FUJITSU

shaping tomorrow with you

Post-K Supercomputer with Fujitsu's Original CPU, Powered by ARM ISA

Toshiyuki Shimizu
Vice President, System Development Division,
Next Generation Technical Computing Unit
FUJITSU LIMITED

June 27th, 2017

Outline

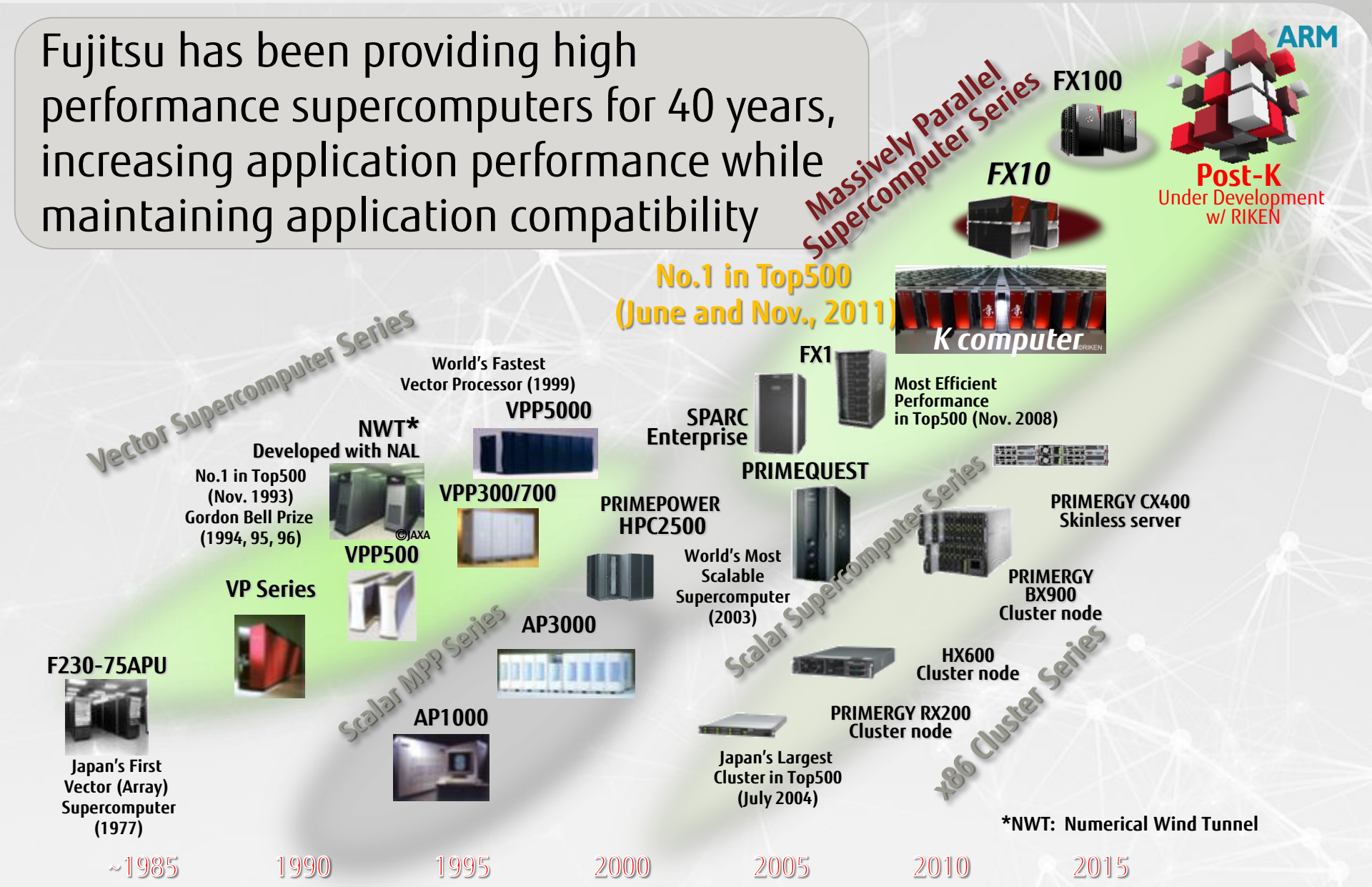
FUJITSU

- Fujitsu's HPC solutions
- Post-K development
  - Goals and approach of Post-K
  - Software and applications
- Summary

Fujitsu Supercomputers

FUJITSU

Fujitsu has been providing high performance supercomputers for 40 years, increasing application performance while maintaining application compatibility



Fujitsu HPC Solutions to Meet Customer Demands

FUJITSU

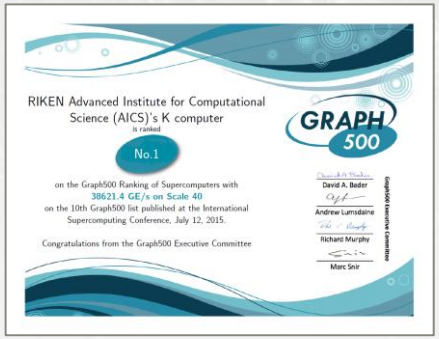
- Providing supercomputers w/ Fujitsu-developed CPU & x86 clusters
  - High performance, high scalability, and high reliability
- "Single system image" operation w/ Fujitsu system software
- Post-K is being developed to focus on high application performance and low power consumption
  - State-of-art technologies & additional features for the future

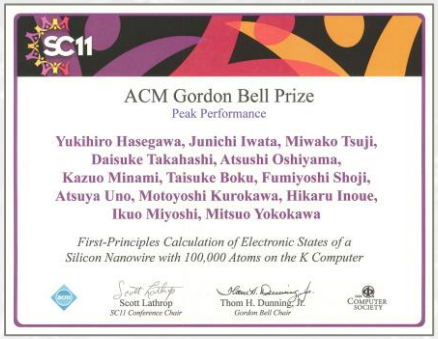
Achievements with the K computer

FUJITSU

- Prestigious Benchmark Awards
  - TOP500: 10.5Pflops, 93% efficiency — No. 7
  - HPCG: 602Tflops, 5.3% efficiency — No. 1
  - Graph500: 38.6TTEPS — No. 1
  - HPC Challenge Class 1: No.1 in all categories — No. 1
    (1) Global HPL, (2) Global Random Access, (3) EP STREAM, (4) Global FFT
- Gordon Bell Prize Awards
  - "First-Principles Calculation of Electron States of a Silicon Nanowire with 100,000 Atoms on the K computer" (2011)
  - "4.45 Pflops Astrophysical N-Body Simulation on K Computer – The Gravitational Trillion-Body Problem" (2012)
  - "Simulations of Below-Ground Dynamics of Fungi: 1.184 Pflops Attained by Automated Generation and Autotuning of Temporal Blocking Codes" (2016 finalist)

at SC16
6 years from the initial delivery





Latest News from ISC17 Last Week

FUJITSU

- K computer kept #1 positions for Graph500 & HPCG

- Post-K would be a very worthy successor to the K computer heritage

Outline

FUJITSU

- Fujitsu's HPC solutions
- Post-K development
  - Goals and approach of Post-K
  - Software and applications
- Summary

Post-K Goals and Approaches

FUJITSU

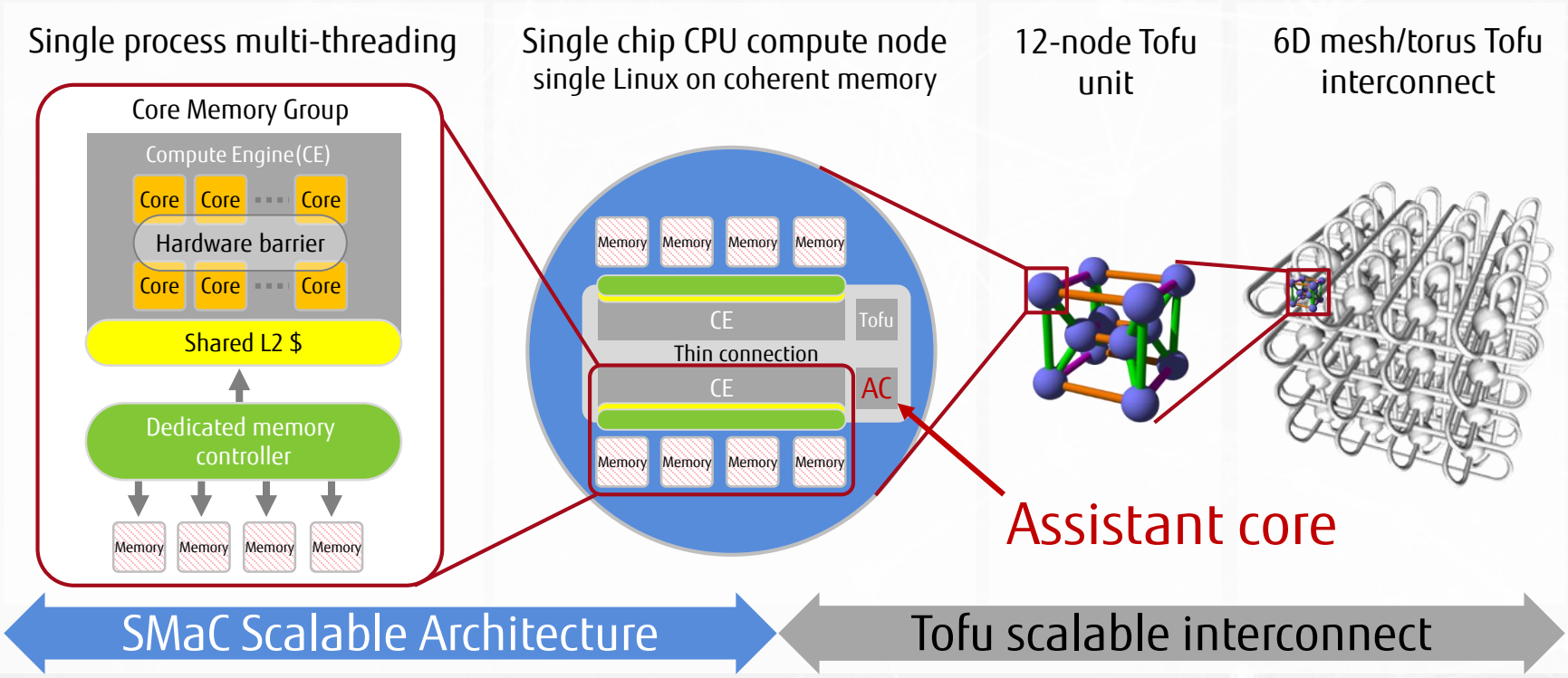
- Post-K Goals
  - Attains high application performance and good power efficiency
  - Keeps application compatibility while advancing from predecessors
  - Provides good usability and better accessibility for users
- Our Approaches
  - Develops high performance and scalable CPU w/ custom designed CPU core
  - Maintains performance balance for application compatibility & performance
  - Adopts ARM ISA and its standard frameworks

High & Scalable Performance Introduced in FX100

FUJITSU

- A scalable, many-core micro architecture concept, "**SMaC**"
- Assistant core for OS daemon and MPI offload to minimize OS Jitter
- Tofu interconnect enables the larger configuration w/ scalability

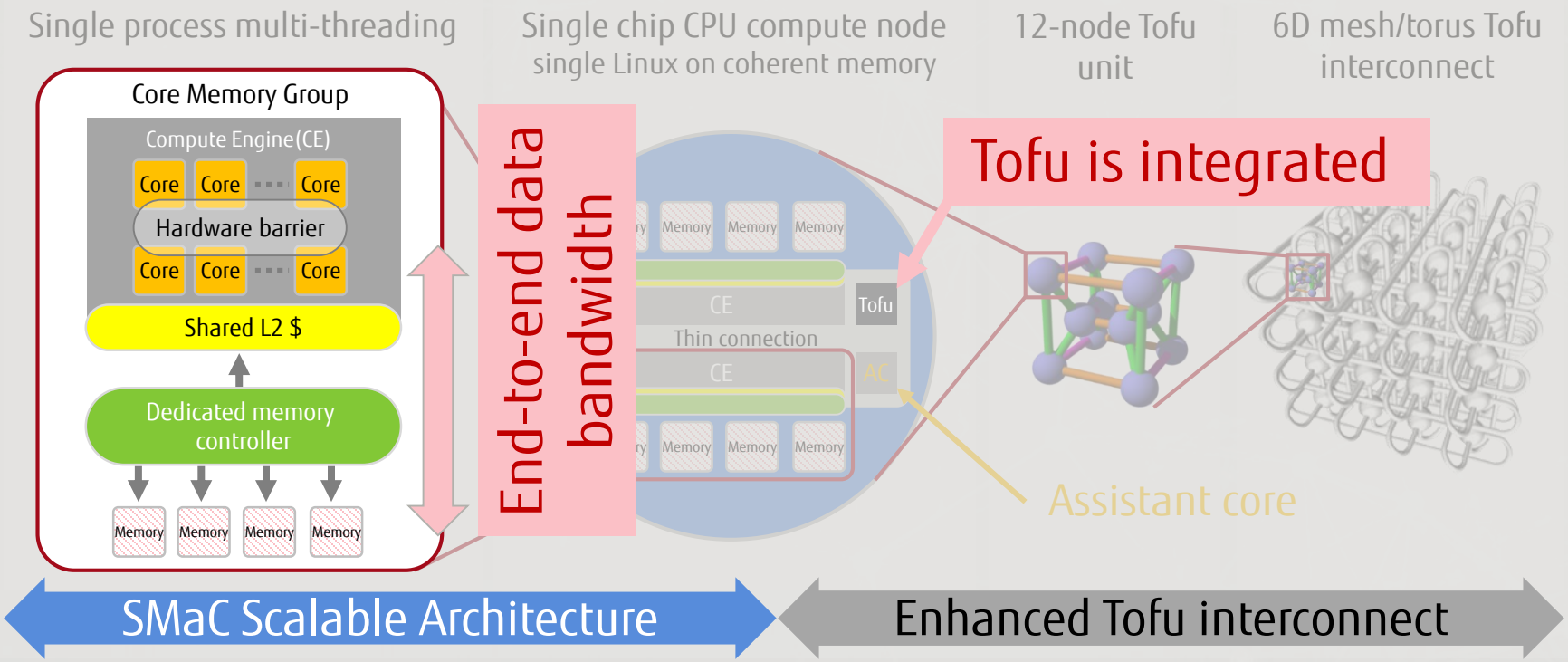
Conceptual architecture of FX100 and beyond



Performance Balance Realized in FX100

- End-to-end data bandwidth by SMaC
- Tofu interconnect is integrated into the CPU

Conceptual architecture of FX100 and beyond



Adopting ARM Standard Architecture

FUJITSU

- ARMv8-A with SVE
  - The latest HPC extension promises the high performance codes
  - Co-operate with ARM communities and utilize OSS
    - Linaro, OpenHPC, OpenSFS, Open MPI, OpenMP, and etc.
    - Contribute our experiences w/ HPC applications and optimization
  - Getting involved in the ARM HPC ecosystem by providing high performance machines in applications and low power consumption
- ARM's standard frameworks, SBSA, SBBR, etc.
  - Assure software compatibility among ARM platforms

Post-K Supports a New Data Type: FP16

FUJITSU

- FP16 is one of the key features for further optimization opportunities regarding hardware, system software, and applications

Challenges

- Power consumption
- Bandwidth
- Cost

Reducing data bits & their movement

- Smaller data types resolve, directly

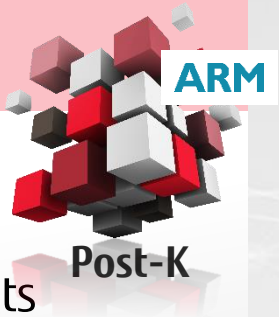
Modern Processors

GPUs, Xeon Phi and Fujitsu processors will support: new data types

Post-K CPU will support

Packed vectors of:

- Half precision FP16 elements
- 8 & 16 bit fixed-point elements



Applications

- Existing numerical apps
- Brand-new apps, incl. deep learning

Mixed precision: Linear Algebra
Relaxed precision: Molecular Dynamics
Half precision: Deep Learning

Post-K Hardware Features

FUJITSU

- Fujitsu CPU cores support the ARM SVE instruction set architecture
- Fujitsu CPU & Tofu maintain the programming models and provide high application performance
- FP16 (“giant vector throughput”) for supercomputers

	Functions & architecture	Post-K	FX100	FX10	K
CPU Core	Instruction set architecture	ARMv8-A	SPARC V9		
	SIMD width	512bit	256bit	128bit	128bit
	Double precision (64bit)	✔	✔	✔	✔
	Single precision (32bit)	✔	✔	✔	✔
	Half precision (16bit)	✔	-	-	-
Interconnect	Tofu interconnect	Enhanced	Tofu2	Tofu	Tofu

Outline

- Fujitsu's HPC solutions
- Post-K development
  - Goals and approach of Post-K
  - Software and applications
- Summary

Post-K Software Stack

FUJITSU

- Valuable feedbacks through "co-design" from application R&D teams

Post-K Applications (in next slides)

FUJITSU Technical Computing Suite / RIKEN Advanced System Software

Management Software	Hierarchical File I/O Software	Programming Environment
System management for highly available & power saving operation	Application-oriented file I/O middleware	XcalableMP
Job management for higher system utilization & power efficiency	Lustre-based distributed file system FEFS	MPI (Open MPI, MPICH)
		OpenMP, COARRAY, Math Libs.
		Compilers (C, C++, Fortran)
		Debugging and tuning tools

ARM

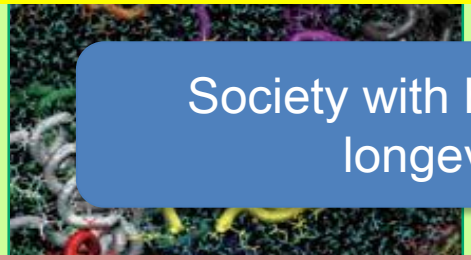
Linux OS / McKernel (Lightweight Kernel)

Post-K System Hardware

Post-K
Under Development
w/ RIKEN

Target science: 9 Priority Issues

①Innovative Drug Discovery



RIKEN Quant. Biology Center

②Personalized and Preventive Medicine

Inst. Medical Science, U. Tokyo

Society with health and longevity

③Hazard and Disaster induced by Earthquake and Tsunami

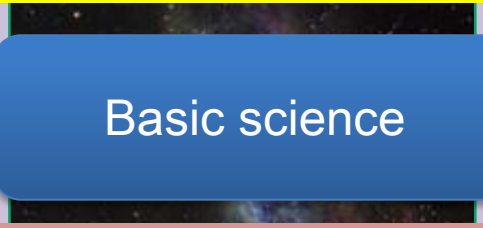
Disaster prevention and global climate

⑧ Innovative Design and Production Processes for the Manufacturing Industry in the Near Future

C

Industrial competitiveness

⑨Fundamental Laws and Evolution of the Universe



Cent. for Comp. Science, U. Tsukuba

Basic science

④Environmental Predictions with Observational Big Data

Center for Earth Info., JAMSTEC

⑦New Functional Devices and High-Performance

Inst. For Solid State Phys., U. Tokyo

⑥Innovative Clean Energy Systems

Grad. Sch. Engineering, U. Tokyo

⑤High-Efficiency Energy Creation, Conversion/Storage and Use

Inst. Molecular Science, NINS

Energy issues

Presented by Dr. Sato

Target science: Exploratory Issues

Interactive Models of Socio-Economic Phenomena and their Applications

Frontiers of Basic Science - challenge to extremes -

Formation of exo-planets (second Earth) and Environmental Changes of Solar Planets

Mechanisms of Neural Circuits for Human Thoughts and Artificial Intelligence

Presented by Dr. Sato

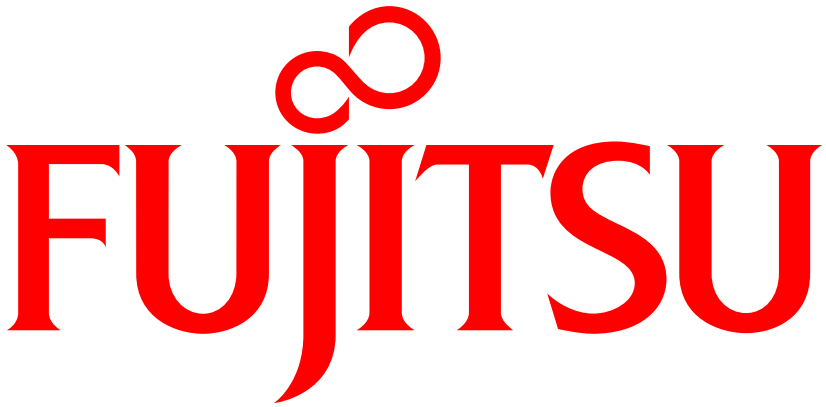
Summary

- Fujitsu's HPC solutions
- Goals and approach of Post-K
- Software and applications

ARM

Linaro

Post-K
Under Development
w/ RIKEN



shaping tomorrow with you