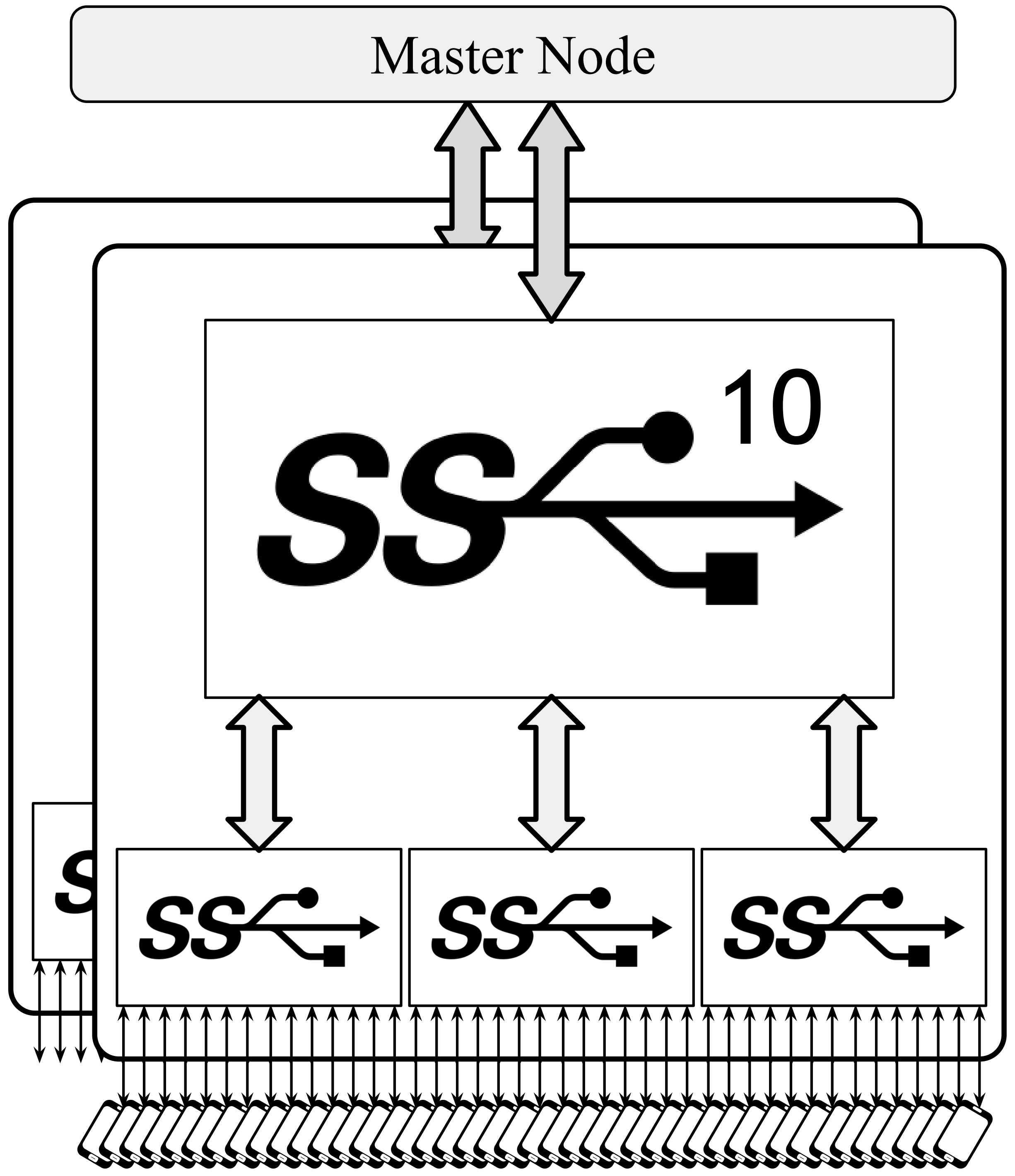


84 ×  ≈ 

SoC TDP = 3.5 W

Networking

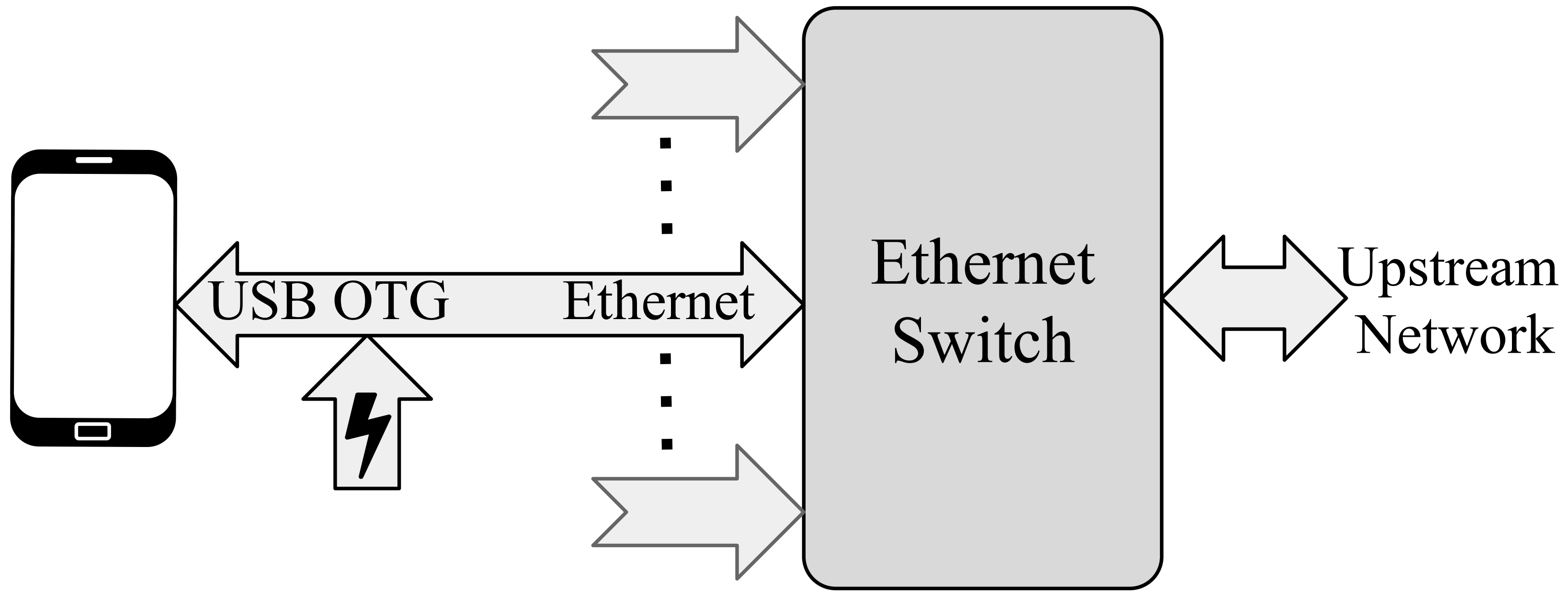
1. USB Tree + Master Node ✓



Establish virtual Ethernet through master node

Master becomes single point of failure

2. USB On-The-Go (OTG) ✓

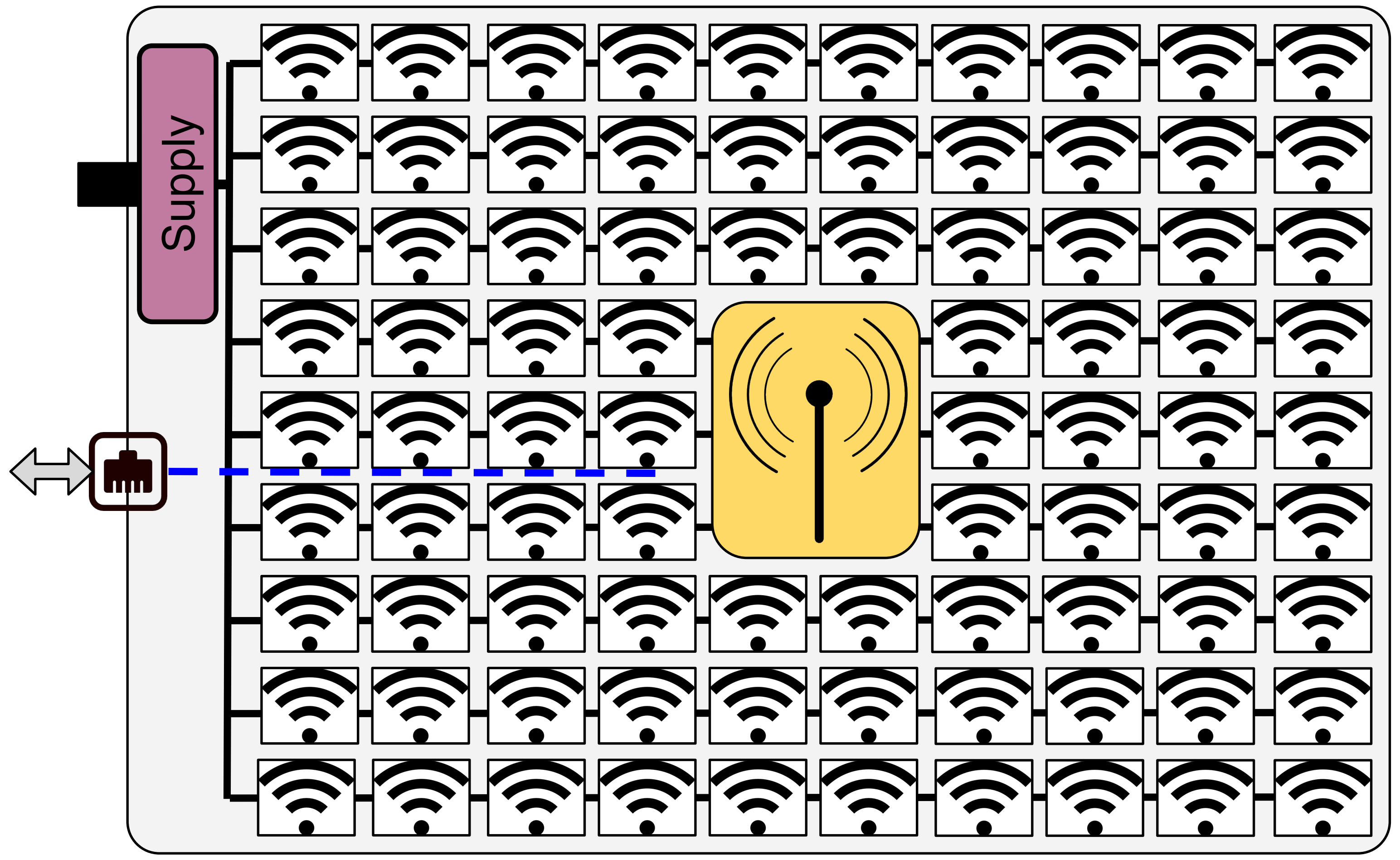


High BW per Device

No Need for a Master Node

Ethernet Switch Cost (price+space)

3. Intra-server WiFi ✗



Low SNR and high congestion.

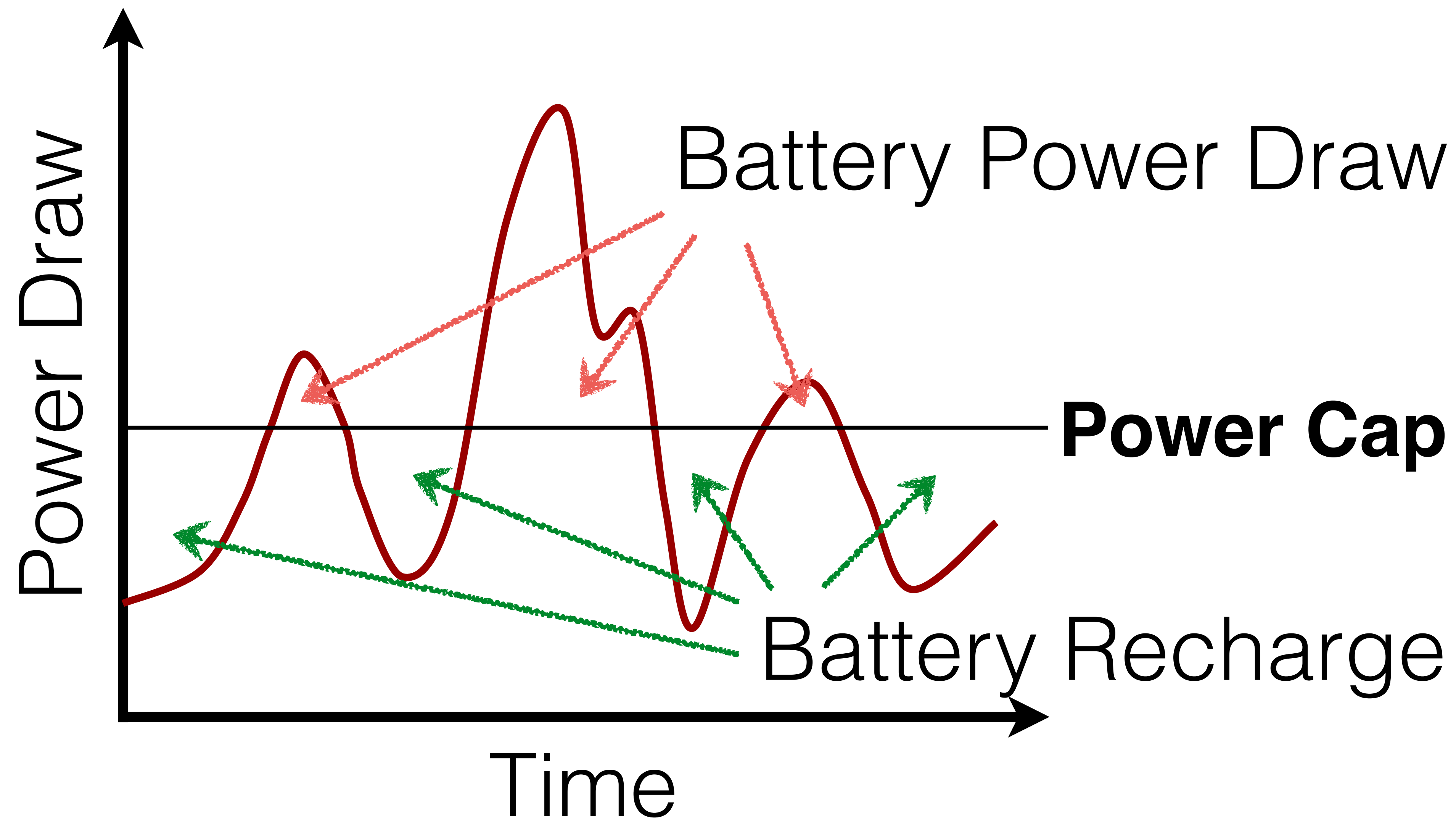
↓

Low BW

High Energy

High Latency

Mobile Batteries as Distributed UPSs



Batteries could be used to perform power capping in data centers.

Mobile batteries are designed for high-density energy storage.

Average mobile battery: > 3100mAh
After 3 years (15% dep/yr): >1900mAh
84 device per server: ~160Ah
(4x-8x the typical UPS density)

Targeted Applications?

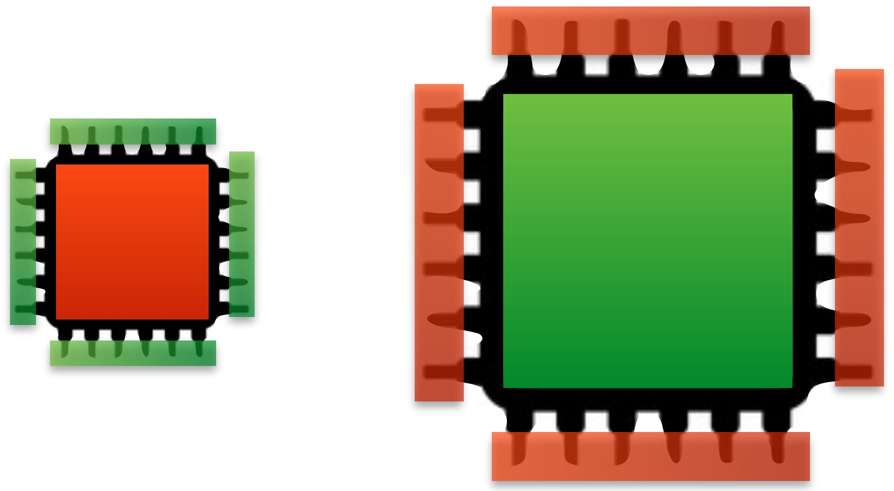
Lower CPU Performance

High Relative I/O Bandwidth

Non-CPU Elements of Mobile SoC

Lower Reliability

I/O-intensive Application



Smaller cores generally have better I/O to compute ratio.

Mobile cores have better performance-per-Watt.

Prior examples:

Fast Array of Wimpy Nodes [Andersen et al., SOSP '09]

- Using low-end embedded CPUs in a key-value store system.
- Two orders of magnitude more queries per Joule.

Web Search Using Mobile Cores [Reddi et al., ISCA '10]

- Comparing Atom to Xeon processors or perform web search.
- Better energy efficiency
- Worse QoS

Low-end VM Provisioning

amazon web services	vCPU	Mem (GB)
`t2.nano`	1	0.5
`t2.micro`	1	1

	vCPU	Mem (GB)
`f1-micro`	0.2	0.6
`g1-small`	0.5	1.7

Each mobile device (on average):

- > 2GB of memory
- > 5 cores

Multiple tiny burstable instances can be provisioned on each mobile device.

GPU-accelerated Dwarfs

- Current GPU-accelerated IaaS instances use beefy GPUs (e.g. EC2 P2 instances)
- Mobile SoCs are equipped with smaller GPUs
- Enabling low-end GPU acceleration for small VMs

Lower-reliability Nodes

- Dynamic reliability platforms use resource heterogeneity for cost saving while meeting SLAs
- Mobile devices can be used as low-cost low-reliability nodes

Does it make economic sense?

TCO Comparison with a Similar-density Server

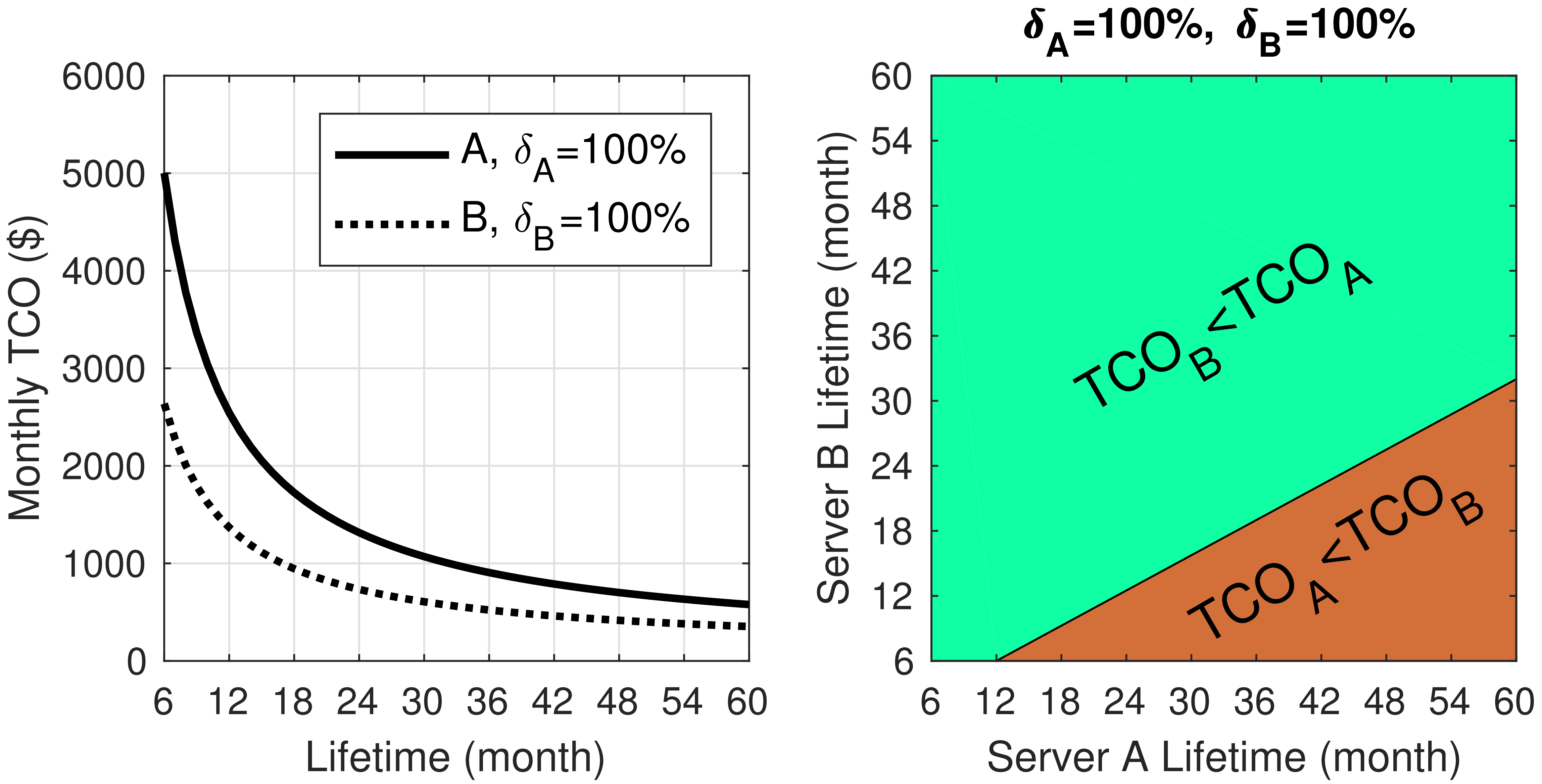
System	Server	CPU/SoC	Server Height	CPU per Server	Grade per CPU	Total RAM	Total Storage	Per Rack Unit (1U)		
								Grade	Memory	Storage
A	Lenovo Flex System x880 X6 [21]	Intel Xeon E7-8890 v3	1.2U	2	74482 [14]	144 GB (18×8)	1.56 TB ($2\times$800GB)	124,137	120 GB	1.30 TB
B	Proposed Server	Snapdragon 805 (Samsung Galaxy Note 4)	2U	84	3060 [14]	252 GB (84×3)	2.63 TB ($84\times$32GB)	128,520	126 GB	1.32 TB

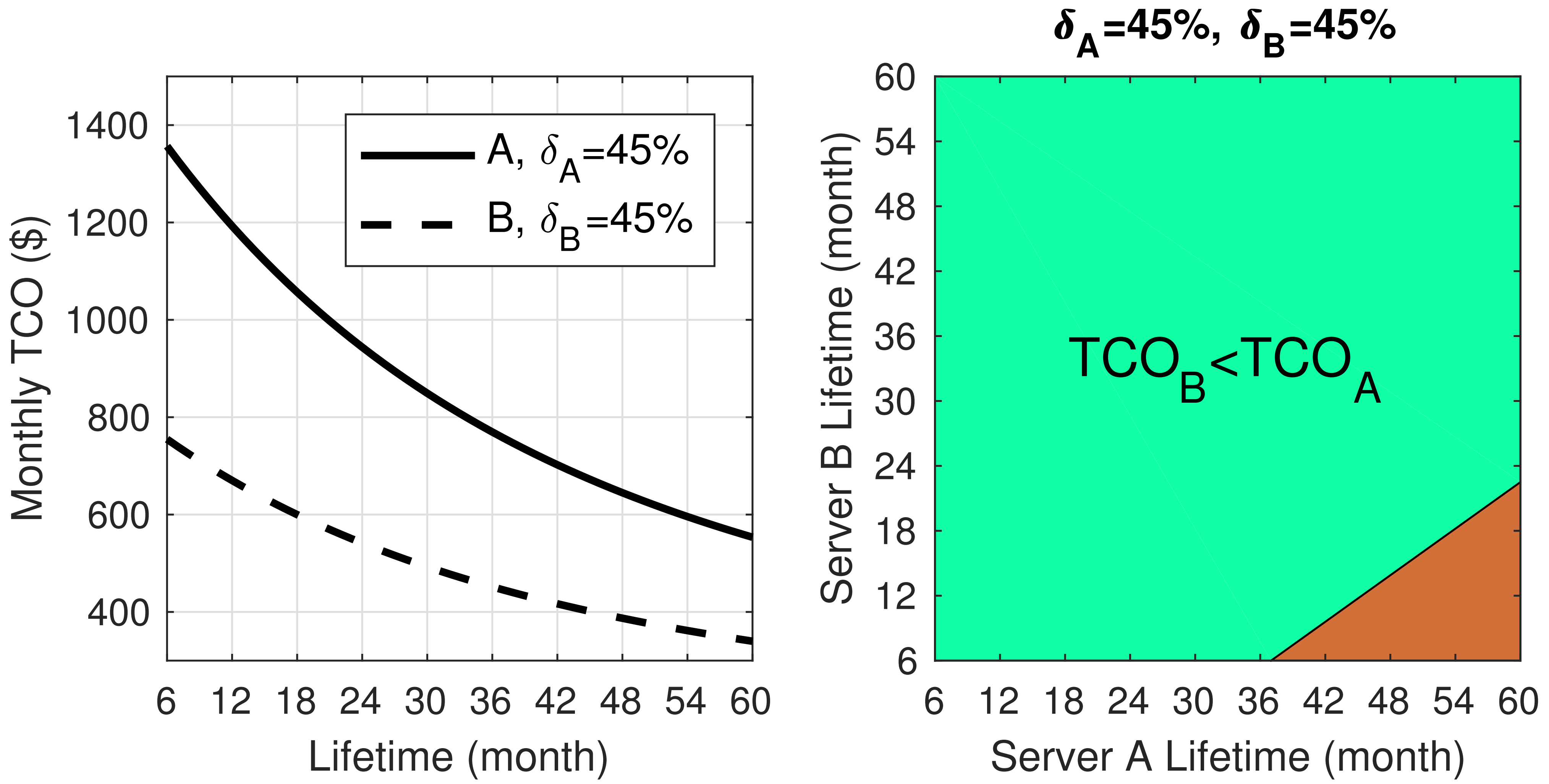
Two simplifying assumptions:

1. Parallelizable workload (using Geekbench 4 cross-platform benchmark)
2. Considered eBay retail price for used phones (could be much cheaper)

TCO: Total Cost of Ownership

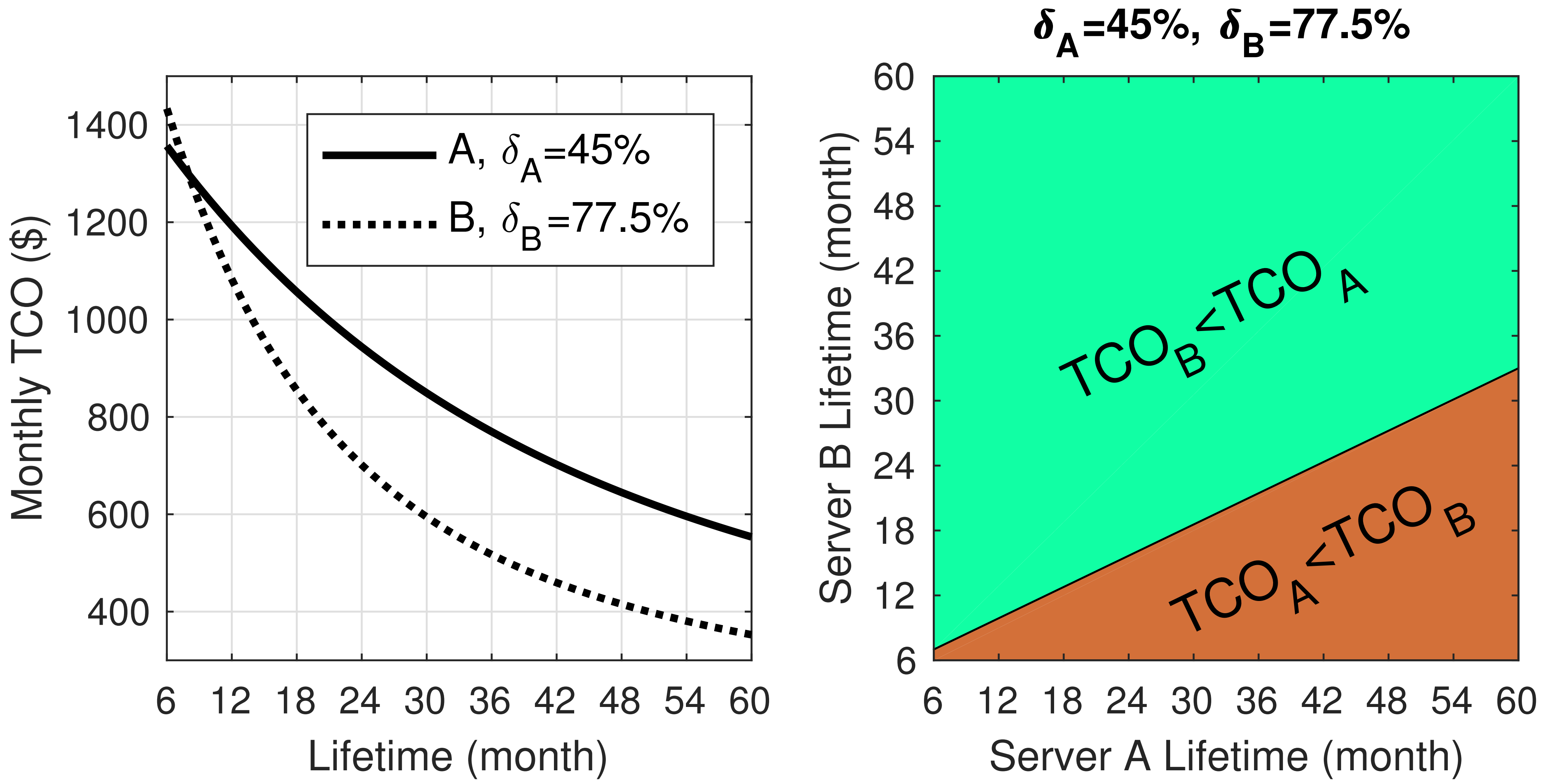
TCO comparison with a Similar-density Server



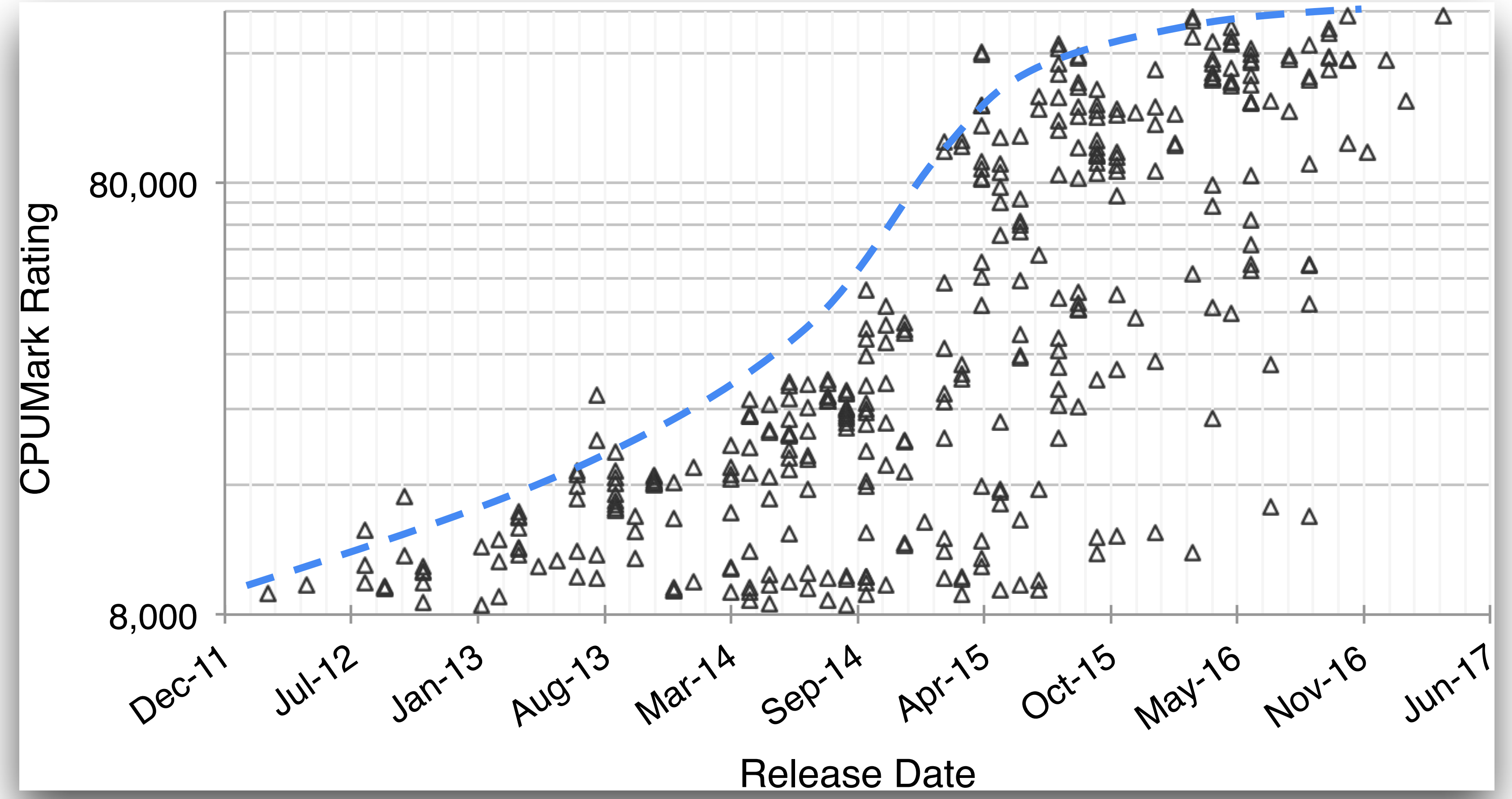


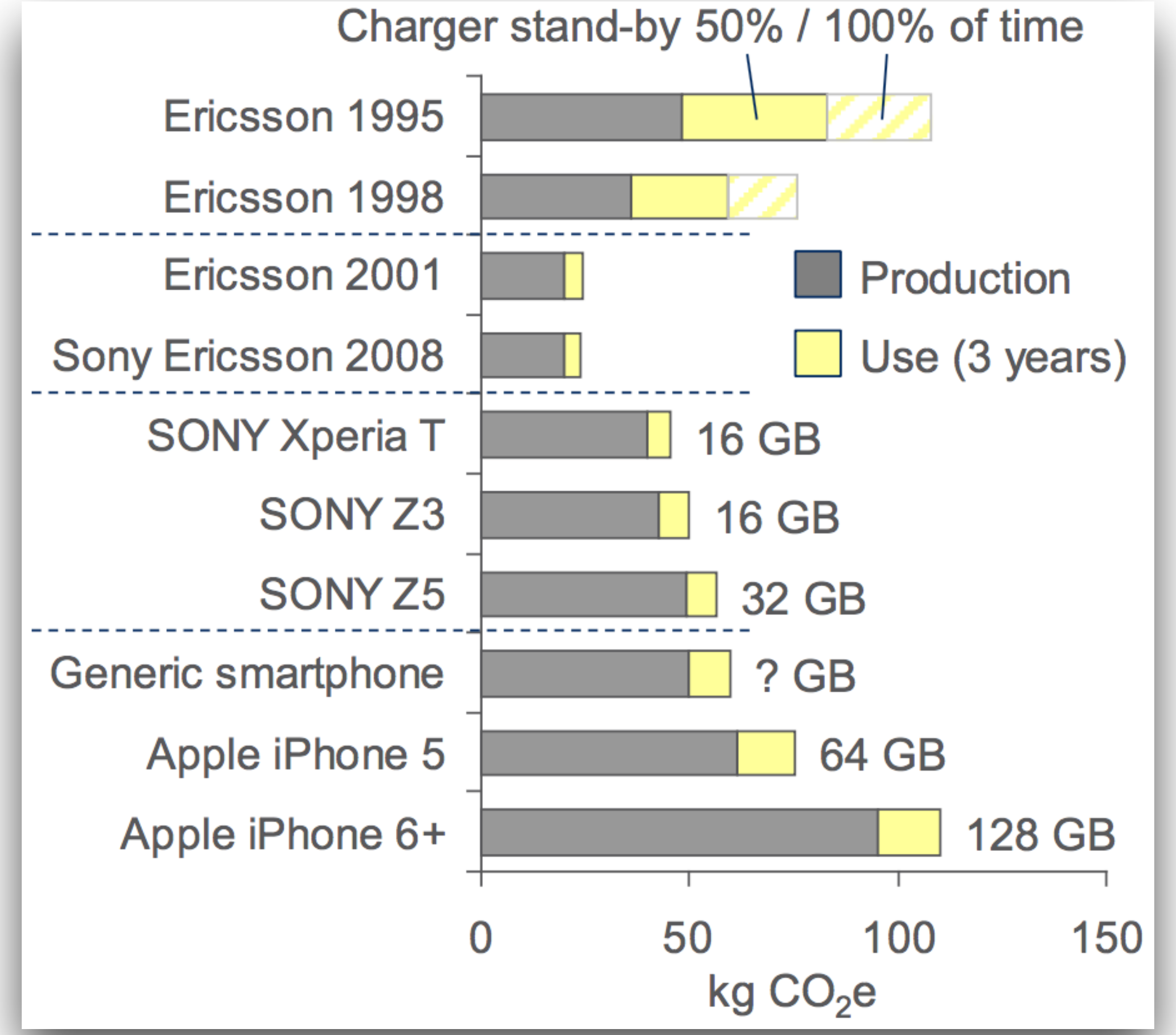
δ: annual depreciation rate
(determines the residual value)

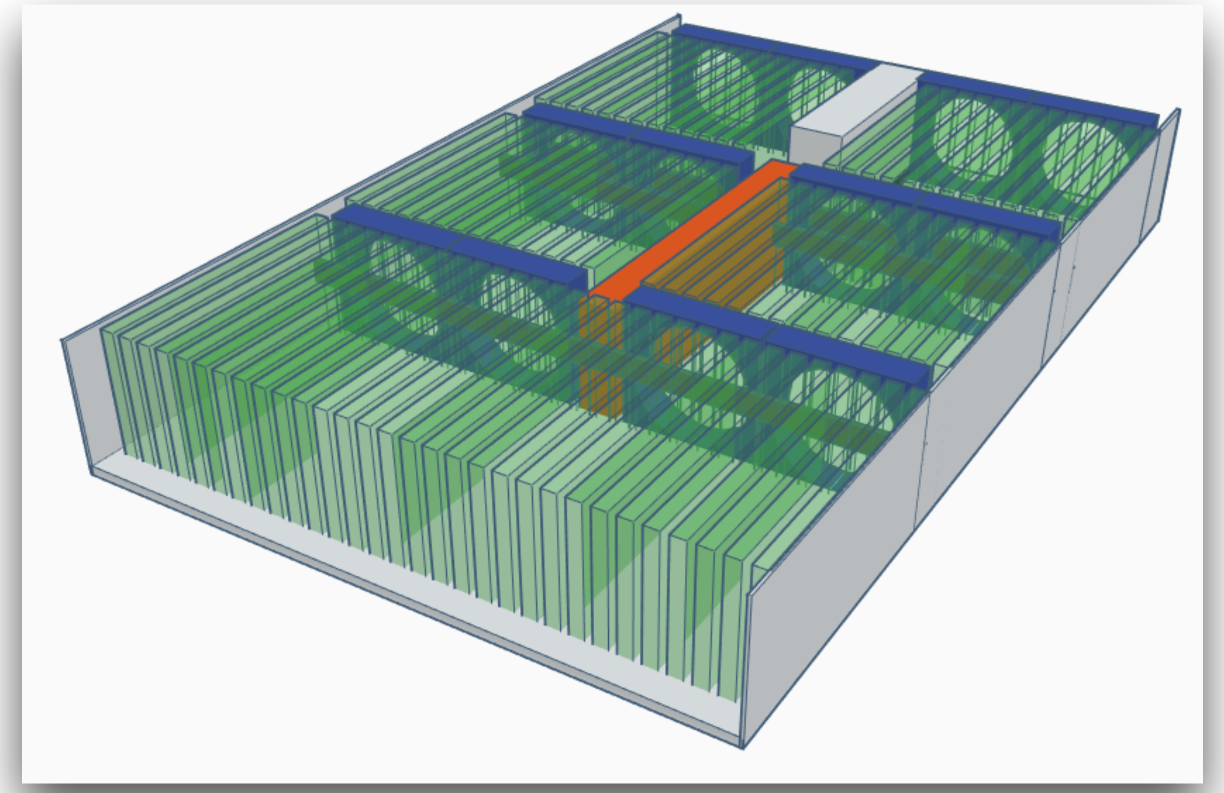
A: Lenovo Flex server
B: Our proposed server

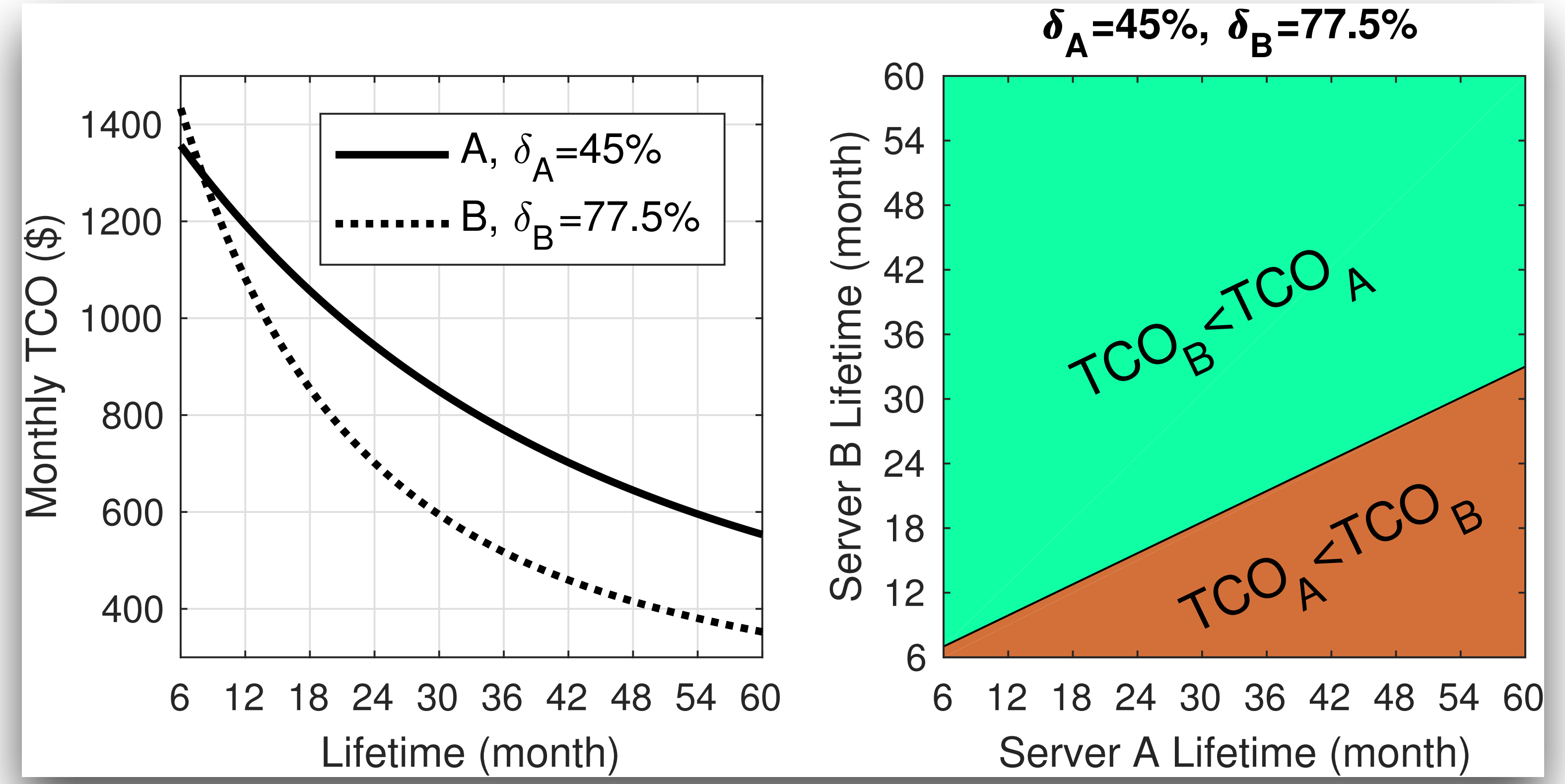


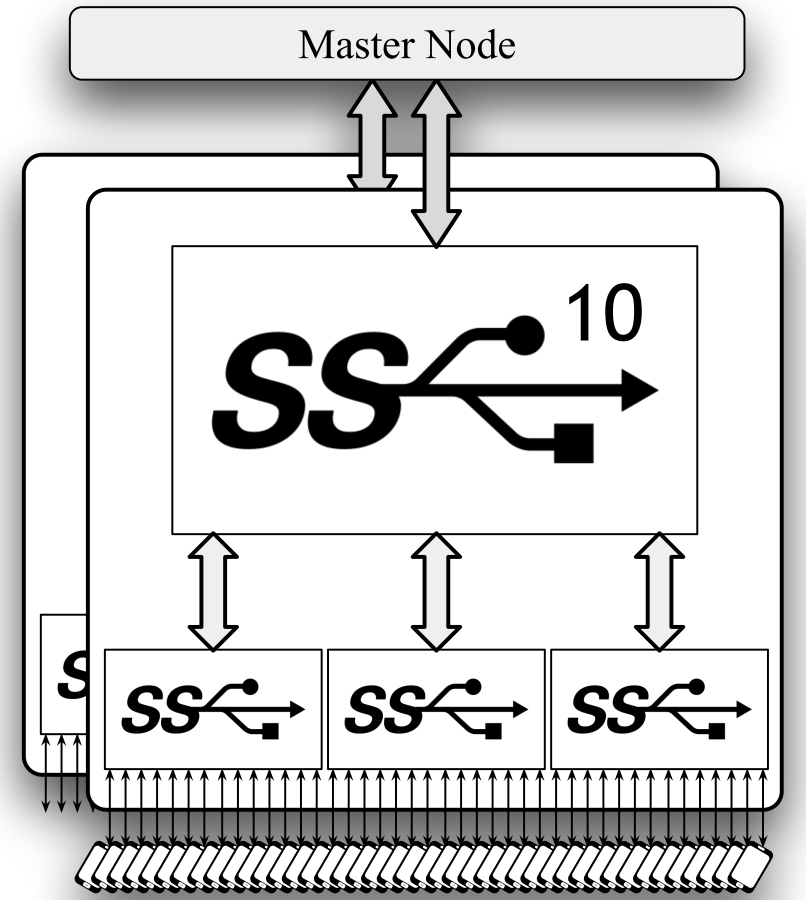
Thanks for your attention!

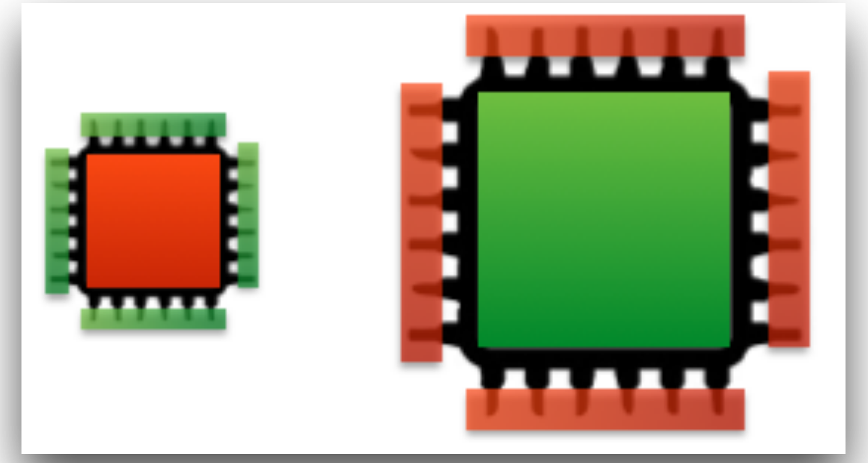












Next slide: Discussion Topics

Some Discussion Topics

- Reliability of used mobile devices under data center workload
- The best management scheme (centralized, distributed, server-level, etc.)
- Using SoC accelerators for domain-specific applications. (security, neural net, etc.)
- Dealing with extreme heterogeneity
- Security concerns with used phones