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shaping tomorrow with you

Supercomputer "Fugaku" and Beyond

June 23rd, 2020

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From “K computer” to Supercomputer “Fugaku”

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K computer

Ranked Top500 No.1 in 2011
Competitive in various fields

HPCG No.1 (2017)

ACM AWARDS Gordon Bell Prize Finalist (2016)

GRAPH 500 No.1 (2018)

© RIKEN

PRIMEHPC FX10

PRIMEHPC FX100

World fastest Supercomputer “Fugaku”

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- K computer was shut down in August, 2019 after 7 years of operation
- The last rack of Supercomputer “Fugaku” was delivered in May 2020
  - Software adjustment is ongoing for the general use scheduled in FY2021
- Fugaku tech FX1000 & FX700 are GA already, and A64FX CPU is supplied to HPE

Benchmark Results and “Fugaku” Specification

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		K computer, SPARC64 VIIIfx	Fugaku, A64FX
System spec.	Instruction set architecture	SPARC-V9 HPC-ACE	Armv8.2-A SVE 512bit
	Double precision performance	11.28 Petaflops	537 Petaflops
	Half precision (AI) performance	-	2.15 Exaflops in half precision
	Total memory bandwidth	5.64 PB/s	163 PB/s
	Interconnect	Tofu interconnect	Tofu interconnect D
ISC 2020	TOP500 (Petaflops)	10.51 (#1 at June/Nov. of 2011)	415.5 (#1)
	HPCG (Petaflops)	0.6027 (#1 Nov. 2016~Nov. 2017)	13.366 (#1)
	HPL-AI (Petaflops)	—	1,421 (#1)
	Graph500 (GTEPS)	31,302.4 (2014~2019.6 #1)	70,980 (2020.6 #1)

- TOP500: Performance of solving the linear equation (dense matrix) Ax = b, which is common in science and engineering. The standard performance indicator for supercomputers
- HPCG : Performance of solving the linear equation with sparse coefficient matrix using Conjugate Gradient method
- HPL-AI: Performance of solving the linear equation utilizing lower precision floating point calc., like fp16, which AI often utilizes
- Graph500: Performance of big data processing. Integer and memory access speed related to the graph search/traverse are evaluated

Technical Innovations and Features of “Fugaku”

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Faster applications: Leading-edge technology

- The world's first CPU w/ Arm’s HPC extension, SVE, for which Fujitsu collaborated as a lead partner
- An arithmetic unit (512 bit SIMD) with 4x of K and half-precision (FP16) used in AI
- HBM2 for high memory BW
- Tofu interconnect D for efficient massively parallel processing (Enhanced Tofu for K)

Energy efficient and reliable: in-house hardware and software

- Original CPU, system, and software for stable and improved operation of large systems
- Efficient hardware with software control of power-saving features (power knob)
- Fujitsu's CPU design and leading-edge Si-tech to achieve world-class power efficiency

Ease and breadth of use: Adoption of industry standards

- Original CPU "A64FX" using Arm architecture widely used in smartphones and IOT devices
- Red Hat Enterprise Linux (RHEL 8.1), which is widely used for servers, etc.

"Fugaku" from Launch to Benchmark

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Dec. 2nd, 2019 Shipment began

~ Lock-down around the world~

Supply chain (routes, etc.) was modified
Work sharing w/ suppliers was optimized
Manufacturing and assembly order were modified to minimize the impact of stockout
Domestic production of substitutes was considered

Apr. 7th, 2020 COVID-19 related research trial use of "Fugaku"

1/6 of computing resource of "Fugaku"

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Supercomputer Fugaku will be used to help fight against COVID-19

Japanese Page

The supercomputer Fugaku, which is currently being installed in Kobe, Japan under a RIKEN-led project, will be put to use to help combat the COVID-19 pandemic, by giving priority to research selected by the Japanese Ministry of Education, Culture, Sports, Science and Technology.

The installation of the new supercomputer began in December 2019, and it is scheduled to go into full-fledged open use in 2021. However, some of the nodes will go into trial use in FY2020, which begins on April 1.

The following projects will be eligible to have priority use of the new supercomputer.

(1) Research seeking to reveal the characteristics of the new coronavirus
(2) Research aiming to identify compounds that can be used as therapeutic agents against the coronavirus
(3) Research that could help improve the diagnosis and treatment of COVID-19
(4) Projects that can reveal insights into the spread of infections and its socio-economic impact
(5) Other projects that have the potential to contribute to countermeasures against the new coronavirus

In February 2019, it was agreed that one of the uses of Fugaku would be to help resolve important scientific and social challenges based on the policy of Society 5.0 adopted by the Japanese government, and the decision to put the machine partly to use to combat the new virus was made in that spirit.

"One of the most important missions of Fugaku as Japan's flagship supercomputer is to protect the well-being of citizens using its massive computing power", says Satoshi Matsuoka, Director of the RIKEN Center for Computing Sciences (R-CCS). "To combat the global pandemic of the COVID-19 virus, we will rapidly provide access to the capabilities of Fugaku, leapfrogging its preparation, to accelerate the scientific process of diagnosis, treatment, as well as general prevention of infection spread, to contribute to the early termination of the pandemic".

https://www.riken.jp/en/news_pubs/news/2020/20200407_1/index.html

May 13th, 2020 Shipment completed

~ Benchmark run~

Work remotely, except for hardware replacement

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Delivery of supercomputer Fugaku completed

Japanese Page

The delivery of the 400 racks of the supercomputer Fugaku, which is being developed based on a plan initiated by the Ministry of Education, Culture, Sports, Science and Technology in 2014 to build the next generation flagship supercomputer of Japan for use in a wide range of applications that will address social and scientific issues of high priority, has been completed. It was recently announced that even while development continues, the new supercomputer will be put to use on research projects aimed at combatting the COVID-19 pandemic.

According to R-CCS Center Director Satoshi Matsuoka, "Despite the hardship caused by the novel coronavirus pandemic, the tireless efforts of the Fujitsu staff and all those involved made it possible to successfully complete the delivery on time."

Matsuoka continues, "With Fugaku, we are committed to achieve scientific breakthroughs in the future, as well as to drive innovation that can make Society 5.0 a reality."

For more details, see the notice on the RIKEN R-CCS website.

https://www.riken.jp/en/news_pubs/news/2020/20200514_1/index.html

COVID-19 Measures and Benchmark Results

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COVID-19 measures

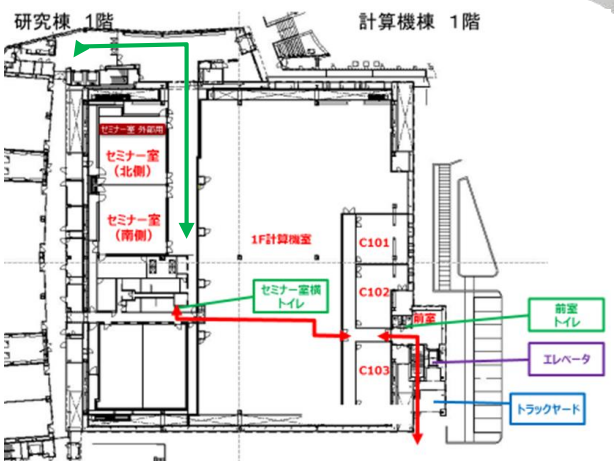
Prevention of infection

- Work remotely, on-site to the minimum
- Avoid crowded trains. Sometimes walk instead
- Separate rooms and restrooms to reduce risk
- Thorough implementation of rules such as take & record temperature, sanitize hands, and wear mask

Minimizing infection effects

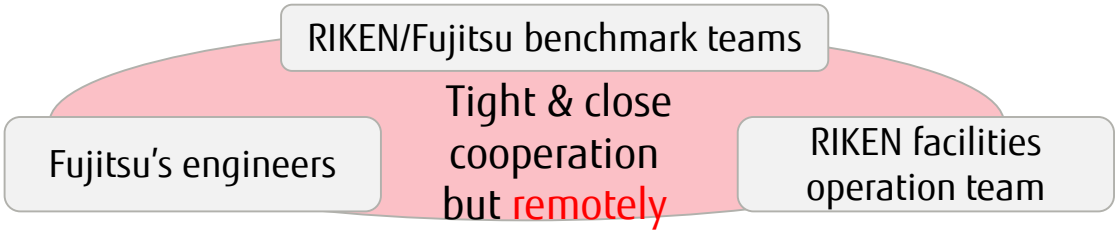
- Backup system dividing into more than two groups
- Range of disinfection and procedures were simulated

No infection, no delay, installation completed!



22 guys in remote conference working on the benchmark at 21:50, May 29

Benchmark run succeeded thru *new normal* work style



“Fugaku” and Fujitsu Commercial Supercomputers

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Lineup of supercomputers equipped with A64FX CPU

Fugaku “富岳”

Developed with RIKEN

- 150k nodes
- Water-cooled
- Tofu interconnect D
- Fujitsu / RIKEN original software

FUJITSU Supercomputer PRIMEHPC

PRIMEHPC FX1000
for highly scalable system

- 384 nodes/ Rack
- Water-cooled
- Tofu interconnect D
- Fujitsu original software

PRIMEHPC FX700
easier adoption w/ de facto tech

- 8 nodes/ 2U Chassis
- Air-cooled
- InfiniBand
- OSS/ ISV software

A64FX Performance and Power using OSS Real Apps

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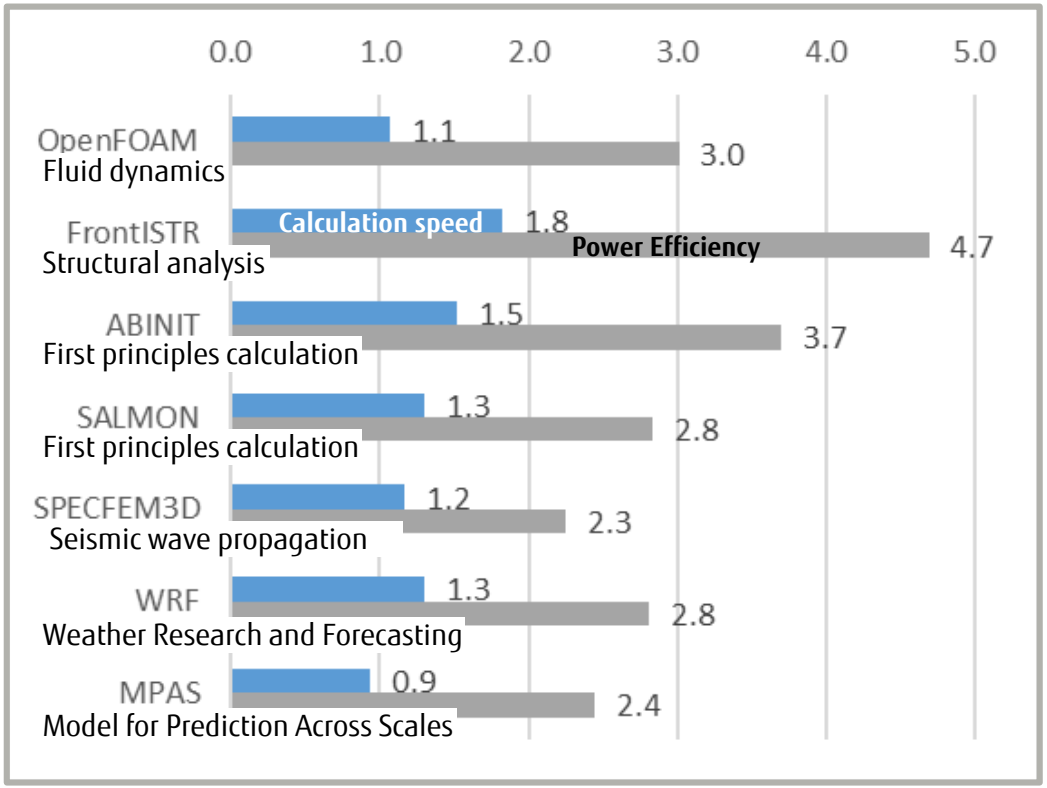
Performance scaling of a A64FX over 2x x86



- Latest x86 and A64FX w/ the same number of cores*
  - Up to 1.8 times faster
  - Up to 4.7 times lower energy

* A64FX : 48 cores ×1 CPU (2.2 GHz)
x86 CPU : 24 cores ×2 CPU (2.9 GHz)

- Scalable performance obtained by
  - Enhanced microarchitecture for HPC
  - Energy-saving design & implementation

Commercial Applications

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- Fujitsu works with vendors to make commercial apps available for FX1000, also for FX700 and Fugaku with binary compatibility.

(as of June 2020)

Engineering (Structural analysis, Fluid dynamics and Electronics)

Available soon

- LS-DYNA (by Ansys, Inc.)
- Poynting (by Fujitsu Limited)
- ADVENTURECluster (by Allied Engineering Co.)
- CONVERGE CFD SOFTWARE (by Convergent Science)
- Altair Radioss™ (by Altair Engineering, Inc.)
- HELYX® (by ENGYS Ltd. & VINAS Co., Ltd.)
- Ansys Fluent (by Ansys, Inc.)
- JMAG® Simulation Technology for Electromechanical Design (by JSOL Corporation)

In a research & development phase

- Chemistry*
  - Amber
  - Gaussian16 (by Gaussian, Inc.)
- Marc (by MSC Software Ltd.)
- VASP
- scFLOW (by Software Cradle Co., Ltd.)
- VPS (PAM-CRASH) (by ESI Group)
- Simcenter STAR-CCM+ (by Siemens Industry Software Inc.)

*Collaboration with Australian National University

**All application names used in this slide are trademarks or registered trademarks of their respective venders.

Global Partnership

- Supercomputer partnership with Cray (inherited to HPE)
  - HPE sells commercial supercomputer w/ A64FX
- Apps evaluation & ecosystem development on Arm SVE with overseas leading research institutes
  - Provides evaluation environment
    - Jülich Supercomputing Centre (Germany)
    - EPCC (Britain), etc.
  - Collaboration to build up an ecosystem with Barcelona Supercomputing Center in Spain

https://www.cray.com/products/computing/cs-series/fujitsu-arm-processor

Solving the Social Issues by Supercomputer

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~ Social Issues ~

Social issues

- Health and longevity
- Safe and secure society
- Climate problem
- Industrial competitiveness
- Sustainable energy
- ・・・

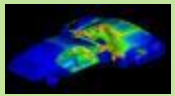
Specific area

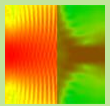
- **Life science**
- **Disaster prevention and the environment**
- **Manufacturing**
- **Energy**

Future / Now / Past

【Simulation】

- Fluid dynamics
- Crash and structure
- Materials
- :





【Data analysis】

- AI(Deep Learning)
- Big data analysis
- :

~ Supercomputer ~

Supercomputer will be used as the infrastructure to support solving the social issues & digital transformation

Summary

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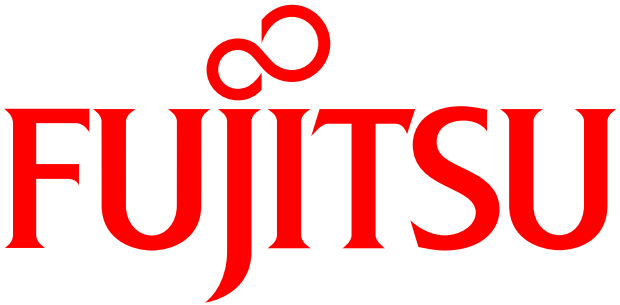
- Flagship supercomputer "Fugaku" is designed and developed thru co-design with RIKEN effort and Fujitsu's full range of over 40 years experience of development on hardware and software of supercomputers
- Ranked #1 in many benchmarks by design and implementation for high "Fugaku" application performance
- The world's fastest "Fugaku" performance is expected to help realize Society 5.0, which requires high speed simulation and AI capabilities
  - Advanced use for COVID-19 related research, for example
- Developing *Fugaku tech*, A64FX and PRIMEHPC FX1000 & FX700, into business globally

Fujitsu aims to provide a prosperous future through the fruits of supercomputers around the world. With the advent of the digital age, high speed simulation with AI capable supercomputers will be widely used in many fields.



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