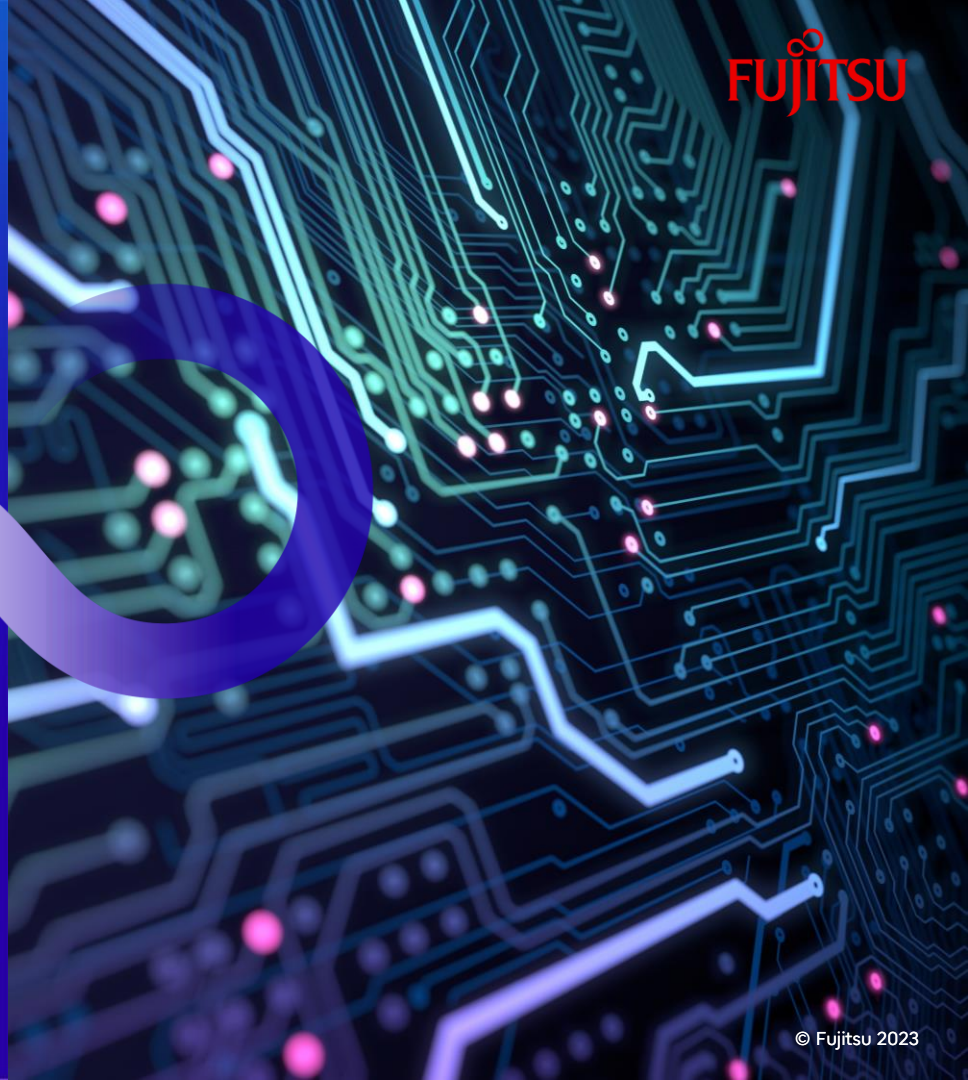
Next Arm Processor FUJITSU-MONAKA and Its Technologies



Fujitsu Processor Development

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

Performance

512-bit SIMD for HPC and AI
High Bandwidth Memory
Scalable Many-core Architecture
Virtual Machine Architecture
Software on Chip
High-speed Interconnect
HPC-ACE
System on Chip
Hardware Barrier
Multi-core Multi-thread
L2$ on Die
Non-blocking $
O-O-Execution
SuperO-Scalar
Single-chip CPU
Store Ahead
Branch History
Prefetch

Reliability

$ ECC
Register/ALU Parity
Instruction Retry
$ Dynamic Degradatio
Error Checkers/History

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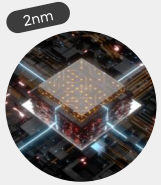
HPC

UNIX

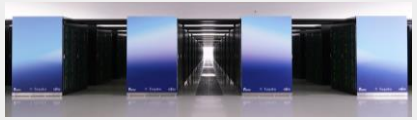
Mainframe

SPARC 64
SPARC 64 II
GS 8600
350nm
GS 8800
GS 8800B
250nm
SPARC 64GP
SPARC 64GP+
GS 8900
180nm
130nm
SPARC 64V
SPARC 64V+
GS21 600
90nm
GS21 900
SPARC 64VI
SPARC 64VII
65nm
GS21 1600
SPARC 64VIIIfx
45nm
SPARC 64IXfx
40nm
SPARC 64XIfx
20nm
SPARC 64X
SPARC 64X+
SPARC 64XII
GS21 2600
28nm
GS21 3600
A64FX
7nm
2nm



FUJITSU-MONAKA

Supercomputer Fugaku



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Technology Generation

~1999 2000 2005 2010 2015 2020

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 including AI and HPC, 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

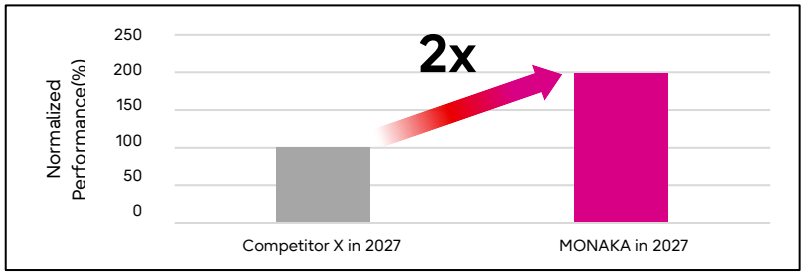
High Reliability

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

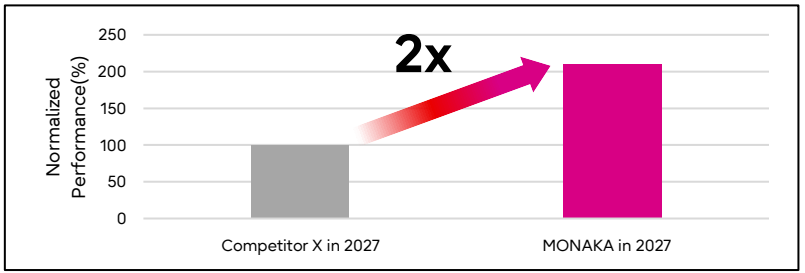
Easy to Use

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

Application Performance

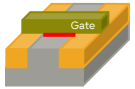
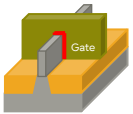
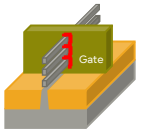


Performance per Watt



Semiconductor Trends -High Performance-

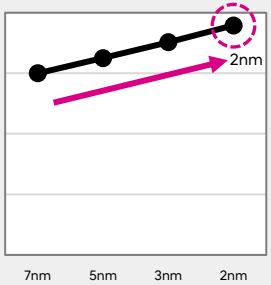
- (Pros.)
  Continuing improvements in semiconductor performance and power consumption, due to advancements in transistor structures
- (Cons.)
  Facing challenges with the slowdown in increasing cache memory capacity and the drastic increase in cost

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

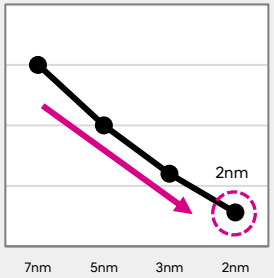
Semiconductor Trends*

*Fujitsu estimation

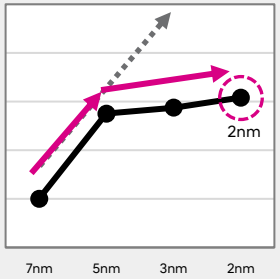
Frequency



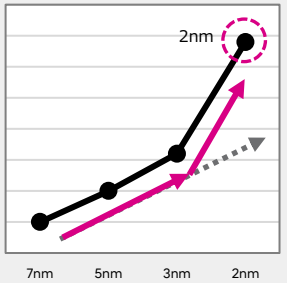
Power Consumption



Cache Memory Capacity



Cost



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

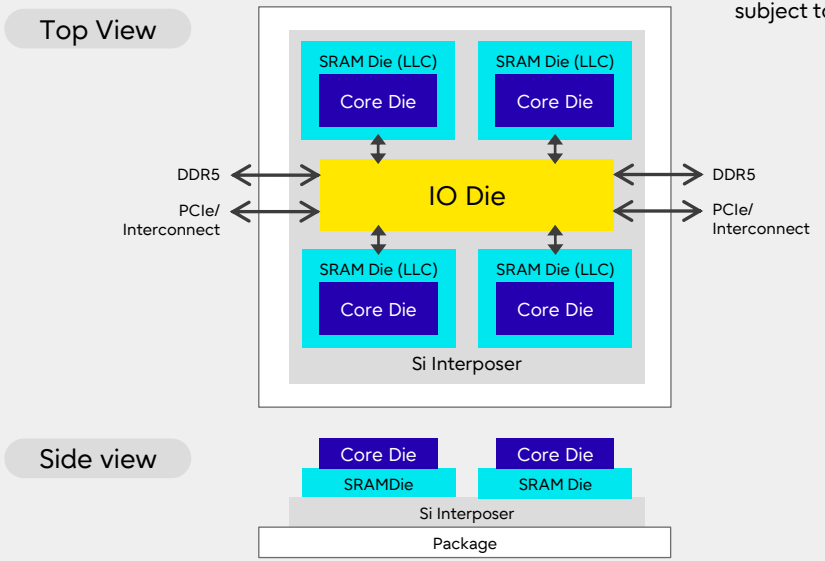
3D Microarchitecture -High Performance-

- **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**

subject to change

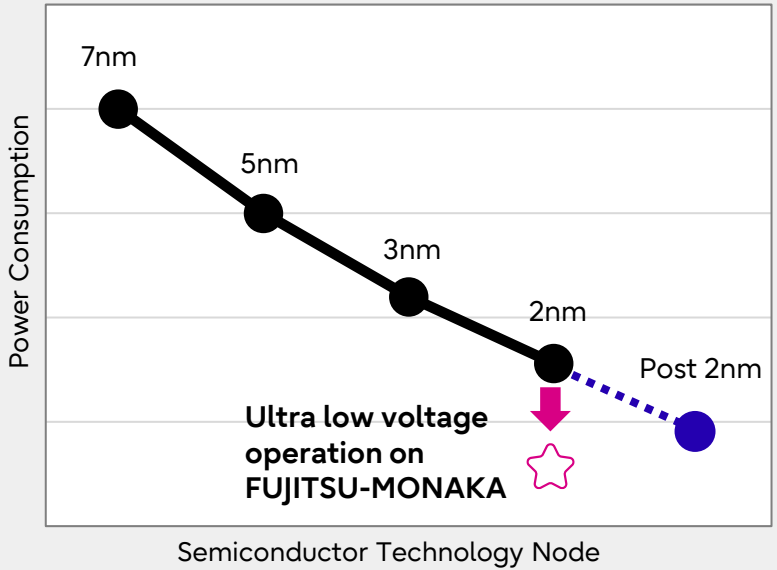


Ultra Low Voltage Technology -Energy Efficient-

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*



- 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

*Fujitsu estimation

Security Enhancements -High Reliability-

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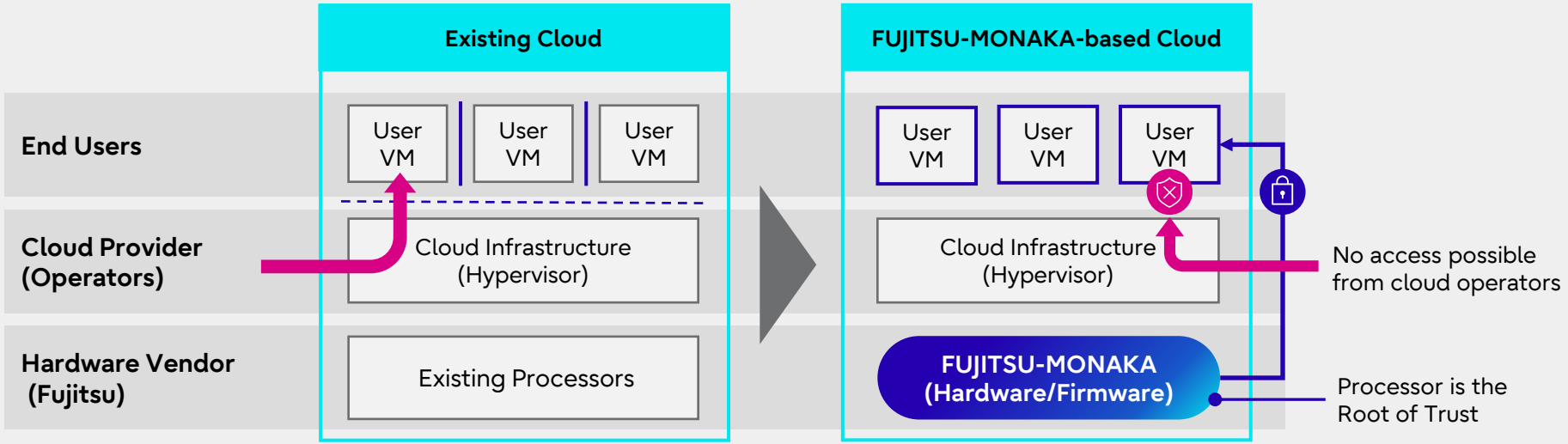
Confidential Computing

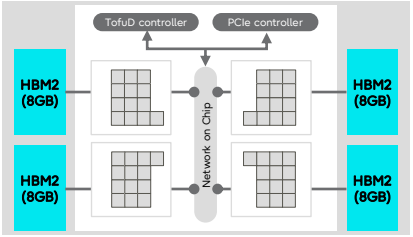
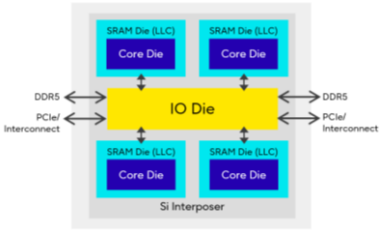
- Protect end-user data in memory by encrypting every VM with a different key generated by the processor hardware and firmware
- Expected to be an essential technology in cloud, edge and HPC environments which deals with sensitive data



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

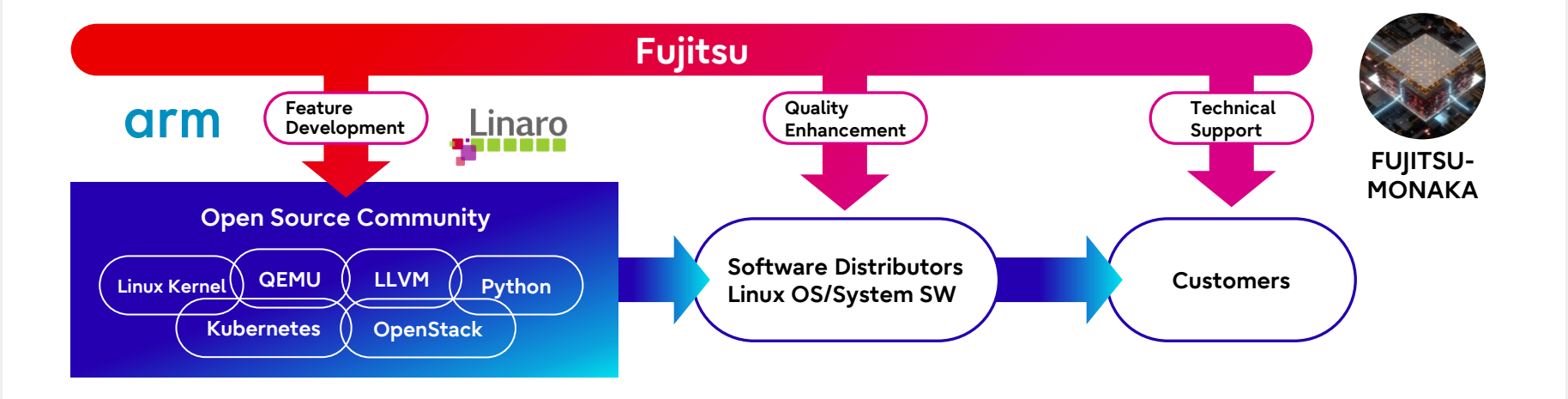
Processor encrypts each VM's memory with a different key.
User data is not accessible from cloud operators.
(Protected even if the cloud infrastructure is compromised)

Comparison between A64FX and FUJITSU-MONAKA

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 -

- **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



Conclusion

FUJITSU

- Fujitsu develops high performance and energy-efficient processor called FUJITSU-MONAKA using our own microarchitecture and innovative 3D many-core architecture
- We continue and expand software development with communities and partners for easy-to-use
- This processor will meet future computing demand of performance, power, reliability and usability for wide range of usage in the datacenter including AI and HPC
- We will contribute to the realization of carbon-neutral society
  by our computing technologies and collaboration with users and partners

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

Thank you