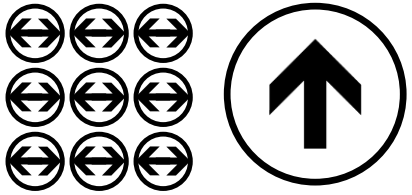
AppliedMicro X-Gene® ARM Processors

Optimized Scale-Out Solutions for Supercomputing

AppliedMicro X-Gene® Processor Philosophy

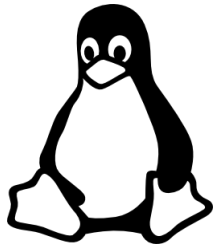
- **Few workloads are compute bound**
  - Most are limited by memory capacity, bandwidth, or I/O
  - HPC workloads are better served by GPGPU

- **Scale-out versus scale-up**
  - High density
  - Performance per Watt
  - Performance per $



- **Balance**
  - Strong CPU with an optimized ARMv8 core
  - Large memory capacity / bandwidth – adequate memory is not an upsell
  - Low power – power efficiency is not an upsell

- **Open Source**
  - Open Source Software
  - Open Source Hardware



A bit about X-Gene® ARM technology being deployed in the enterprise, today…

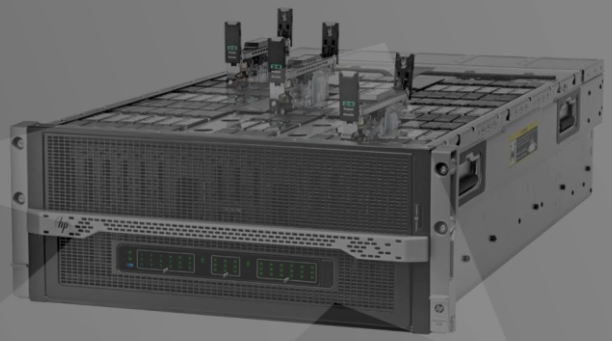
Emergence of the Optimized ARM Scale-Out Data Center

applied micro™

Real Solutions

Validated Results

Lower TCO



System Architecture

- *High Density*
- *Power-efficient*
- *Top-Tier Suppliers*

Apache

mongoDB

redhat

KVM

ubuntu

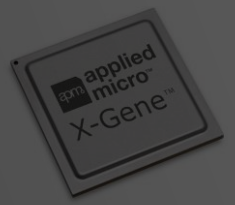
Xen

Linaro

CentOS

Software Ecosystem

- *Mature, optimized toolchain*
- *Broad Linux support*
- *Open-source workloads*



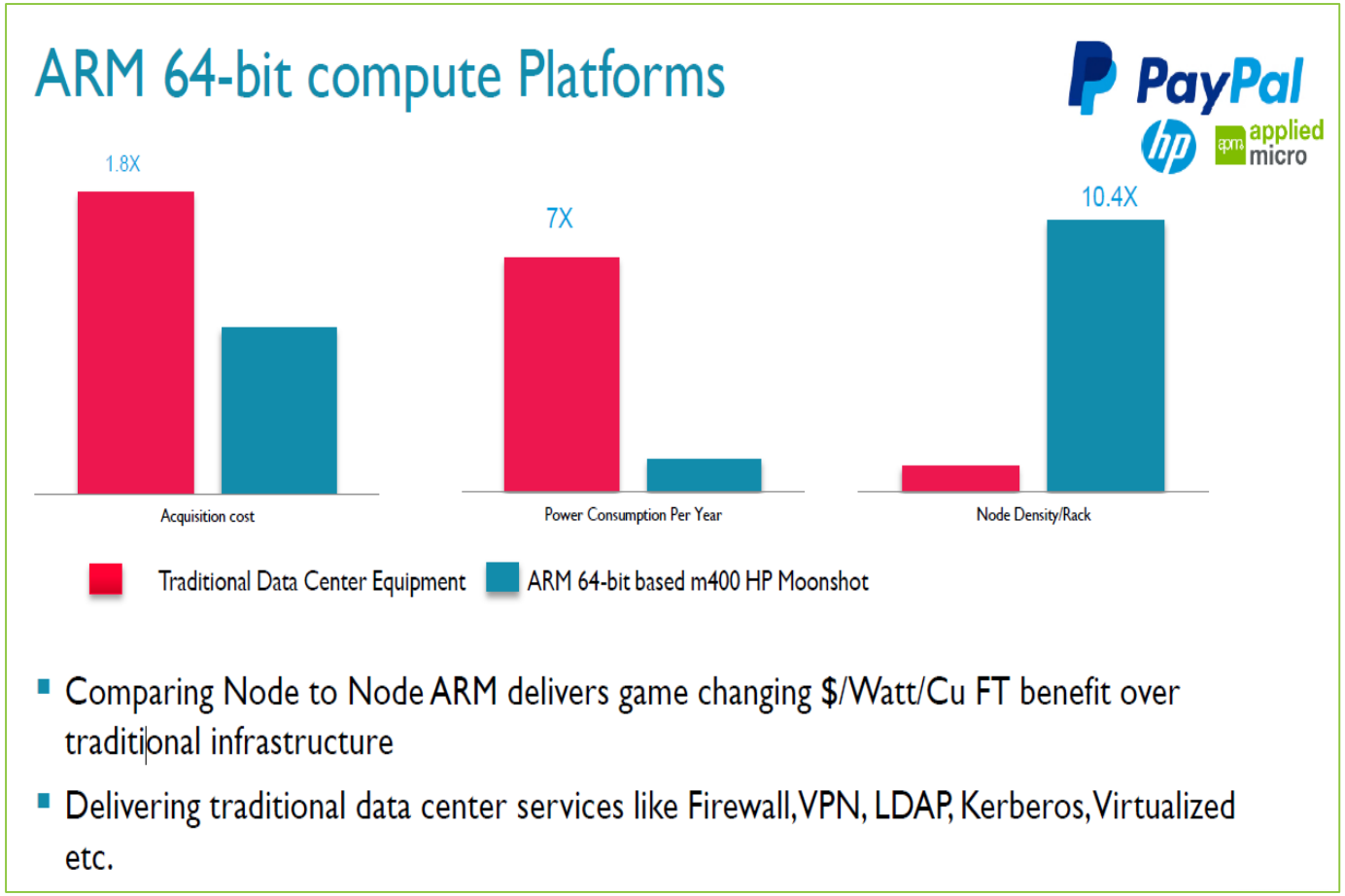
Processor Architecture

- *Strong compute*
- *Large memory*
- *Low power*
- *Cost-effective*

X-Gene® Technology in the Enterprise

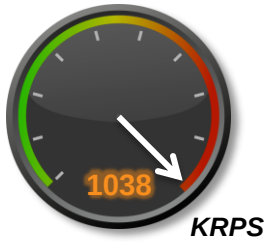
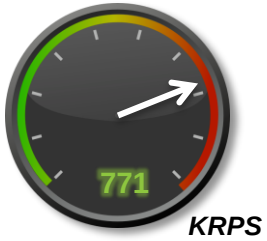
Demonstrating Value in Leading IT organizations - Today

- **Node Density / Rack**
  900% Higher
- **Power Consumption**
  85% Lower
- **Acquisition Cost**
  45% Lower



Source: PayPal

Real Workload Performance
Web Server (WRK Benchmark)

	Performance (higher is better)	**Latency** (lower is Better)	**Bandwidth** (higher is better)
AppliedMicro X-Gene® 2			
Intel Xeon® E5-2630v3			

X-Gene 2 (8c @ 2.4 GHz)
- *4 node 1U / ½ width sled*
- *64GB DDR3-1600*
- *4 x 10GbE (integrated)*
- *Wall power: ~190 Watts*

Xeon e5-2630v3 (8c/16t @ 2.4 GHz)
- *2P 1U / ½ width sled*
- *64GB DDR4-2133*
- *4 x 10GbE (NIC)*
- *Wall power: ~180 Watts*

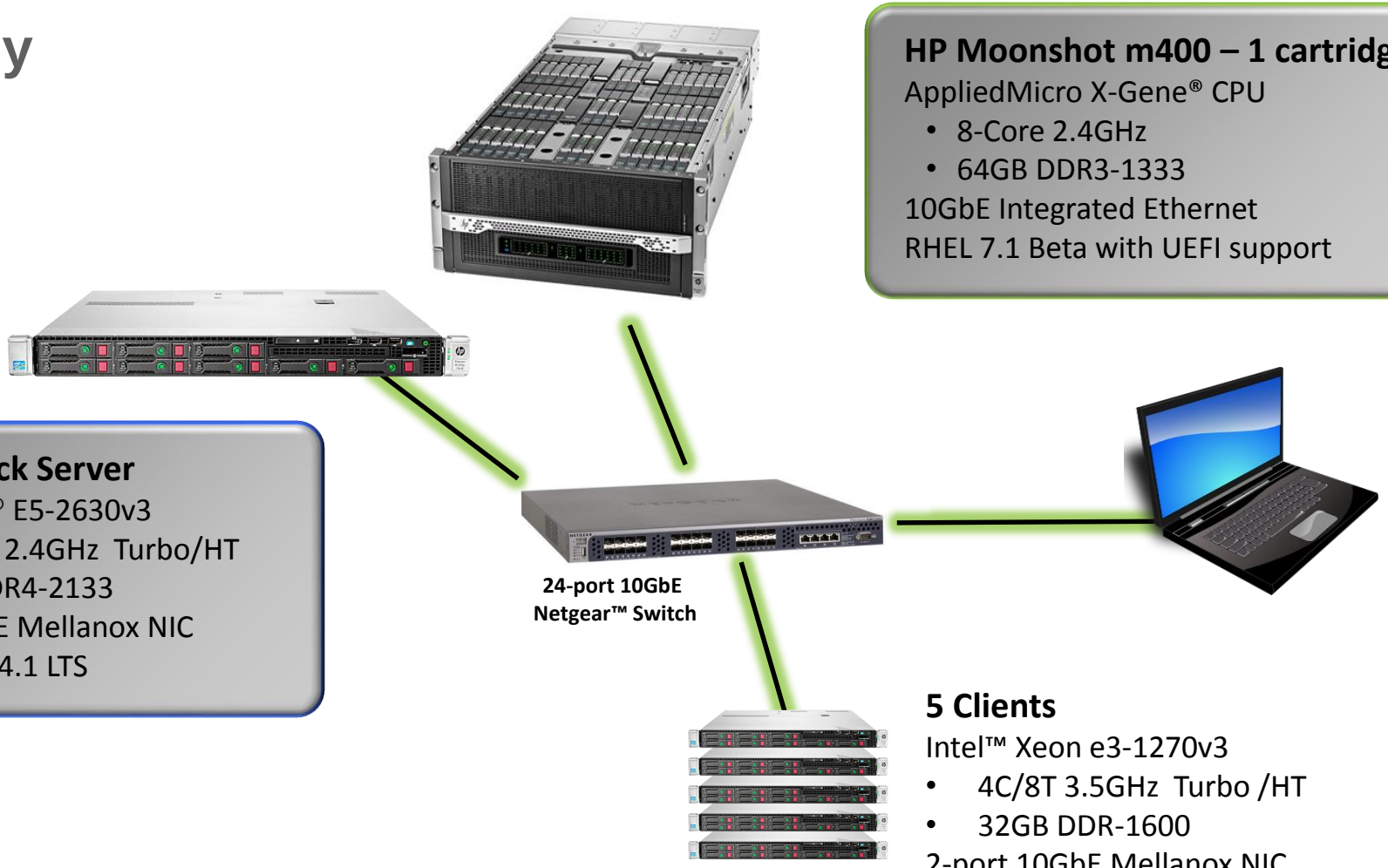
Up to 35% Higher Performance | Lower TCO

Standard CPU benchmarks do not always translate to delivered workload performance

Source: AppliedMicro

Real Workload Performance
In-Memory Database (MongoDB - YCSB)

Hardware Topology



HP Moonshot m400 – 1 cartridge
AppliedMicro X-Gene® CPU
- 8-Core 2.4GHz
- 64GB DDR3-1333

10GbE Integrated Ethernet
RHEL 7.1 Beta with UEFI support

1U / 2P Rack Server
Intel™ Xeon® E5-2630v3
- 16C/32T 2.4GHz Turbo/HT
- 64GB DDR4-2133

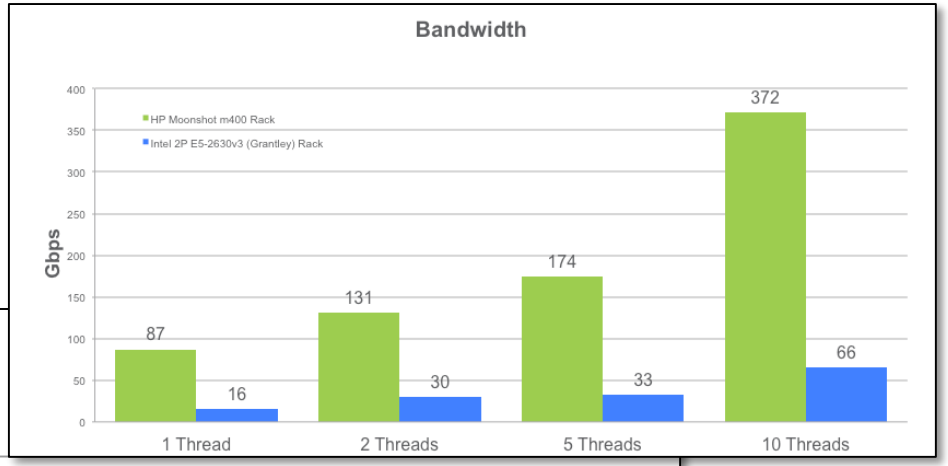
2-port 10GbE Mellanox NIC
Ubuntu 14.04.1 LTS

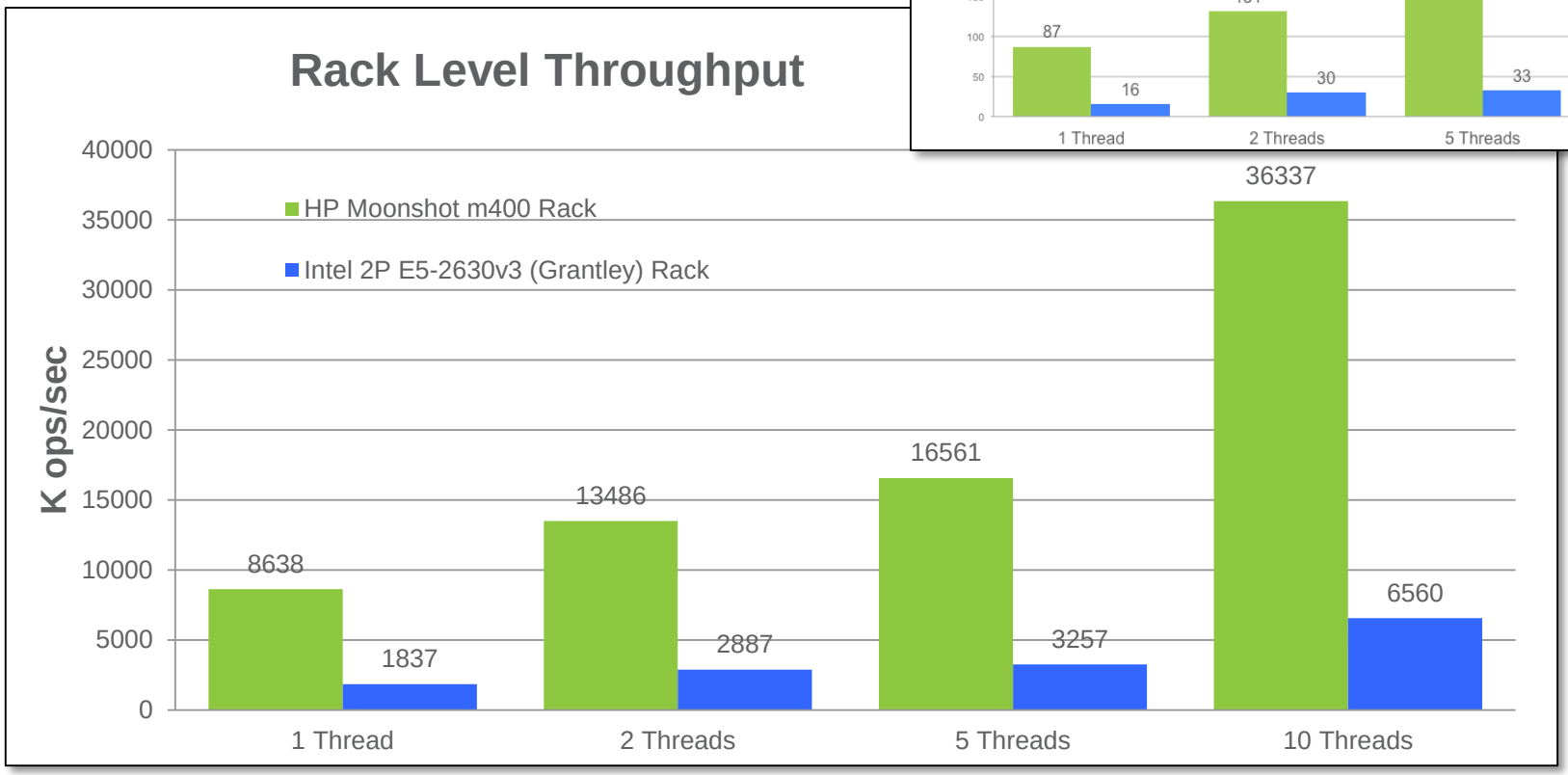
5 Clients
Intel™ Xeon e3-1270v3
- 4C/8T 3.5GHz Turbo /HT
- 32GB DDR-1600

2-port 10GbE Mellanox NIC
Ubuntu 14.04 LTS

Real Workload Performance
In-Memory Database (MongoDB - YCSB)

Rack-Level Scalability
5x the throughput of a Haswell Xeon® e5 2P rack server implementation





42U Rack, 9 Moonshot m400 chassis/rack

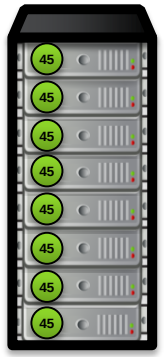
Lower TCO with X-Gene® Technology
Web / Application Tier @ 30kW/Rack

Traditional Intel Xeon® E5 2P/1U

270 Web Servers + 45 Application Servers

- Nine racks
  - 35 servers per rack
  - 2 TOR switches per rack
- 315 total nodes

HP Moonshot with m400 (X-Gene® CPU)



Web servers (32GB)

App servers (64GB)

270 Web Servers + 90 Application Servers*

- One rack
  - 8 Moonshot Chassis
  - 2 TOR Switches
- 360 total 1P m400 nodes

55%+ Hardware Acquisition Cost Savings

Additional TCO reduction via simplified management and lower power

Source: HP

X-Gene® ARM Processor Software Ecosystem

redhat

PEAP

ubuntu

openSUSE

debian

CentOS

Operating Systems

KVM

Xen

OpenJDK

ORACLE Java

Hypervisors & Java

theobroma SYSTEMS

GNU

Compilers

denx software engineering

UBOOT

TianoCore Open Platform Firmware Development

UEFI

American Megatrends

MEGARAC®

Management

Aptio

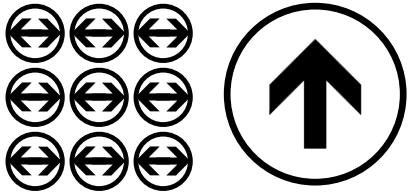
UEFI

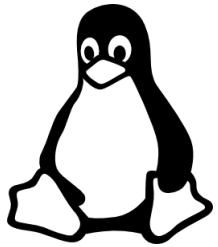
Tools & BIOS

…but what about High Performance Computing?

AppliedMicro X-Gene® HPC Philosophy

- **Workloads are compute bound**
  - …but ‘general purpose’ compute is not the path to exascale
- **Scale-out versus scale-up**
  - High density
  - Performance per Watt
  - Performance per $
- **Balance**
  - Power-efficient CPU with an optimized, power-efficient ARMv8 core
  - High performance GPUs for the ‘heavy lifting’
  - A better alternative to ‘brute force’ high performance computing
- **Open Source**
  - Open Source Software
  - Open Source Hardware





X-Gene® Processor Platforms

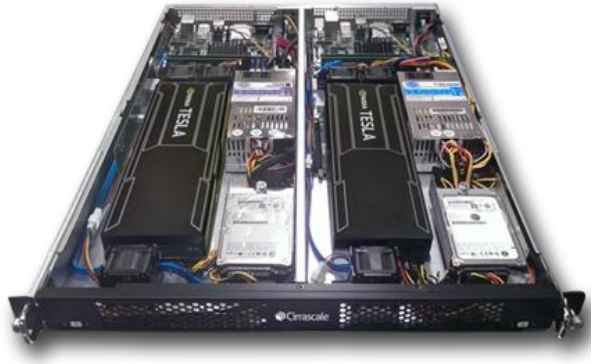
Multiple SKUs from Leading OEM and ODM Partners

Gigabyte MP30-AR0

applied micro™

Multiple New Platforms in Development

HP ProLiant m400



Cirrascale RM1905D

E4 ARKA RK003

Mitac Datun

The ARM Revolution has Expanded to Supercomputing

64-bit X-Gene® ARM Servers in production today

- The “one size fits all” data center is no longer sufficient
- AppliedMicro is powering the transition
  - Proven: real customers in production today
  - Performance: balanced 64-bit ARM compute with large memory
  - Economics: TCO savings via both lowered CapEx and OpEx

Sandia National Laboratories

“HP Moonshot is a first-of-a-kind system that’s enabling us to **extend the range of our calculations to solve really complex problems** in a highly efficient 64-bit architecture.”

James Ang, Technical Manager, Sandia National Laboratories

THE UNIVERSITY OF UTAH CloudLab

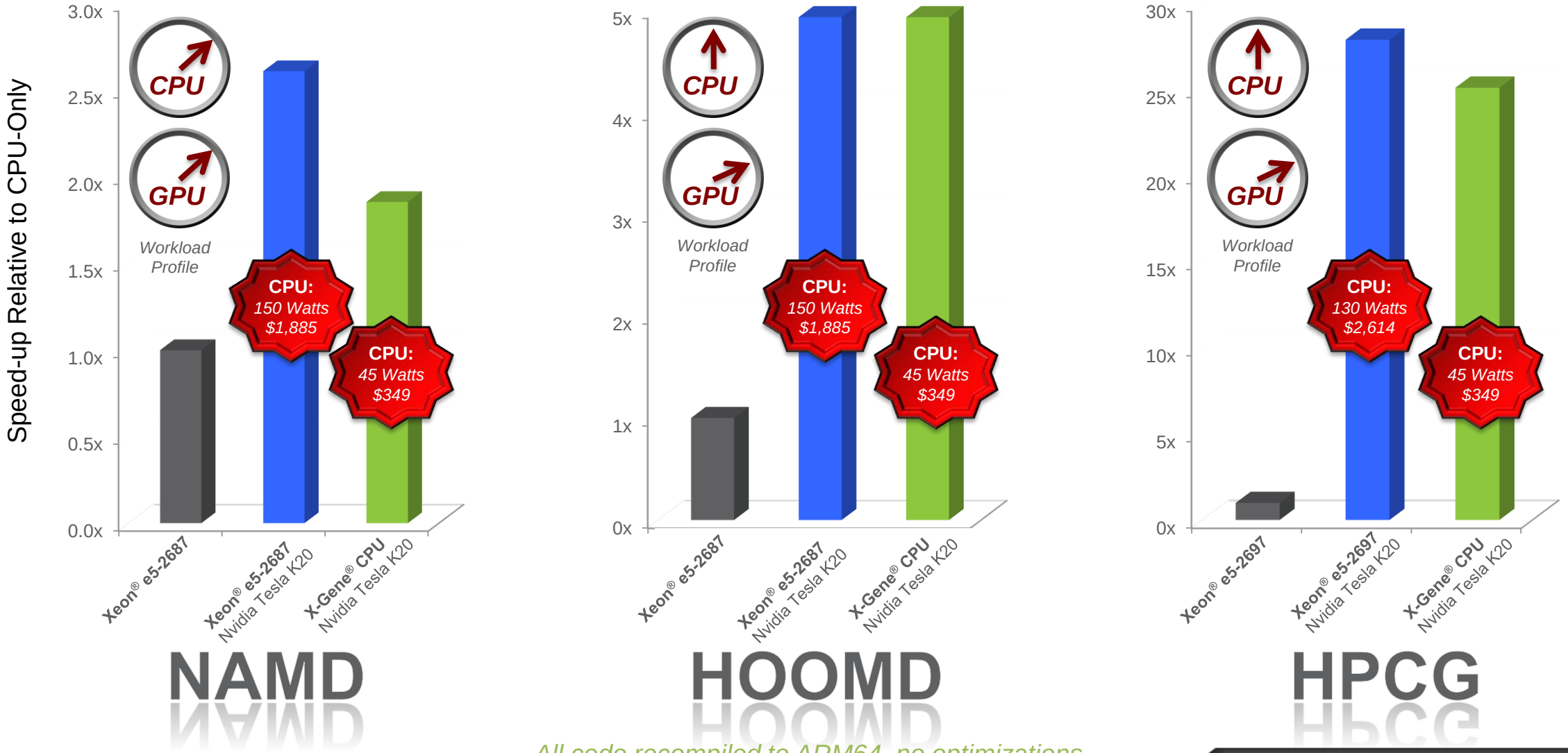
"HP Moonshot offers capabilities that will be critical to the future of cloud computing. It empowers researchers to **develop fundamental breakthroughs** that have the potential to change the performance, reliability, and security of future clouds.”

Robert Ricci, Research Asst. Professor of Comp. Science, University of Utah

University of Utah Cloudlab on 315 ARM nodes: https://www.youtube.com/watch?v=ylA4FKibfXU&sns=em

X-Gene® Processors in HPC

The Efficiency of ARM & the Power of Tesla™ GPUs



All code recompiled to ARM64, no optimizations

Source: nVidia

Delivering Performance that Matters.

There is a better answer to ‘brute force’ HPC: heterogeneous compute

Platforms with X-Gene® ARM technology and Nvidia GPUs is in production

The software ecosystem is established

The results are compelling

apm
applied
micro™