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Comparative Benchmarking of the First Generation of HPC-Optimised Arm Processors on Isambard

University of Bristol

http://gw4.ac.uk/isambard/

GW4

Isambard system specification

- **10,000+** Armv8 cores
  - **Cavium ThunderX2 32core 2.1GHz**
- Cray XC50 Scout form factor
- High-speed **Aries** interconnect
- Full Cray HPC optimised software stack
- **Technology comparison:**
  - **x86, Xeon Phi, Pascal GPUs**
- Phase 1 installed March 2017
- Phase 2 (the Arm part) arrives July 2018
- £4.7m total project cost over 3 years

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Isambard's core mission: evaluating Arm for production HPC

Starting by optimizing the top 10 most heavily used codes on Archer

- **VASP**, **CASTEP**, **GROMACS**, **CP2K**, **UM**, HYDRA, **NAMD**, **Oasis**, **SBLI**, **NEMO**
- Note: 8 of these 10 codes are written in FORTRAN

Additional important codes for project partners:

- **OpenFOAM**, **OpenIFS**, WRF, CASINO, LAMMPS, …

RED = codes optimised at the first Isambard hackathon

BLUE = codes optimised at the second hackathon

Isambard progress to date

- 8 early access (whitebox) nodes delivered mid October 2017
- We've been able to compile and run most of the hackathon codes **out of the box**
- Using Cray CCE, GNU and Arm Clang/Flang/LLVM toolchains
- Our systems were upgraded to B0 beta silicon in late Feb 2018
- Performance already looks very exciting
  - We released A1 single socket benchmark results at SC17
  - **First dual socket B0 results released here at CUG 2018!**


RAISING
STEAM
1ST ISAMBARD HACKATHON - BRISTOL
NOVEMBER 2ND & 3RD 2017


Isambard
STOKING
THE FIRE
2ND ISAMBARD HACKATHON-BRISTOL
MARCH 19TH & 20TH 2018

OpenCFD®

University of York

University of Southampton

KTH Vetenskap och Konst

ETH Zürich

University of Vienna

University of Bristol

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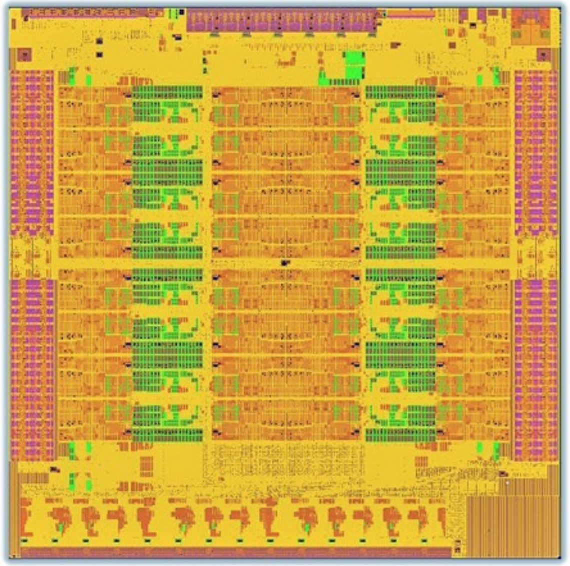
Processor	Cores	Clock speed GHz	FP64 TFLOP/s	Bandwidth GB/s
Broadwell	2×22	2.2	1.55	154
Skylake (Gold)	2×20	2.4	3.07	256
Skylake (Platinum)	2×28	2.1	3.76	256
Knights Landing	64	1.3	2.66	$\sim$490
ThunderX2	2×32	2.2	1.13	320

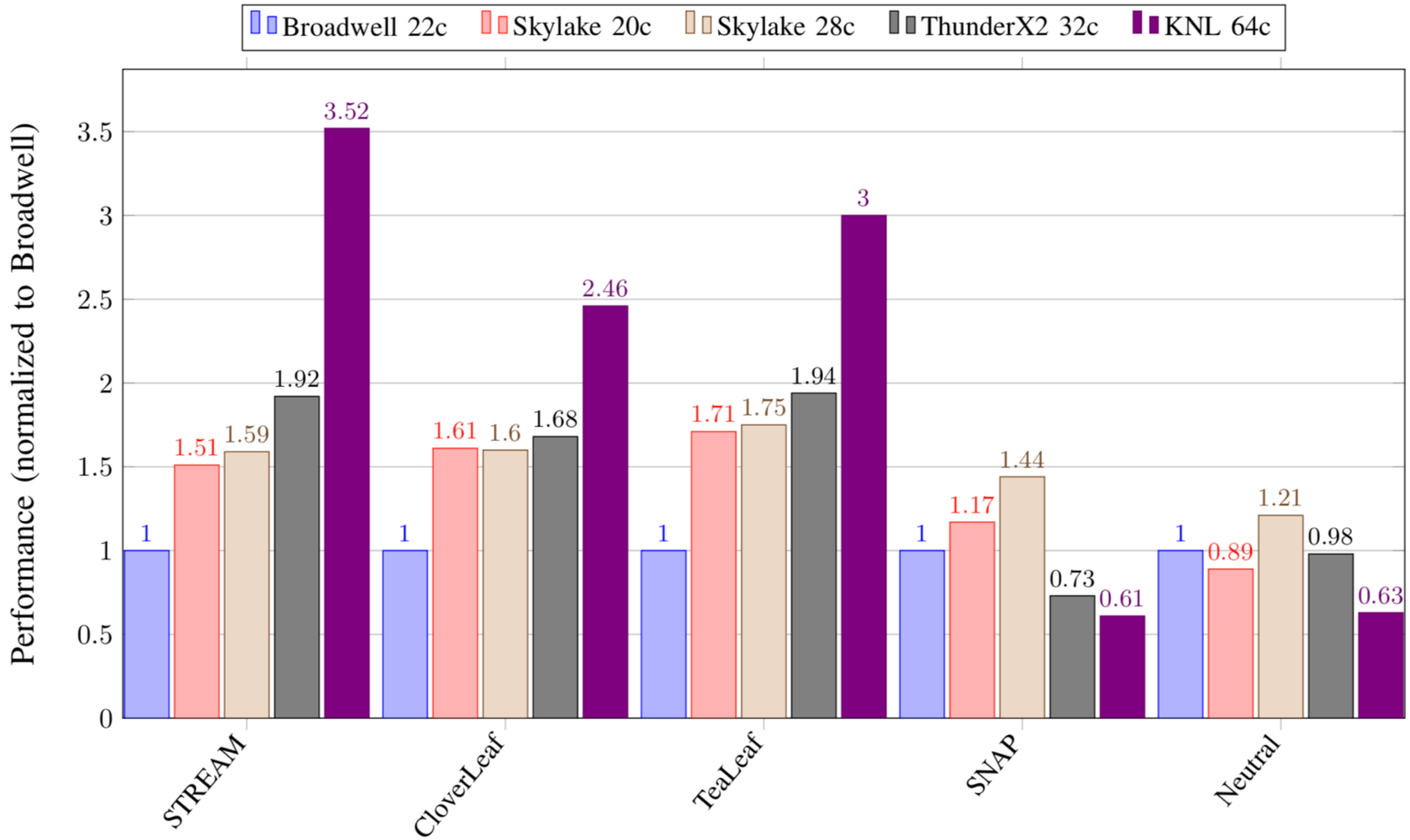
BDW 22c Intel Broadwell E5-2699 v4, **$4,115** each (near top-bin)
SKL 20c Intel Skylake Gold 6148, **$3,078** each
SKL 28c Intel Skylake Platinum 8176, **$8,719** each (near top-bin)
TX2 32c Cavium ThunderX2, **$1,795 each** (near top-bin)

Cavium ThunderX2, a seriously beefy CPU

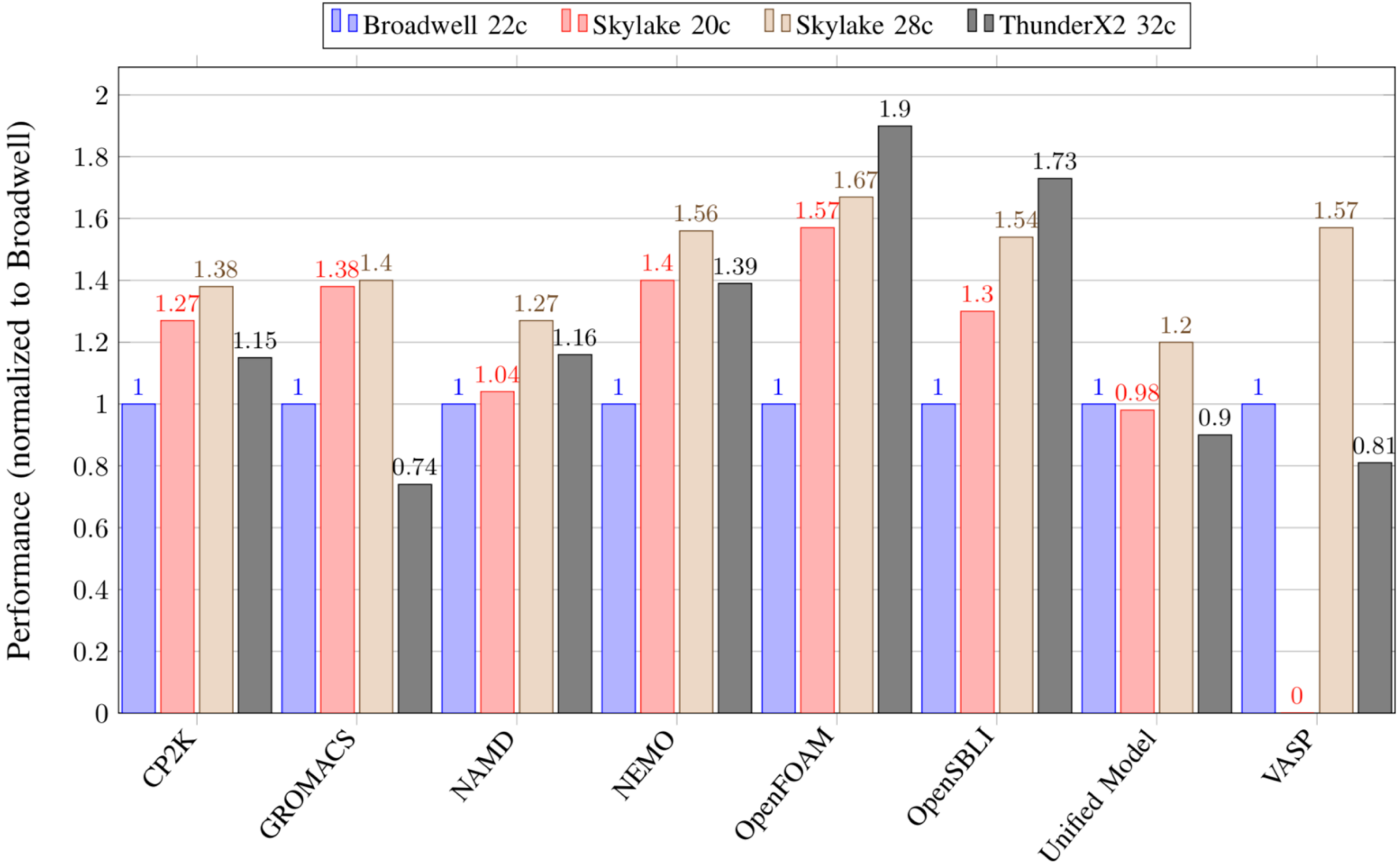


- 32 cores at up to 2.5GHz
- Each core is 4-way superscalar, Out-of-Order
- 32KB L1, 256KB L2 per core
- Shared 32MB L3
- Dual 128-bit wide NEON vectors
  - Compared to Skylake’s 512-bit vectors, and Broadwell’s 256-bit vectors
- 8 channels of 2666MHz DDR4
  - Compared to 6 channels on Skylake, 4 channels on Broadwell
  - AMD’s EPYC also has 8 channels

Performance on mini-apps



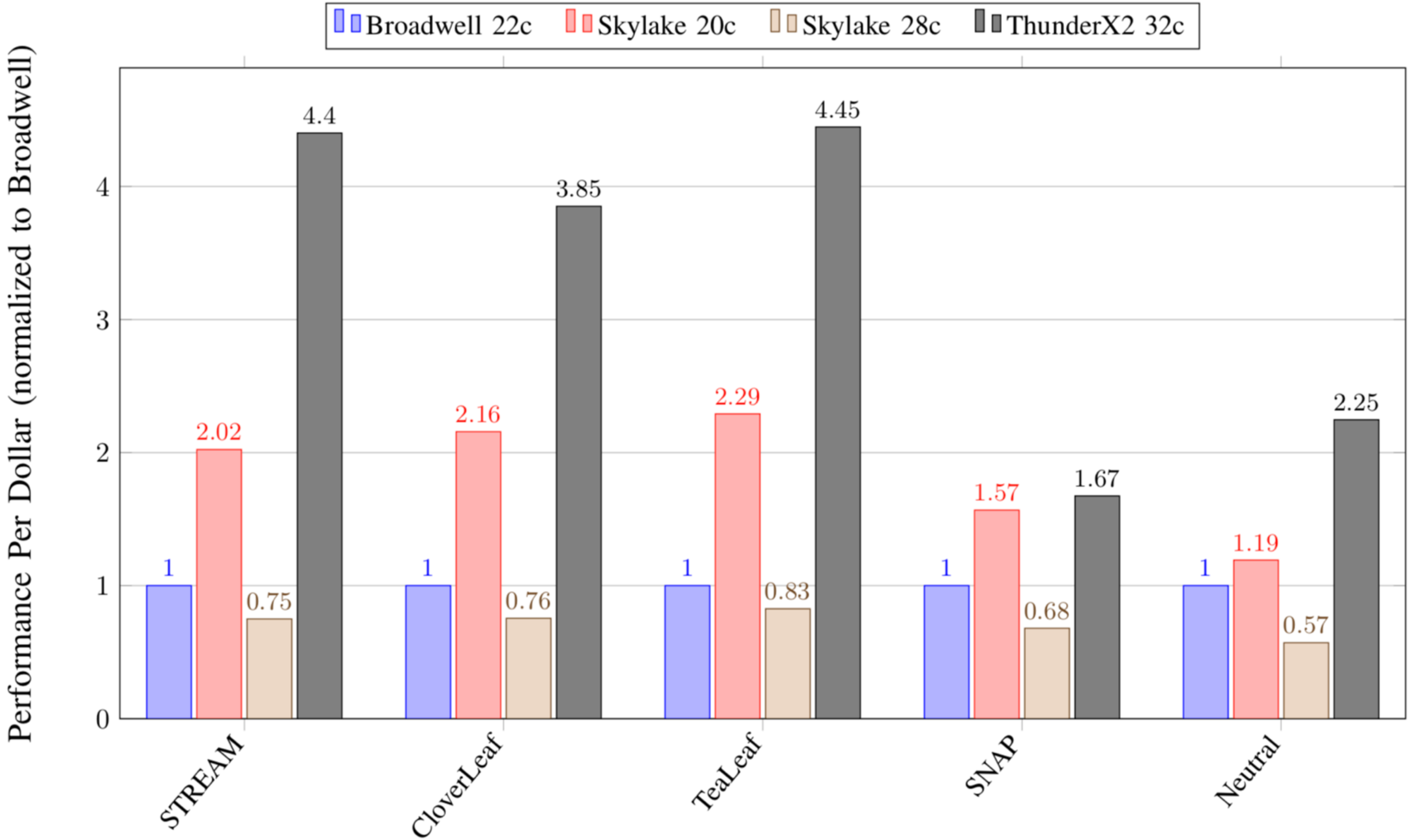
Performance on heavily used applications from Archer



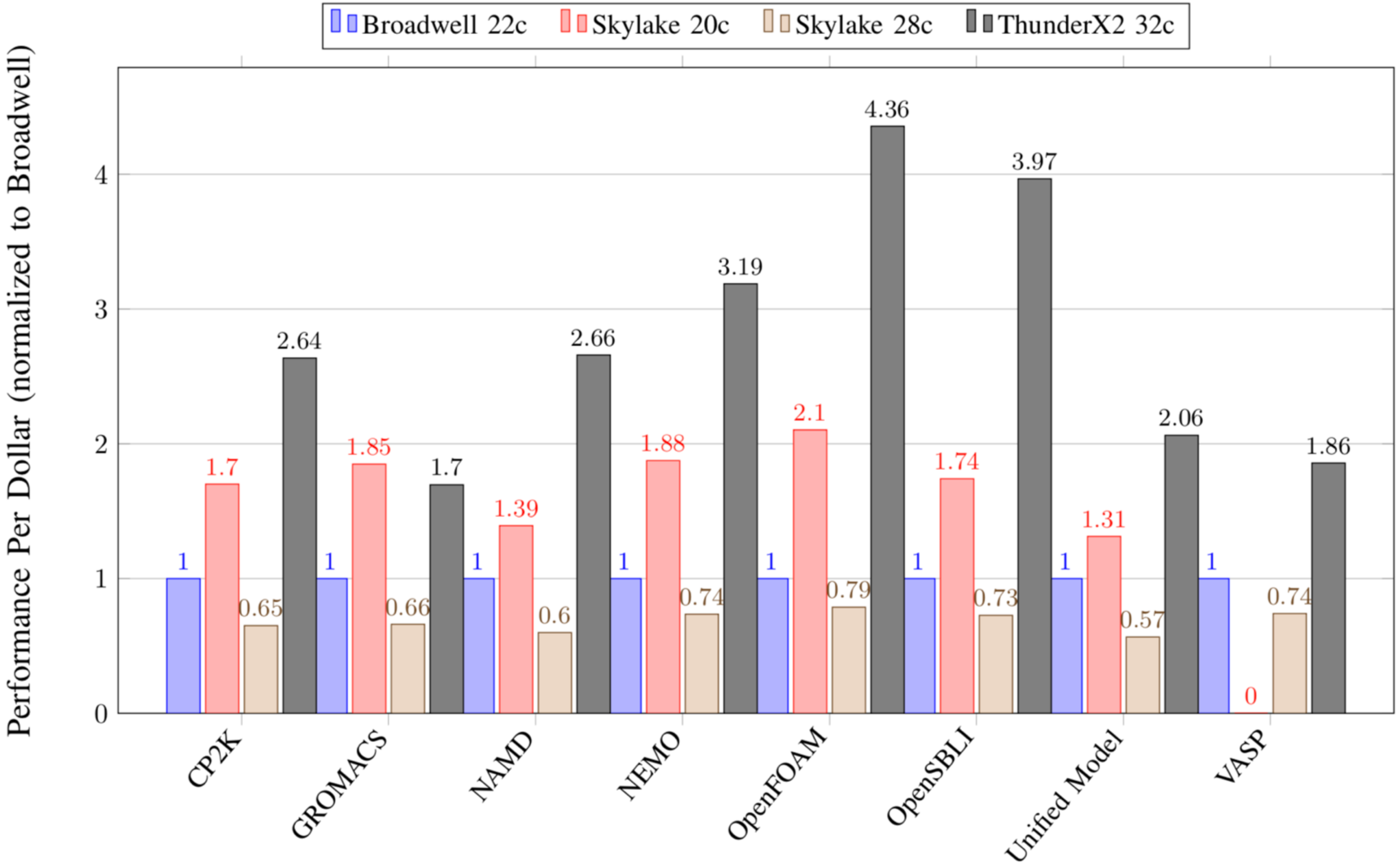
Comparing performance per Dollar

- Hard to do this rigorously
  - RRP is not what anyone pays
  - Whole system cost has to be taken into account
  - Purchase price vs. TCO
- However, we *can* form some useful intuition
  - The following charts were generated by taking the performance results, dividing by the official published list prices of the CPUs only, then renormalizing to Broadwell

Performance per Dollar: mini-apps



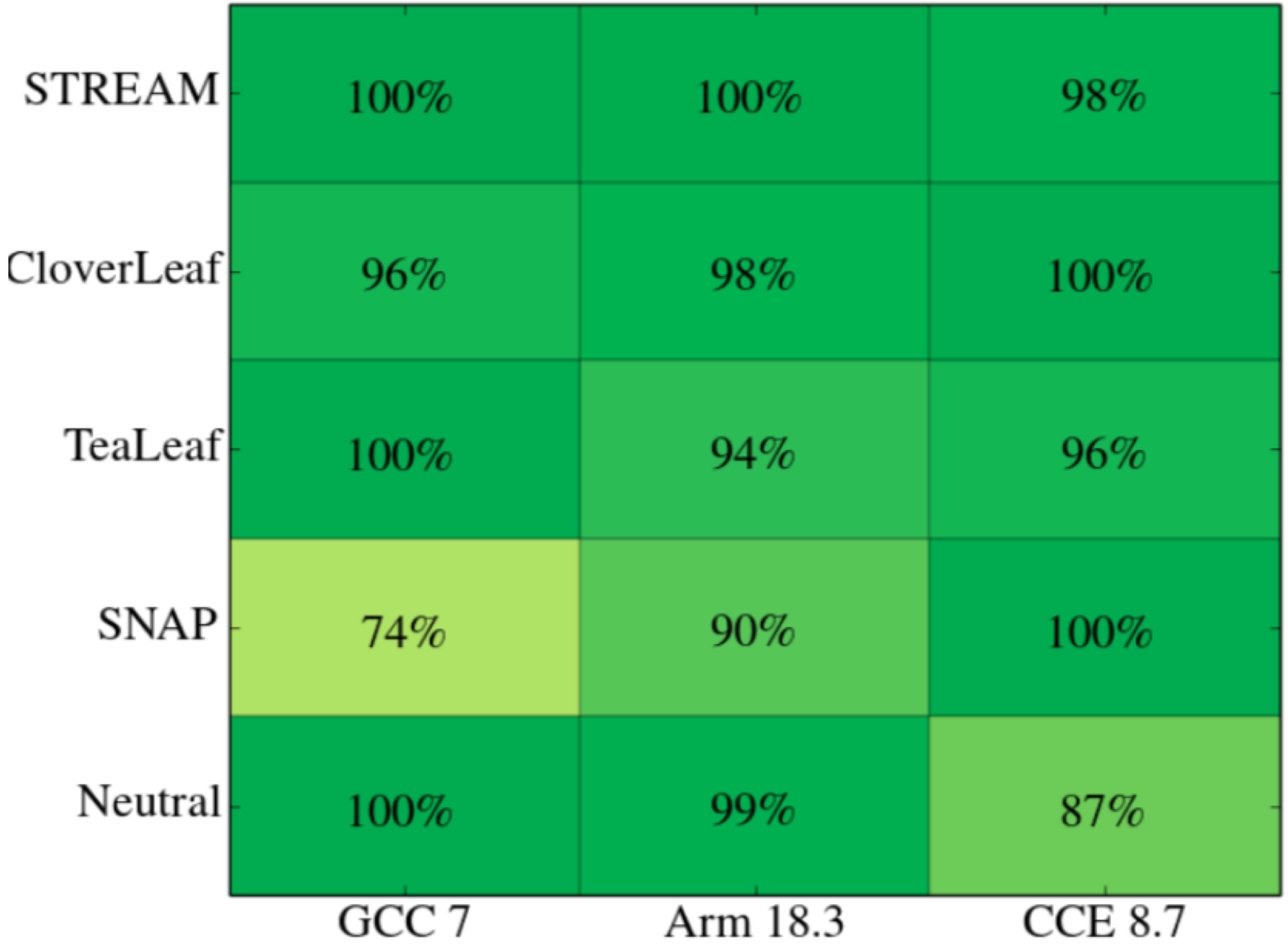
Performance per Dollar: applications



Key observations

- **For memory bandwidth bound codes** such as OpenFOAM and SBLI, **ThunderX2 has a clear performance advantage**
- **For compute-bound applications** such as GROMACS and VASP, the wider vectors of **the latest x86 CPUs win out**
- **For all the other codes we tried, ThunderX2 performance is comparable to Skylake**
- **The performance per dollar results are even more compelling for ThunderX2**

Comparison of compilers on Arm



Benchmark	ThunderX2	Broadwell	Skylake	Xeon Phi
STREAM	GCC 7	Intel 18	Intel 18	Intel 18
CloverLeaf	Arm 18.2	Intel 18	Intel 18	Intel 18
TeaLeaf	GCC 7	Intel 18	Intel 18	Intel 18
SNAP	CCE 8.6	Intel 18	Intel 18	Intel 18
Neutral	GCC 7	Intel 18	Intel 18	Intel 18
CP2K	GCC 7	GCC 7	GCC 7	—
GROMACS	GCC 7	GCC 7	GCC 7	—
NAMD	Arm 18.2	GCC 7	Intel 18	—
NEMO	CCE 8.7	CCE 8.7	CCE 8.7	—
OpenFOAM	GCC 7	GCC 7	GCC 7	—
OpenSBLI	CCE 8.7	Intel 18	Intel 18	—
UM	CCE 8.6	CCE 8.5	CCE 8.6	—
VASP	CCE 8.7	CCE 8.6	CCE 8.6	—

Conclusions

- Early results show **ThunderX2 performance is competitive with current high-end server CPUs,** while **performance per dollar is compelling**
- The full Isambard XC50 Arm system is due to be installed in July 2018, aiming to open for science by the end of the summer
- The signs are that **Arm-based systems are now real alternatives for HPC**

For more information

Comparative Benchmarking of the First Generation of HPC-Optimised Arm Processors on Isambard

S. McIntosh-Smith, J. Price, T. Deakin and A. Poenaru, CUG 2018, Stockholm

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