

FUJITSU Supercomputer PRIMEHPC FX1000

A supercomputer based on technologies cultivated through the supercomputer Fugaku, enabling the creation of ultra-large-scale systems of over 1.3 EFLOPS.

The FUJITSU Supercomputer PRIMEHPC FX1000 features technologies developed together with RIKEN for use in the supercomputer Fugaku to provide high performance, high scalability, and high reliability, as well as one of the world's highest levels of ultra-low power consumption. The PRIMEHPC FX1000 helps pioneer new horizons in the fields of research and development using supercomputers. It has a minimum hardware configuration of 48 nodes in Japan and 192 nodes overseas.

A supercomputer with a newly developed Arm CPU

The A64FX, developed by Fujitsu, is the world's first CPU to implement a Scalable Vector Extension (SVE), an extension of the Armv8.2-A instruction set architecture for supercomputers. Manufactured using the state-of-the-art 7nm process, the A64FX has 48 computing cores and either two or four assistant cores. It can provide a theoretical peak double-precision floating-point operations performance of 3.3792 TFLOPS. Furthermore, it is capable of high-throughput single-precision/half-precision floating-point computation and 8bit/16bit integer operations using its 512-bit wide SIMD units. This calculation performance shines in processing applications such as AI.

Each node consists of one processor, and uses HBM2 (High Bandwidth Memory 2), a world first for a general-purpose CPU. Each node has a tremendous 1,024 GB/s of memory bandwidth.

Tofu Interconnect D (TofuD), which is used to connect nodes, has the same 6D mesh/torus architecture while increasing the amount of simultaneous transmission 1.5-fold compared to previous models. It directly connects nodes with low latency and high bandwidth (6.8 GB/s per link). The scalable TofuD can connect up to around 390,000 nodes, creating ultra-large-scale systems of 1.3 EFLOPS or more.

Microarchitecture with high processing performance

The A64FX's microarchitecture was developed using technologies that Fujitsu has refined through its experience with supercomputers, mainframes, and UNIX servers.

The A64FX carries on from the CMG (Core Memory Group) of the PRIMEHPC series, which enables scalable performance improvement when using multiple cores, as well as VISIMPACT (Virtual Single Processor by Integrated Multi-core Parallel Architecture), which realizes highly efficient hybrid parallel processing, OS interrupt processing by assistant cores, and MPI asynchronous communication. The A64FX also enhances functions such as SIMD functions.

The A64FX also features further improvements of the energy-saving technologies developed for the K computer and the PRIMEHPC series to provide high job execution performance and exceptional performance/power rates in large-scale systems.

High-density installation and efficient direct water cooling

The PRIMEHPC FX1000 has two nodes on a compact 23 cm x 28 cm board (CMU: CPU Memory Unit). Up to 192 CMUs can be installed in a dedicated rack, for up to 384 nodes per rack, an exceptional installation density.

The main components are directly water cooled, achieving a water-cooling ratio of 90% or greater. This enables high-density installation while maintaining a high level of reliability. Lowering component temperatures using water cooling reduces leak currents and power consumption, as well as lowering component failure rates.

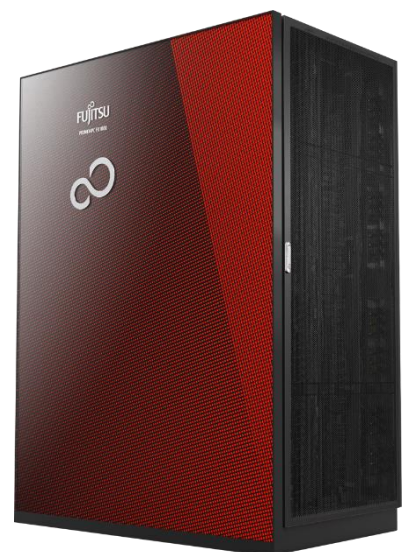
HPC software stack with an extensive usage track record

The FUJITSU Software Technical Computing Suite, which has an extensive track record of use in large-scale systems, is used for the software stack, offering excellent operability and stability. FUJITSU Software FEFS, a scalable distributed file system, compilers for high-level optimization for the A64FX, and other software improve application execution performance.


The industry-standard Red Hat Enterprise Linux is used as the OS, so software migration is easy.

The reliability and operability to support large-scale systems

The PRIMEHPC FX1000 provides total support for large-scale system reliability, availability, and operability. It does this through the A64FX, with RAS functions refined by Fujitsu through use in mission-critical servers; TofuD, with its highly flexible 6D mesh/torus architecture; its software stack, which provides efficient system management and job operation management functions, and more.



FUJITSU Supercomputer PRIMEHPC FX1000 Specifications

	CPU	Name	A64FX
		Instruction set architecture	Armv8.2-A SVE
		Number of cores	Computational node: 48 cores + 2 assistant cores I/O and computational node: 48 cores + 4 assistant cores
		Clock	2.2 GHz
		Theoretical peak performance	3.3792 TFLOPS (double precision)
	Node	Architecture	1 CPU/node
		Memory capacity	32 GiB (HBM2, 4 stacks)
		Memory bandwidth	1,024 GB/s
		Interconnect	Tofu Interconnect D
	Main unit	Form factor	Dedicated rack
		Maximum number of nodes	384 nodes/rack
		Cooling method	Water cooling
	Software	OS	Red Hat Enterprise Linux 8
		HPC middleware	FUJITSU Software Technical Computing Suite

* Trademark and registration symbols (TM, ®) are not always appended to the names of the systems, products, etc., mentioned in this catalog.

* The contents of this catalog are subject to change without prior notice in order to improve the contents herein.

Inquiries

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FUJITSU Supercomputer PRIMEHPC FX700

A high-performance Arm server featuring the A64FX CPU, the same CPU used in the supercomputer Fugaku. Air-cooled and based on standard technology, making it easy to set up.

The FUJITSU Supercomputer PRIMEHPC FX700 is a PRIMEHPC series air-cooled model based on standard technology that features the A64FX CPU for use in the supercomputer Fugaku developed together with RIKEN and the PRIMEHPC FX1000. It is the perfect system for customers that wish to easily take advantage of the high performance of the A64FX. It has a minimum hardware configuration of 2 nodes in Japan and 128 nodes overseas.

A64FX, the newly developed Arm CPU

The A64FX, developed by Fujitsu, is the world's first CPU to implement a Scalable Vector Extension (SVE), an extension of the Armv8.2-A instruction set architecture for supercomputers. Manufactured using the state-of-the-art 7nm process, the A64FX has 48 computing cores, can provide a theoretical peak double-precision floating-point operations performance of 2.7648 TFLOPS or 3.072 TFLOPS. Furthermore, it is capable of high-throughput single-precision/half-precision computation and 8bit/16bit integer operations using its 512-bit wide SIMD units. This calculation performance shines in processing applications such as AI.

Each node consists of one processor, and uses HBM2 (High Bandwidth Memory 2), a world first for a general-purpose CPU. Each node has a tremendous 1,024 GB/s of memory bandwidth.

Microarchitecture with high processing performance

The A64FX's microarchitecture was developed using technologies that Fujitsu has refined through its experience with supercomputers, mainframes, and UNIX servers. The A64FX carries on from the CMG (Core Memory Group) of the PRIMEHPC series, which enables scalable performance improvement when using multiple cores, as well as VISIMPACT (Virtual Single Processor by Integrated Multi-core Parallel Architecture), which realizes highly efficient hybrid parallel processing. It also enhances functions such as SIMD functions.

Easy-deployment form factor and air cooled design

The PRIMEHPC FX700 has a 2U chassis that can be mounted in standard 19-inch racks and can hold up to four blades. Each blade contains two nodes, and each unit can consist of up to eight nodes. It is air cooled, making it easy to deploy high-performance Arm servers in environments without specialized water-cooling equipment.

Industry-standard interconnect and OS

The interconnect among compute nodes is the industry-standard InfiniBand. InfiniBand is widely used as an interconnect in PC clusters, and can be used to construct equivalent topologies. The FUJITSU Supercomputer PRIMEHPC FX700 uses the Red Hat Enterprise Linux OS, offering a high level of software migratability.

Development environment that leverages the performance of the A64FX


Development environments such as compilers are supplied by Fujitsu, providing powerful support for the development and optimization of applications for the A64FX CPU.

HPC software support

Bright Computing's Bright Cluster Manager, a cluster management software, and Altair's Altair PBS Professional, a job scheduler are supported.



FUJITSU Supercomputer PRIMEHPC FX700 Specifications



	CPU	Name	A64FX
		Instruction set architecture	Armv8.2-A SVE
		Number of cores	48 cores
		Clock	1.8 GHz or 2.0 GHz
		Theoretical peak performance	2.7648 TFLOPS or 3.072 TFLOPS (double precision)
	Node	Architecture	1 CPU/node
		Memory capacity	32 GiB (HBM2, 4 stacks)
		Memory bandwidth	1,024 GB/s
		Interconnect	InfiniBand EDR / HDR100 ^(*) ^(*) EDR and HDR100 cannot be mixed
	Main unit	Form factor	2U rack-mount chassis
		Maximum number of nodes	8 nodes/chassis
		Cooling method	Air cooling
	Software	OS	Red Hat Enterprise Linux 8
		HPC middleware	<ul style="list-style-type: none"> FUJITSU Software Compiler Package FUJITSU Software Technical Computing Suite ^(*) ^(*) Only distributed file system (FEFS) is supported Bright Cluster Manager (Bright Computing) Altair PBS Professional (Altair)

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FUJITSU Processor A64FX

Innovative Arm-based HPC processor

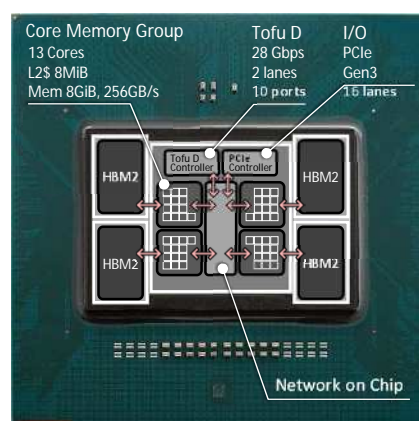
Designed for the new generation of massive parallel computing



The A64FX processor (called A64FX, below) is a superscalar processor of the out-of-order execution type. The A64FX is designed for high-performance computing (HPC) and complies with the ARMv8-A architecture profile and the Scalable Vector Extension for ARMv8-A.

The processor integrates 52 processor cores including assistant cores; a memory controller supporting HBM2; a Tofu interconnect D controller; and a root complex supporting PCI-Express Gen3. The A64FX adopts several characteristic architectures for HPC.

The A64FX becomes the heart of supercomputers that can perform quick simulations and analyze large data sets. Supercomputers with this processor perform at a high level, are highly reliable and offer a strong performance vs. power ratio.



A64FX Main Features

Predicated Operations	Enables selectively operate, load, and store only specific SIMD elements
Four-operand FMA	In the operation of $A \times B + C \Rightarrow D$, the register of A, B, C, and D can be freely selected Although Armv8-A SIMD has only $A \times B + C \Rightarrow C$ operations, the A64FX realizes Four-operand FMA by packing with MOVPRFX instruction
Gather/Scatter	Reads discontinuous data in memory and converts to SIMD (vectorization) Writes SIMD (Vector) data to non-contiguous area in memory
Math. Acceleration	Speeds up when finding trigonometric and exponential functions
Compress	Aggregates data that is sparse on registers
First Fault Load	Suppresses and records traps other than the first element in memory access instructions
Hardware Barrier	Supports synchronization between software processes or threads through hardware for simplification of programs and higher-speed synchronization processing
Sector Cache	Provides software with a method of controlling the use of the L1 and L2 cache by partitioning each cache
FP16/ INT16/ INT8 Dot Product	Introduced for AI applications

Fujitsu Processor A64FX Specifications

CPU Specifications		
ISA	Arm v8.2 + SVE	
Number of Processor Cores	48 compute cores, and 2 or 4 assistant cores *	
Threads	48	
Base Frequency	1.8GHz, 2.0GHz, 2.2GHz	
Turbo Frequency	None (same as base frequency)	
SIMD Width	512bit	
L1I Cache Size	3MiB (64KiB /core)	
L1D Cache Size	3MiB (64KiB /core)	
L2 Cache Size	32MiB (8MiB x 4)	
Cache-Line Size	256 bytes	
Memory Controller	4	
SVE-Implemented Vector Length	128 / 256 / 512bits	
Peak Flops; D / S / H [FLOPS]	1.8GHz	2.8T / 5.5T / 11.1T
	2.0GHz	3.1T / 6.1T / 12.3T
	2.2GHz	3.4T / 6.8T / 13.5T
Peak Int Ops; 8 / 4 / 2 / 1B [OPS]	1.8GHz	2.8T / 5.5T / 11.1T / 22.1T
	2.0GHz	3.1T / 6.1T / 12.3T / 24.6T
	2.2GHz	3.4T / 6.8T / 13.5T / 27.0T
Network	Tofu interconnect D [68GB/s x2 (in/out)] *	
IO / Socket	PCIe Gen3 16 lanes [15.75GB/s(in/out)] (Need chipsets for USB/SATA)	
Process Technology	7 nm CMOS FinFET	
Number of Transistors	8,786M pcs	
Package Signal Pins	594 BGA pins	

* Only when the frequency is 2.2 GHz

Memory Specifications		
Memory Bandwidth	1,024 GB/s	
Memory Capacity	32 GiB	
Number of HBM2 Stacks Per Package	4	
HBM2	Data Signal Transfer Rate	2.0 Gbps
	Data Width	1,024 bits
	Memory Bandwidth	256 GB/s
	Memory Capacity	8 GiB

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Supercomputer Fugaku Development

*RIKEN named the Post-K computer Fugaku

In collaboration with RIKEN, Fujitsu is developing the world's top-level supercomputer, capable of realizing high effective performance for a broad range of application software.

Advanced
Technology

Fujitsu Contributions to Supercomputer Fugaku National Project

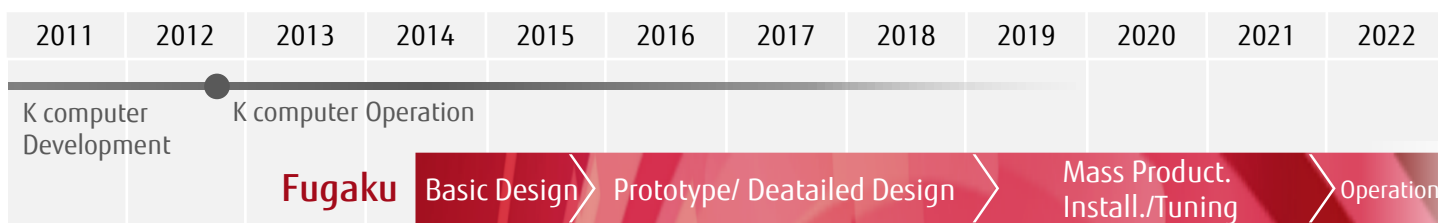
■ Fugaku Development

• System Characteristics

We are aiming to achieve the development goals of having an effective application performance that is up to 100 times greater than that of the K computer and power consumption of 30-40 MW (the K computer's power consumption is 12.7MW), and to create the world's top-performing general-purpose supercomputer. To be more precise, our aim is to balance various factors, such as i) power consumption, ii) computational performance, iii) user convenience, and iv) ability to produce ground-breaking results, characterized by its all-around capabilities, compared to any other system in the world.

• Fujitsu's Efforts

Fujitsu, through efficient use of not only cutting-edge technology, but also the cultivation of know-how and performance experience with the K computer and the Supercomputer PRIMEHPC Series, is developing the entire system; from the processor to the software. In particular, in regards to the processor, Fujitsu chose Armv8-A SVE, the latest instruction set architecture for high performance servers, and is working hard to extract the potential maximum performance from it. Moreover, utilizing the technologies created through the development of Fugaku, Fujitsu will productize the commercial supercomputer, and launched globally in November 2019.



K computer

World's No.1 in TOP500
June and November 2011



Fugaku

World's First Four Crown Winner in June 2020
TOP500, HPCG, HPL-AI, Graph500



PRIMEHPC FX10



PRIMEHPC FX100



PRIMEHPC FX1000



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