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

- 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.

- 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 microarchitecture

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

3D many-core architecture

- Leading-edge process technology
- Ultra low voltage operation

Confidential Computing

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

High-performance

- High-performance
- Easy to Use

Energy Efficient

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

High Reliability

- High Reliability
- Confidential Computing
- Mainframe class RAS for stable operation

Application Performance

Performance per Watt

- 2x normalized performance for MONAKA in 2027 compared to Competitor X in 2027
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

Semiconductor Trends*

<table>
<thead>
<tr>
<th>Technology node</th>
<th>Planar</th>
<th>FinFET</th>
<th>GAA (Gate-All-Around)</th>
</tr>
</thead>
<tbody>
<tr>
<td>~20nm (K computer: 45nm)</td>
<td>16nm ~ 3nm (Fugaku: 7nm)</td>
<td>2nm~ (MONAKA: 2nm)</td>
<td></td>
</tr>
</tbody>
</table>

*Fujitsu estimation

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 \times 2 \text{ 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

Side View
Ultra Low Voltage Technology - Energy Efficient

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

Reduction 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

Trend of Semiconductor Power*

- Ultra low voltage operation on FUJITSU-MONAKA

*Fujitsu estimation
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.

### Existing Cloud

<table>
<thead>
<tr>
<th>End Users</th>
<th>User VM</th>
<th>User VM</th>
<th>User VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Provider (Operators)</td>
<td>Cloud Infrastructure (Hypervisor)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware Vendor (Fujitsu)</td>
<td>Existing Processors</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

### FUJITSU-MONAKA-based Cloud

<table>
<thead>
<tr>
<th>User VM</th>
<th>User VM</th>
<th>User VM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloud Infrastructure (Hypervisor)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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)

- Processor is the Root of Trust

- No access possible from cloud operators

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## Comparison between A64FX and FUJITSU-MONAKA

### A64FX

- **Armv8-A Architecture**
  - SVE for HPC and AI

- **48 cores x 1 socket**

- **Low voltage**

- **2.5D**
  - CPU 7nm
  - HBM2

- **HBM2 4 channels**

- **PCI Express 3.0 Tofu Interconnect**

- **Air cooling and water cooling**

### FUJITSU-MONAKA

- **Armv9-A Architecture**
  - SVE2 enhanced for HPC and AI
  - Confidential Computing

- **144 cores x 2 sockets**

- **Ultra low voltage**

- **3D chiplet**
  - Core die 2nm
  - SRAM die/IO die 5nm

- **DDR5 12 channels**

- **PCI Express 6.0 (CXL3.0)**

- **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
Thank you

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