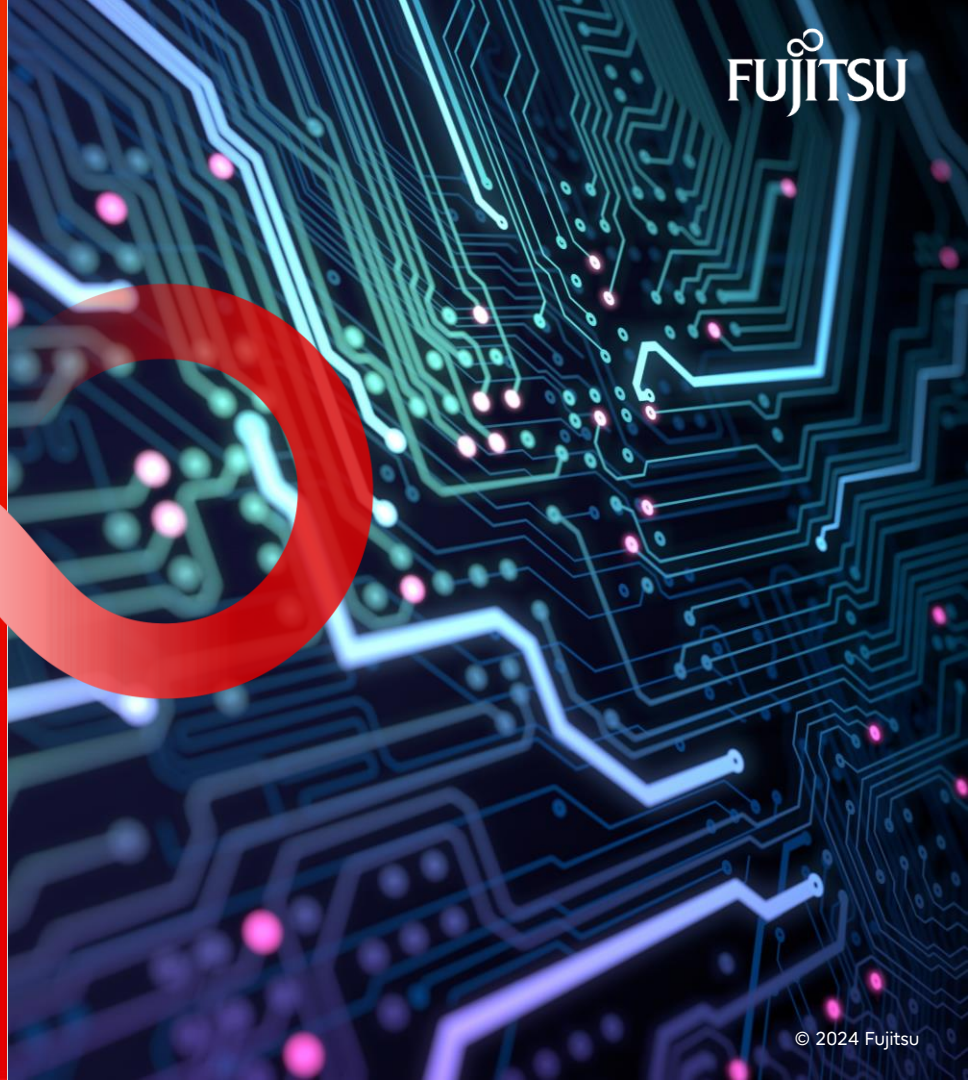
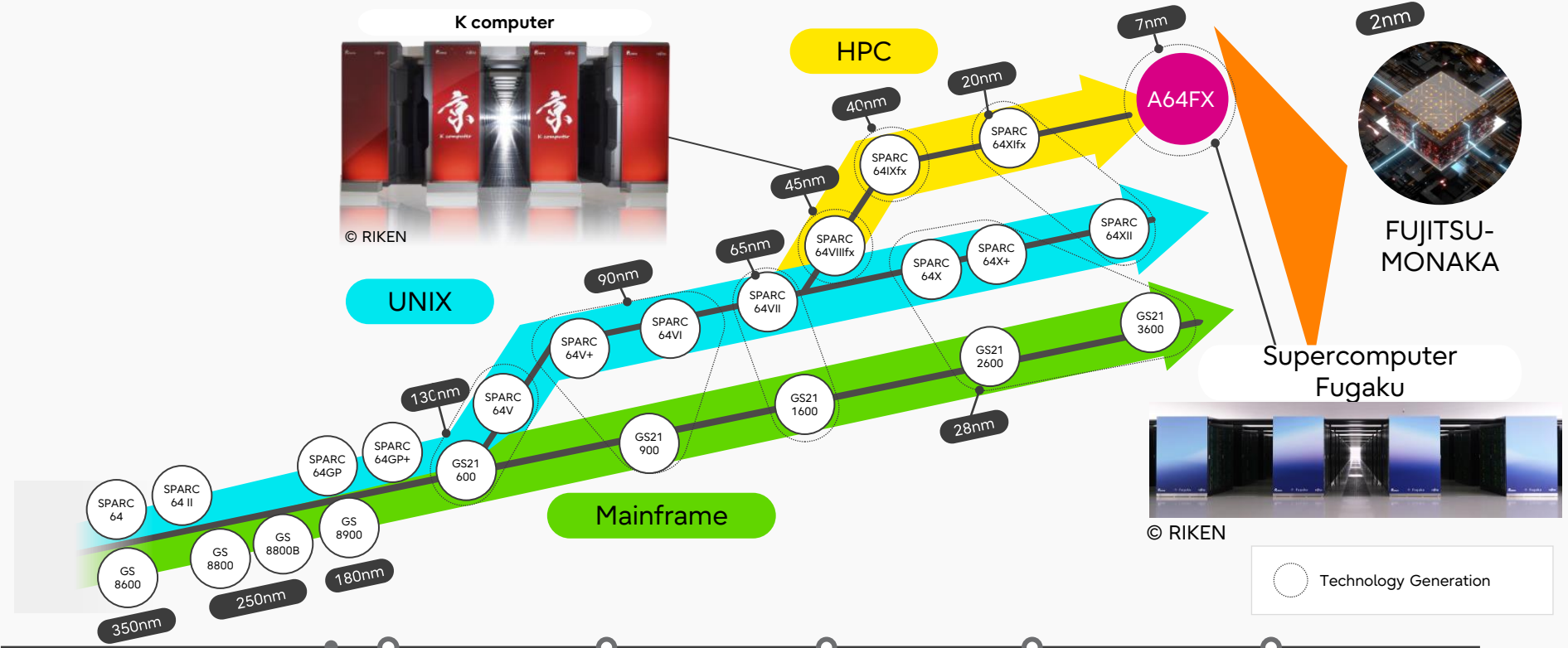
Next Arm Processor FUJITSU-MONAKA and Its Technologies



Fujitsu Processor Development

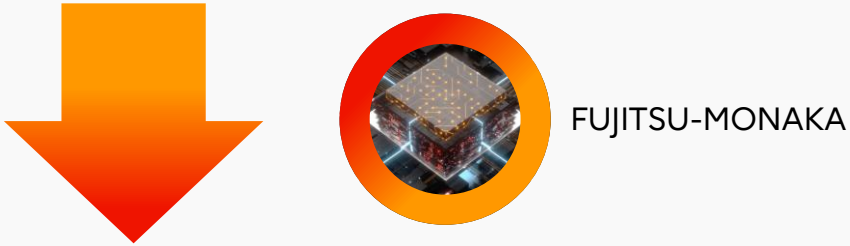
- **Persistent evolution for over 60 years : Always targeting No.1**



The Next Stage as World's Top Processor

FUJITSU

- Creating a new era of computing power is mandatory for the future society with massive data generation and processing
- Ever-increasing power in datacenters is critical, and the power efficiency in CPU (consists of 60%) would be the vital factor for a sustainable future
- Fujitsu shall utilize its Supercomputer success and technology for the solution



FUJITSU-MONAKA

- **Developing the new power efficient CPU "FUJITSU-MONAKA" for datacenters, which will be shipped in 2027**
- **Targeted for wide range of usage in the datacenter and telco/edge including AI, and contribute to the realization of carbon-neutral society**

Fujitsu Arm Processor “FUJITSU-MONAKA”

FUJITSU

Fujitsu microarchitecture | **3D many-core architecture** | **Confidential Computing**

High-performance

- Cloud native 3D many-core design by Fujitsu-proven microarchitecture
- High memory bandwidths

Energy Efficient

- Leading-edge process technology
- Ultra low voltage operation

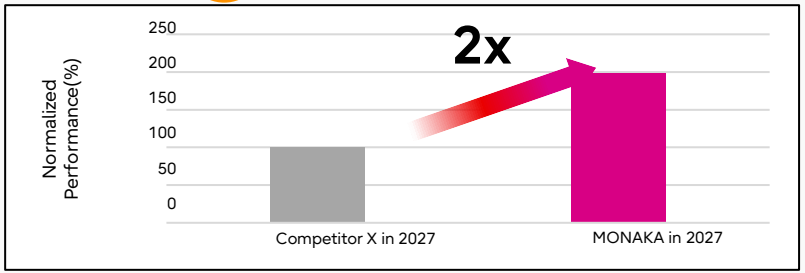
High Reliability

- Multiple VM Confidential Computing
- Mainframe class RAS for stable operation

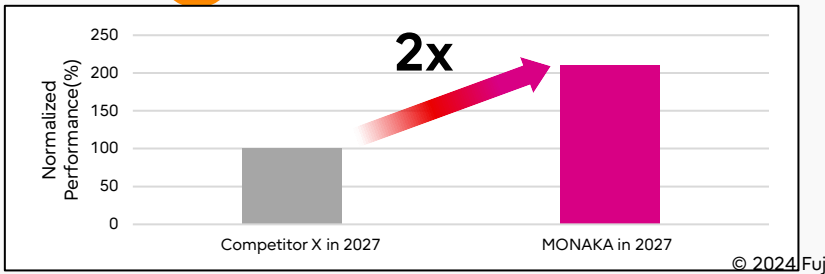
Easy to Use

- Open & de-facto standard software stacks
- Fujitsu compiler technology
- Air-Cooling for easy deployment

Application Performance

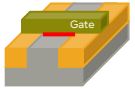
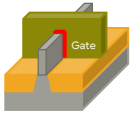
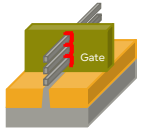


Performance per Watt



Semiconductor Trends –High Performance-

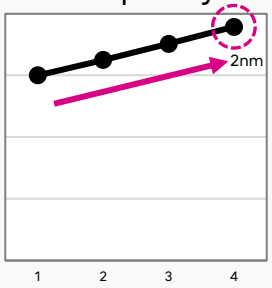
- (Pros.)
  Continuing improvements in semiconductor performance and power consumption, due to advancements in transistor structures
- (Cons.)
  Facing challenges with the slowdown in increasing cache memory capacity and the drastic increase in cost

	Transistor Type		
	Planar	FinFET	GAA (Gate-All-Around)
Technology node	~20nm (K computer: 45nm)	16nm ~ 3nm (Fugaku: 7nm)	2nm~ (MONAKA: 2nm)
Semiconductors Structures			

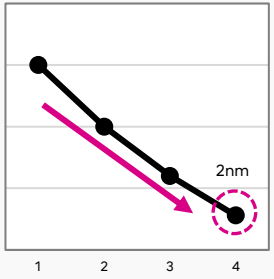
*Fujitsu estimation

Semiconductor Trends*

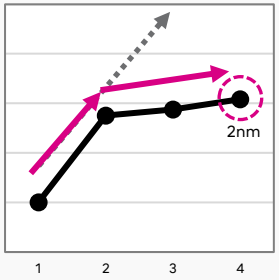
Frequency



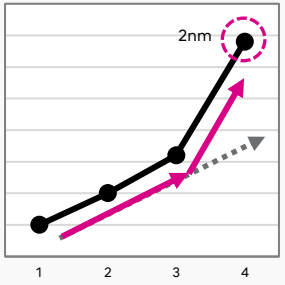
Power Consumption



Cache Memory Capacity



Cost



Architectural innovation is required to meet demand of performance, power and cost

3D Microarchitecture - High Performance

FUJITSU

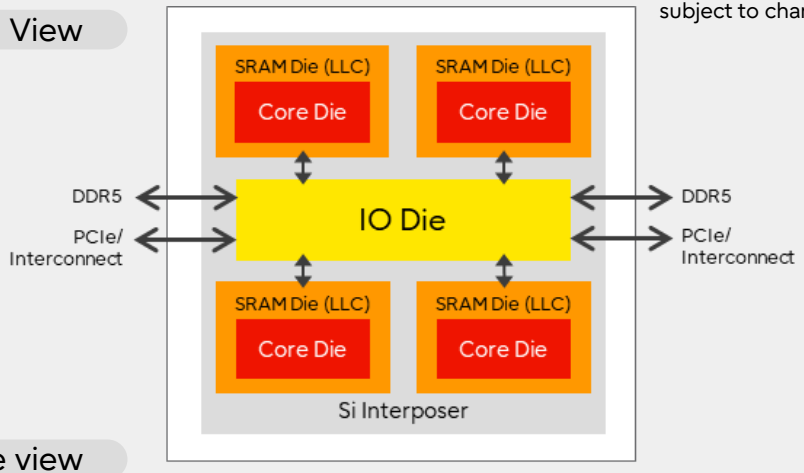
- **FUJITSU-MONAKA adopts the innovative 3D many-core architecture**
  - 2nm is used only for core die (top die), achieving high performance and low power consumption
  - All the last level cache are in 5nm SRAM die (bottom die), tightly coupled with core die through TSV
  - 3D many-core architecture realizes more cores, low latency and high throughput
  - 2nm area is less than 30% of total die size, contributing to cost-efficiency

FUJITSU-MONAKA Specification

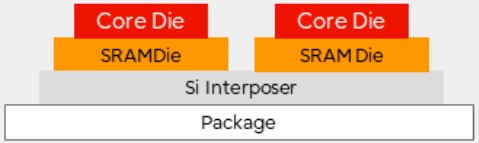
- Armv9-A Architecture
  - SVE2 for AI and HPC
  - Confidential Computing for security
- 144 cores x 2 sockets
- Ultra low voltage for energy-efficiency
- 3D chiplet
  - Core die 2nm
  - SRAM die/IO die 5nm
- DDR5 12 channels
  PCI Express 6.0 (CXL3.0)
- Air cooling

Top View

subject to change



Side view



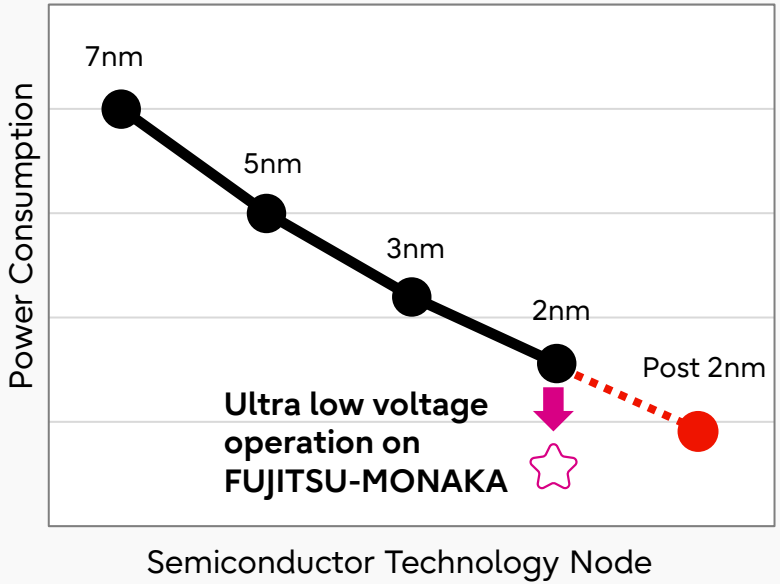
Ultra Low Voltage Technology - Energy Efficient

FUJITSU

subject to change

- FUJITSU-MONAKA's ultra low voltage operation technology enables **energy saving comparable to one generation ahead of 2nm**

Trend of Semiconductor Power*



*Fujitsu estimation

- Reducing power consumption by lowering voltage of the CPU

$$P \propto C V^2 f$$

C : Capacity
V : Voltage
f : Clock Frequency

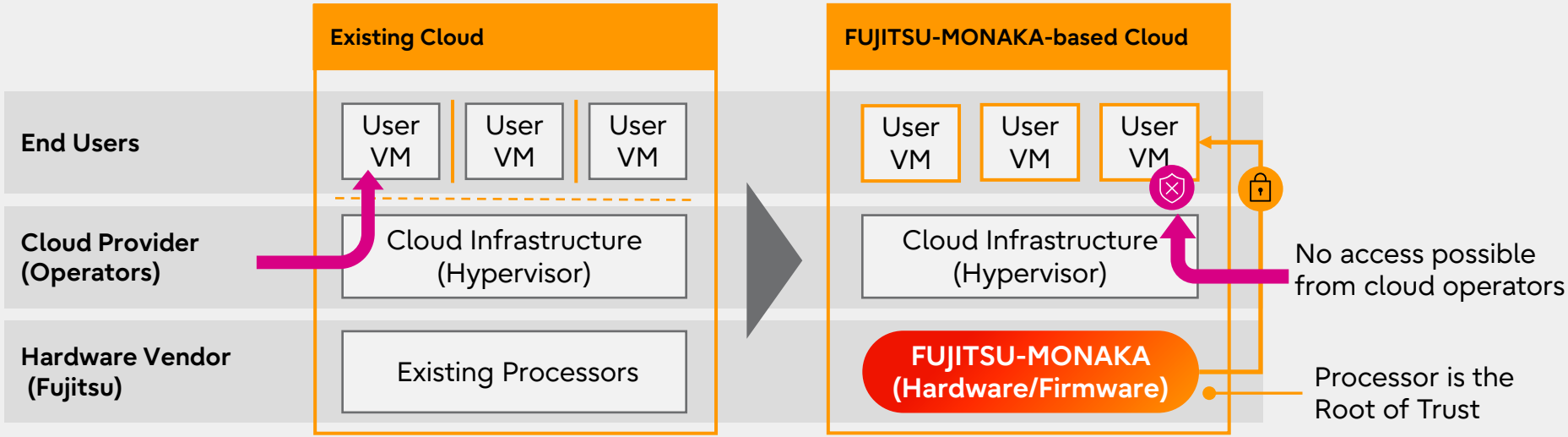
- Fujitsu develops **custom circuits including SRAM by using our proprietary CAD**, which enables stable operation at an ultra low voltage

Security Enhancements - High Reliability

FUJITSU

Confidential Computing

- Protect end-user data in memory by encrypting every VM with a different key generated by the processor hardware and firmware
- Expected to be an essential technology in cloud, edge and HPC environments which deals with sensitive data

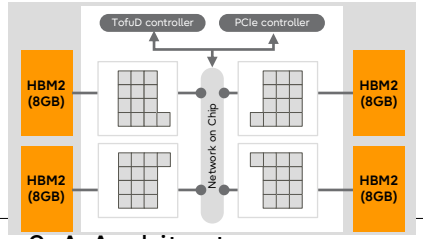
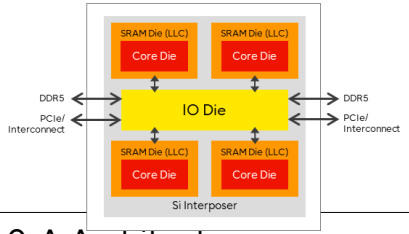


Each user VM is isolated from other users' VMs. However, not protected from cloud operators.

Processor encrypts each VM's memory with a different key. User data is not accessible from cloud operators. (Protected even if the cloud infrastructure is compromised)

Comparison between A64FX and FUJITSU-MONAKA

FUJITSU

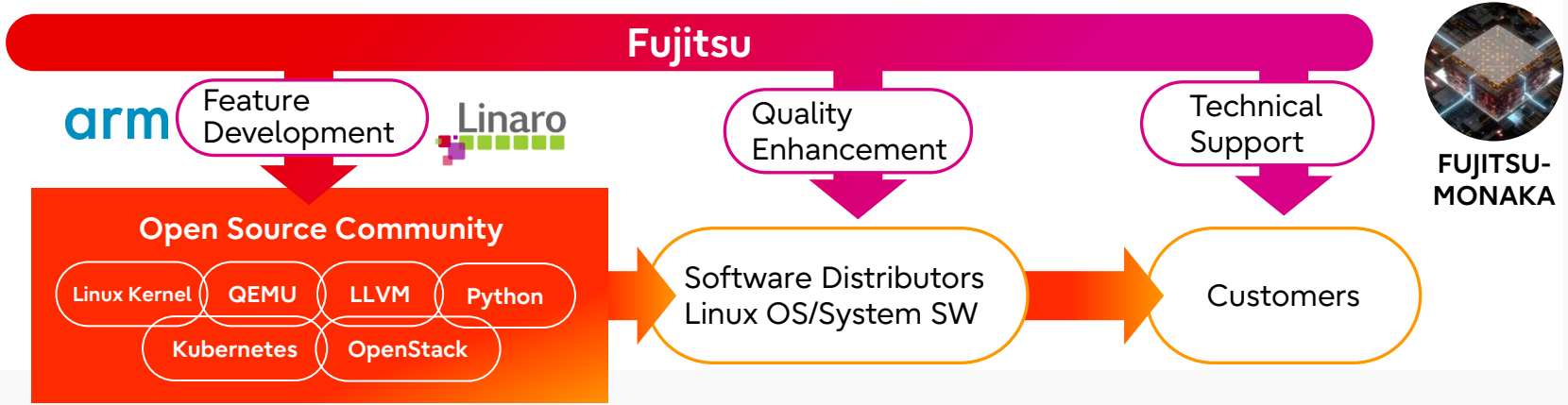
A64FX	FUJITSU-MONAKA
	
Armv8-A Architecture - SVE for HPC and AI	Armv9-A Architecture - SVE2 enhanced for HPC and AI - Confidential Computing
48 cores x 1 socket	144 cores x 2 sockets
Low voltage	Ultra low voltage
2.5D - CPU 7nm - HBM2	3D chiplet - Core die 2nm - SRAM die/IO die 5nm
HBM2 4 channels	DDR5 12 channels
PCI Express 3.0 Tofu Interconnect	PCI Express 6.0 (CXL3.0)
Air cooling and water cooling	Air cooling

Software Ecosystem - Easy to Use

FUJITSU

- **Supports industry standard software**
  - Standard Linux OS support and system architecture
    - Continue and expand OSS development activities for FUJITSU-MONAKA
      - OSS development achievements for Fugaku/A64FX: GCC, glibc, live-patch, papi, etc
    - Comply with standard system architecture (Arm System Ready) and support major distributions
  - Arm software ecosystem
    - Working on the standard tools (Python/Java/LLVM) to provide higher performance on FUJITSU-MONAKA.

▶ Enabling smooth transition of customer assets and continuously enhancing performance



Thank you

* This presentation is based on results obtained from a project subsidized by the New Energy and Industrial Technology Development Organization (NEDO).