High Performance Computing: Where Is It Going?

Kanta Vekaria PhD
This is no ordinary talk!

- Your participation is required……
- As per Linaro’s ethos
- Keep your gadgets ready!

http://linaro.co/hpcx
High Performance Computing

How many do you recognise?
High Performance Computing

1949 ENIAC (Electronic Numerical Integrator And Computer)

1960 Control Data Corporation (CDC) 1604

1964 IBM 360 Model 75

1984 Cray X-MP

1993 Fujitsu Numerical Wind Tunnel
Processing Power Compared

Source: https://www.experts-exchange.com
What is equivalent to the Tianhe-2?

- 33.86 PFLOPS
- 32,000 Intel Xeon
- 48,000 Xeon Phi
- 3.12M Cores
- 1.4PB RAM

How many PlayStation 4s’?

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Processing Power Compared

Source: https://www.experts-exchange.com
HPC - Recap

- BKK16 - Eric Henneneofer from Arm Research
- BUD17 - David Abdurachmanov from CERN
- BUD17 - Chris Adeniyi-Jones from ARM
- Fujitsu, Riken and the Post-K Supercomputer
HPC - Why AArch64?

● 2011: Arm’s first step into the world of HPC via the Mont-Blanc Project
● Competitive on a per core and per socket basis
● The HPC community wants multivendor options
  ○ Strategic requirement - Intel is all proprietary
  ○ Arm ecosystem brings choice and a path to better optimized solutions
  ○ Co-design and Co-development
  ○ Adopting standardisation to achieve platform compatibility
  ○ Arm Scalable Vector Extension (SVE) as a standard architecture
  ○ Massive parallelism is requiring changes to software
  ○ Utilisation of open source software
  ○ Opportunity to modernise software

FORTRAN Matters!
Recent Headlines

- Bull Sequana X1310 the first commercial supercomputer to use Arm processors (Cavium ThunderX2)
- Penguin Computing: Tundra Extreme Scale also featuring Cavium ThunderX2
- “The Machine” research project - HPE
- GW4 Tier-2 HPC service: Isambard - Cray CS-400 system with 10,000+ Arm v8 cores, led by the University of Bristol
HPC - Why Linaro?

- HPC has a large (and growing) open source component
- Some customers require multiple tools chains: proprietary and/or open source
- Library optimisations that benefit all micro-architectures
- A place to co-develop
- Root the foundations to make choice easier
HPC Special Interest Group

Collaborative project building on the work of the Linaro Enterprise Group (LEG)

Driving enterprise-class, open-source HPC development on Arm
Identify and adopt standards in to make HPC deployment on Arm a commercial imperative. Develop real-world use cases that reap the benefits of Arm while ensuring interoperability, modularization, orchestration.

Lower deployment & management barriers
Leverage the Linaro Developer Cloud and other services to develop cost-effective Cloud-based HPC development frameworks and generate reference implementations to accelerate.

Enable the data-driven economy
Machine learning and Deep learning are both critical to the future of HPC. Specifically as the path toward exascale computing. Driving engineering in HPDA and Machine learning algorithms will aid the success of organizations to fully capitalize on these technologies.

Member-driven with Advisory Board
Members determine work completed by engineering resources while advisory board provides subject matter expertise on HPC requirements and guidance and feedback on ongoing HPC SIG strategic direction and roadmap.
### Long Term Strategic Scope

#### HPC
- OpenHPC - Arm enablement, Cloud CI
- Scalable Vector Extension (SVE) for ARMv8
- Dev Tools
  - Compiler optimisations
    - LLVM and GCC for Fortran and C optimisations
    - openMP
  - QEMU
  - Standardised profilers and debuggers
- HPC Orchestration
  - OpenHPC
  - Other OS Packages (SLURM)

#### HPDA
- Mapping key algorithms to a specific industry
- Library optimisations
- Datasets
- Network I/O feeds

#### Application Libraries
- Math and scientific libraries optimised for ARMv8
- MPICH, FFTW, BLAS, cuBLAS, LAPACK, openBLAS, MPI, ScaLAPACK
- And more.....

#### Machine Learning
- MLDM algorithms
- MaTEx
- Research emerging ML projects
- FPGA

#### Runtime auto detection of micro arch.
The Beginnings: OpenHPC

- Open Source HPC Software components
- Supports both Arm and Intel
- Latest Release: OpenHPC 1.3.2
- Arm Developer Preview - Still lots to do!
- TSC Member: Renato Golin (Test Coordinator)
Have you been involved in Deep Learning?

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HPC for Today’s Data-Driven Economy

- **Machine Learning**
  - Program it so that it can ‘learn’ by itself
  - Supervised
    - Neural networks
  - Unsupervised learning
    - Reinforcement Learning
    - Evolutionary algorithms

- **Deep Learning**
  - A form of machine learning
  - Typically Neural Networks
  - Convolutional Neural Network (CNN)

- **How it fits in with HPC**
  - Coupling computational science and machine learning
  - Allows training of models over larger data sets and quicker iterations
  - Supercomputers designed for both computational science as well as machine learning.
Is the term "AI" becoming diluted?

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And what about Artificial Intelligence?

- Everyone is talking about it, even my CEO!
- The term is turning up everywhere
- Meaning is becoming diluted
- ‘True AI’:
  
  Replicate many aspects of human intelligence and become an entity in its own right.
- Tesler’s Theorem “Intelligence is whatever machines haven't done yet”

Google’s neural net-generated dumbbells, complete with phantom limb. (Image credit: Google)
HPC is going mainstream

- Once was the exclusive domain for Scientific Computing
- HPC brings the benefits of advanced algorithms to users at scale.
- Datacentres with HPC environments
- HPC Cloud
  - HPC environments are expensive

- Containerised HPC
  - Cloud HPC environments are also expensive
  - Containers working on bare-metal and cloud provide flexibility and management of workloads.
  - Varied setup for different applications
  - Easy migration to newer software versions

- .....but where does the data live?
HPC for Scientific Computing

- Petaflops was yesterday’s news
- Big movement to exascale computing (exaflops)
- What architecture is going cut it?
  - Co-design
- How do we scale?
  - System power. 200MW no way!
  - Memory bandwidth and capacity
  - Decreasing clock frequencies to conserve power
  - Needs high concurrency
  - Cost of data movement is high and needs to be minimised
  - What about changes to compilers?
And then there is Quantum Computing

- Paul Benioff first applied quantum theory to computers in 1981
- Qubit 0, 1, and both simultaneously
  - Represent subatomic particles
  - Potential to be millions of times more powerful
- Quantum computers could one day replace silicon chips
- D-Wave Quantum Computer

“IBM makes breakthrough in quantum computing” - 14th Sept 2017
“Scientists try to speed up the internet with quantum computing” - 18th Sept 2017
Will we ever get True AI?

http://linaro.co/hpcx
Get involved!

- [http://arm-hpc.gitlab.io](http://arm-hpc.gitlab.io)
- [https://www.linaro.cloud](https://www.linaro.cloud)
- [https://github.com/openhpc/ohpc](https://github.com/openhpc/ohpc)
- [https://github.com/showcases/machine-learning](https://github.com/showcases/machine-learning)

- Tuesday: Reliability, Availability, and Serviceability (RAS) on Arm64 status

- Wednesday:
  - AArch64 Vector Optimizations for Glibc
  - Benchmarking at TCWG

- Thursday: Datacentre Day
  - HPC BoF “Developer’s Journey”
  - An Overview of Post-K Supercomputer Development in Japan

- Friday: Deep Learning on Arm Platforms
Thank You

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Keynotes and videos on: connect.linaro.org
For further information: www.linaro.org