



Case study:

GW4 Alliance puts Arm architecture to the test for HPC



The success of the first Arm-based supercomputer is ushering in a new generation of supercomputers for the HPC community.

Project Isambard

- Isambard is set to be the world's first production Arm-based supercomputer
- Isambard will enable a like-for-like comparison of three different architectures, all from a single common system platform
- So far, the project has ensured that the most heavily-used HPC codes were tested and evaluated, with eight applications taken from the top ten most used codes on ARCHER (the UK's primary Tier 1 academic research computer)

Aims

- To explore the feasibility of an Arm-based system for real HPC workloads
- To provide a comparison of Arm performance against incumbent platforms
- To evaluate the readiness of the Arm HPC software ecosystem

Conclusions

- Arm is a real alternative for production quality supercomputing – with a rich and familiar software ecosystem
- Software porting hackathons found that with Arm “everything just works”
- An exciting future in the development of HPC has opened up

Background

The success of the first Arm-based supercomputer is ushering in a new generation of supercomputers for the HPC community.

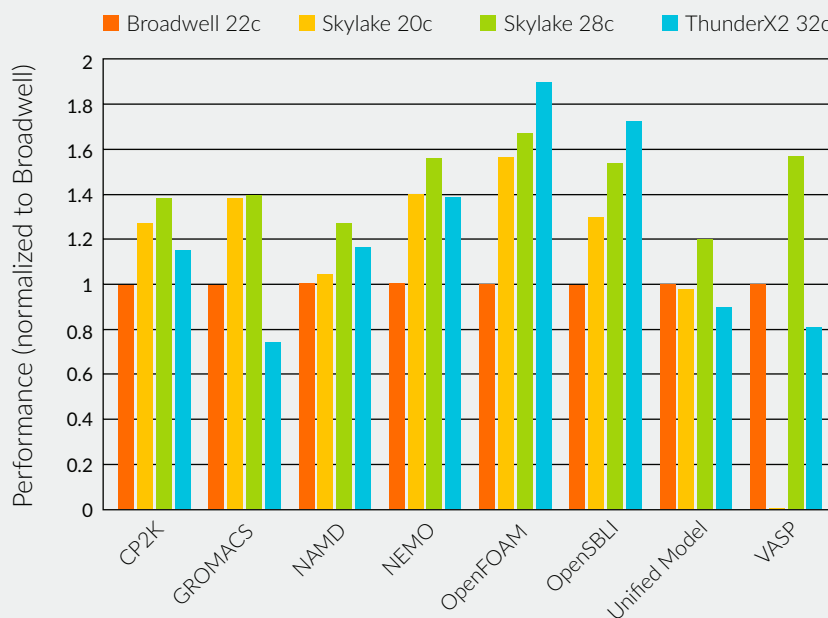
The GW4 Isambard project, funded by the Engineering and Physical Sciences Research Council (EPSRC), is a collaboration between the GW4 Alliance (formed from the universities of Bristol, Bath, Cardiff and Exeter) together with the Met Office, Cray, Arm and Cavium. The development of Isambard will change the future of supercomputing, opening up the path to greater hardware innovation and competition to give scientists more influence over the design of the processors.

Named in honor of the great British Victorian engineer, Isambard Kingdom Brunel, Isambard is a new Tier 2 HPC service for UK-based scientists. It has been designed to provide the first Arm-based Cray XC50 ‘Scout’ system, combining Cavium ThunderX2 CPUs with Cray’s Aries interconnect, as part of the UK’s national HPC service. It enables at scale performance comparisons as it includes over 10,000, high-performance 64-bit Arm cores, making it one of the first and largest machines of its kind anywhere in the world.

Performance

To explore the feasibility of an Arm-based system for real HPC workloads, it was important to test and evaluate heavily used codes. To provide a representative coverage of the styles of codes used, eight applications from the top ten most used codes on ARCHER (the UK's primary Tier 1 academic research computer) were chosen for the study, along with a selection of mini-apps, proxy applications, and applications from project partners. The codes used are relevant to a wide range of sciences including weather modeling, computational fluid dynamics, and even biosciences. Together, they make up 50% of ARCHER usage.

For memory bandwidth bound codes such as OpenFOAM and SBLI, Arm-based processors have a clear performance advantage. This is due to the superior memory bandwidth offered by the Cavium ThunderX2 Arm processor's eight memory channels, which can achieve 249 GB/s for the STREAM Triad benchmark, around 33% more than mainstream x86-based processors. However, compute-bound applications such as GROMACS and VASP perform better on the latest x86-based CPUs, due to their wider vector registers. For most other applications, their performance on Arm-architecture processors is comparable to mainstream x86-based architectures.



The project ran two intensive hackathons attended by around 40 people and all agreed it was an excellent user experience. With access to three different compilers including Cray's own compiler, Arm's Allinea Studio compiler, and the open source GNU toolchain, there were no unexpected software issues and all involved were impressed by the maturity of the software. The main porting effort required was typically to tune the software to the hardware parameters, such as number of cores, number of hardware threads and the size of memory caches.

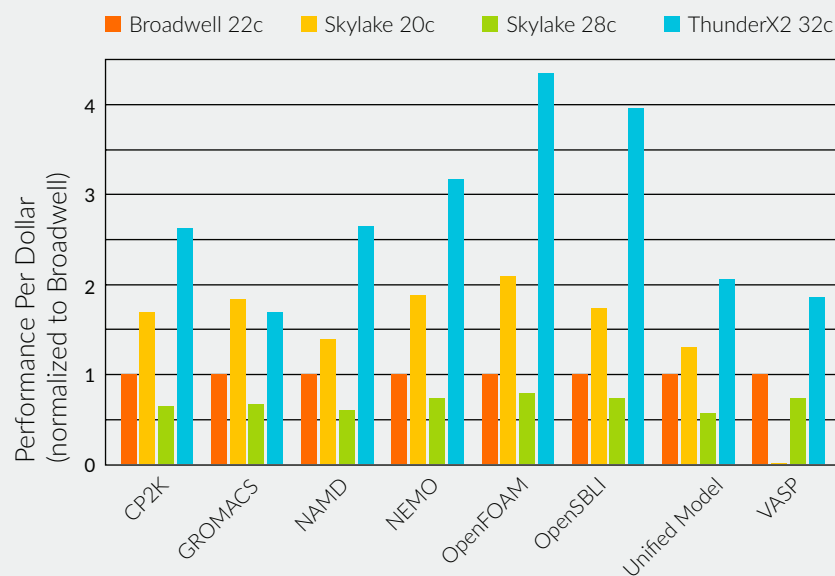
"We have summarised the experience as 'everything just works',"

says Professor Simon McIntosh-Smith, leader of the project and Professor of High Performance Computing at the University of Bristol. "Almost everything we tried was compiled and built to run out of the box. In the future, the user experience to port their application will be to simply compile and run it. It will not be obvious that it is Arm-based and not x86."

The Isambard project demonstrated that Arm-based processors are now capable of providing levels of performance competitive with state-of-the-art offerings from the incumbent vendors. Using the published list prices of the CPUs to compare the respective performance per Dollar of the processors, a metric was devised. This figure is essentially based on normalized performance divided by cost. Performance per dollar for Arm-based processors was also very compelling. This represents an important milestone in the maturity of the Arm ecosystem for HPC, where these processors can now be considered as viable contenders for future procurements.

Benefits for the HPC and wider scientific community

Competition is one of the greatest concerns for those in the supercomputing industry. As the main vendors become more dominant, innovation slows down, choice reduces, and pricing concerns are raised. The Isambard project's findings will change this.



"What we are really exploring is possible routes to new innovations and exciting new developments for High Performance Computing"

says Simon. "In HPC in general, the rate of innovation over the last five to 10 years has slowed down. The systems we are buying today are not significantly different to those we were buying five years ago. The Arm ecosystem is going to be one of the keys to re-stimulating competition, reinvigorating the high performance computing hardware ecosystem."

Arm is a relatively new entrant into the HPC space. Arm licenses the design of CPU cores to companies that make CPU devices. This has enabled several companies that are new to HPC to design CPUs for the HPC market, significantly changing the competitive landscape. The Arm ecosystem therefore includes everyone making Arm based processors and everyone using Arm based software. With multiple production-quality compilers now available for 64-bit Arm processors, developers can have confidence that real applications will build and run correctly, in most cases with no modifications.

"We are talking about invigorating competition between a few monolithic vendors and a whole flexible ecosystem that has different partners designing different chips, at different price points, choosing different trade-offs between core counts, vector widths, memory bandwidth and so on. This ecosystem brings with it lots of software and people who are familiar with the ecosystem. The competition will not be between Arm and the incumbents, but between the whole Arm ecosystem and the incumbents."

The Arm ecosystem will also lead to those involved in HPC having more input into specific processor designs. There is currently little control over the design of processors designed for HPC - high end CPUs are specialist, expensive and built primarily for the hyperscale internet companies such as Google and Facebook. While the number of cores can be selected by customers, there is little or no influence over the rest of the processor design. But the presence of new players in the market will allow scientists to work with the vendor community and Arm to influence processor design to a much more significant degree – a huge step forward for supercomputing.

One aim of Isambard is to enable users to test different platforms side-by-side. The trial will help scientists choose the best architecture for their applications as they have a single platform where they can test out their applications on a range of HPC hardware enabling them to do like-for-like comparison.

"The only area where I think the Arm ecosystem still needs some development is in Math libraries," says Simon. "These are complicated things that take decades to optimize and to add all the functions and features that you want. Where the Arm maths libraries are today is already pretty good, but this is an area where I'd expect to see continued investment and improvement in the future."

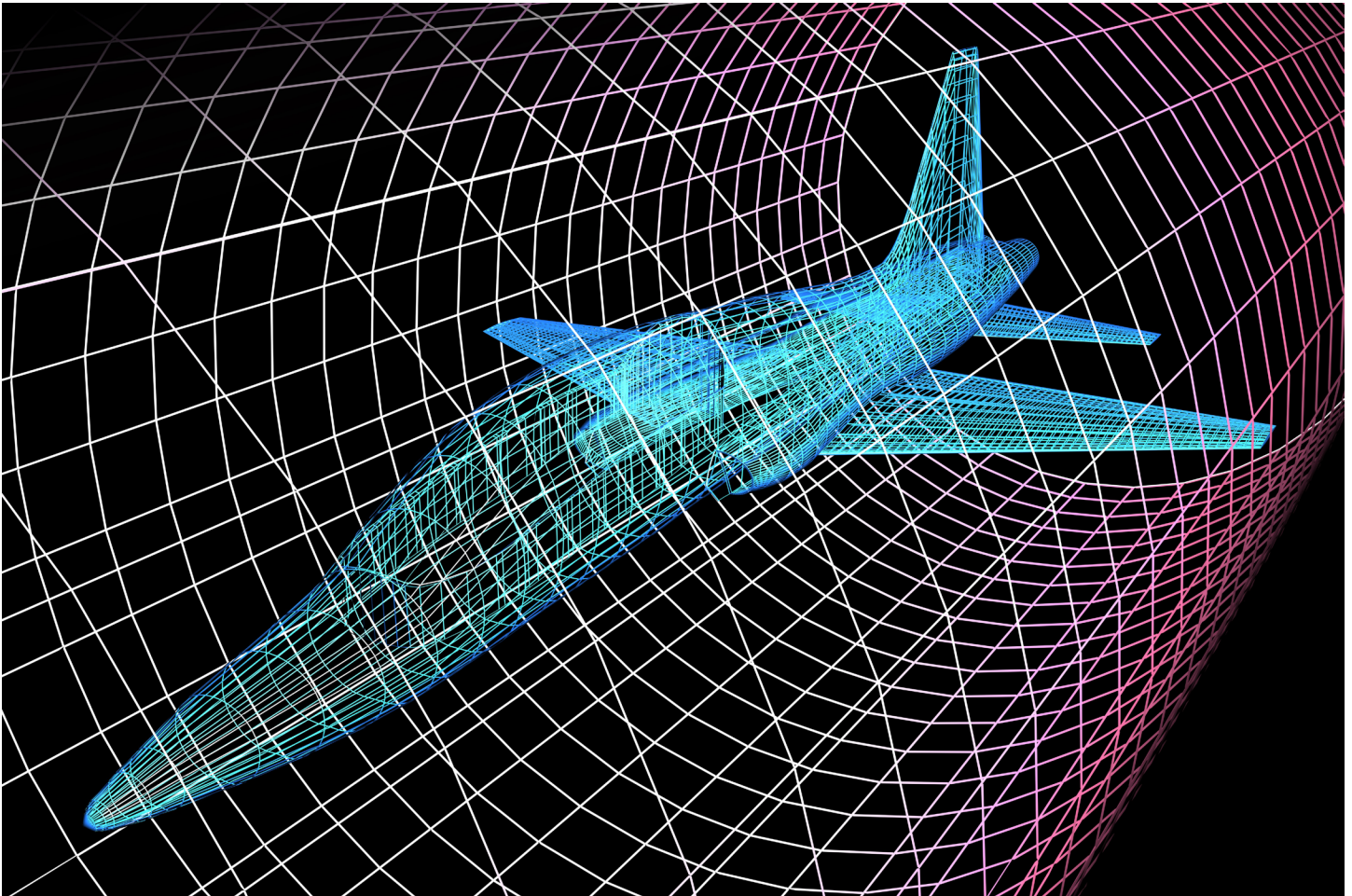
The future

The full Isambard system will be delivered in the summer of 2018 when it will offer a real opportunity for scientists to influence hardware design, boost competition and drive innovation. And with the HPC Arm community now talking to people in the UK and US looking to build an Arm-based exascale machine, Simon is already thinking about Isambard 2.

"We are already exploring future designs that might better suit scientific codes and are getting to talk to the architects in detail in ways we've not been able to do before"

Arm has plenty to offer the HPC world. Ease of use, robustness and performance are all vital to HPC service and the success of Isambard has shown it is a viable alternative to the existing dominant systems, offering CPUs with a performance to match current best-in-class CPUs.

"Arm has been a positive, supportive partner who is contributing to what really makes a difference," Simon concludes. "Isambard has shown that Arm processors are competitive in HPC, ushering in an era of wider architectural choice, with greater opportunities for differentiation between supercomputer vendors. These outcomes should mean that scientists can choose systems more highly optimised to solve their problem, thus delivering even more exciting scientific breakthroughs at greater cost effectiveness than ever before."



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