MERCURY
COMPUTER SYSTEMS

CUSTOMER REFERENCE STORY

Low-Latency Control Loop Computing for High-Value Industrial Equipment

ATCA® and RapidIO® Deliver Double the Performance over Bus-Based Architecture

Situation: Finding a Low-Latency Alternative to Bus-Based Architecture

A leading provider of capital equipment for the semiconductor industry was interested in evaluating how to make a strategic move away from their bus-based architecture. Only one year previously, they had added more processing capacity to their system, but found that the performance of a mission-critical application was again exhibiting unacceptable latency and running out of bandwidth. They realized that they needed an innovative low-latency alternative that would provide a clear, standards-based upgrade path for their extremely demanding control-loop application, which required multiple processors in each control loop and an ambitious update rate. To contain cost and answer stringent time-to-market constraints, the solution would also need the flexibility to accommodate their existing proprietary I/O format.

Five Critical Factors: Proving the Viability of ATCA across Industries

When the company's engineering team approached Mercury, they were exploring the prospect of replacing their bus-based architecture with open-standard AdvancedTCA® (ATCA) equipment that employed RapidIO® switch fabric. They were impressed with the versatility of RapidIO, but they had reservations about the viability of the ATCA standard outside the telecommunications industry.

While they had previously developed their own real-time kernel, they were interested in moving to Linux for the more robust choice of development tools that it would provide. They had concerns, however, about the resulting performance. Additionally, they were not sure that the level of "deterministic" latency they needed, measured in microseconds, would be scalable from the one required in the telecommunications space, measured in milliseconds. They would need to see convincing, rigorous benchmarks and analyses to prove that ATCA could handle their demanding application requirements.

Five critical factors were driving these issues:

- Hardware latency
- Software latency
- Determinism
- Integrating proprietary interfaces
- Time to market

What Mercury Provided

The company engaged Mercury to deliver a proof of concept, including benchmarks and analyses designed to demonstrate that the Ensemble™ 8000 Series ATCA platform could address the five factors that they had identified as critical for the control-loop algorithms at the heart of their application.

Hardware Latency

The company's legacy system used a shared bus for interprocessor communication. This bus-based architecture was introducing significant increases in control-loop latency as multiple processors shared use of the bus according to a time-division-multiplexed design.. Multiple bridge chips between the processors and the shared bus added to the latency in response times. Moving to a serial RapidIO low-latency fabric resulted in lower processor-to-processor latency, because the endpoints were integrated directly into the processors, and the fabric supported low packet latency and cut-through operation of the switches.

Software Latency

Because RapidIO constrained the hardware latency so well, the overall latency was impacted more by software than hardware. Mercury provided optimized low-level drivers to maximize software performance, and then developed interrupt-handling code and Linux scheduling management that supported software structuring to minimize critical-path delays.

Determinism

Because the company's application had hard real-time constraints, breaking the input-to-output latency would result in machine failure and unacceptable performance and downtime. Achieving a low mean latency was insufficient; the peak system-level latency also had to be constrained. Mercury carried out extensive benchmarking to demonstrate deterministic behavior, including data transfer over the RapidIO fabric, driver software overhead, impact of operating system and interrupt management, and fabric traffic disruption due to control and monitoring activities.

Integrating Proprietary Interfaces

The controller was linked to other parts of the system by many proprietary interfaces. Replacing them with a standards-based interface was considered unrealistic. Mercury developed a custom interface AMC to translate between RapidIO and the proprietary protocol. RapidIO endpoint IP was licensed to the company, so that they could extend it to other proprietary interfaces and functionality.

Time to Market

The development of a new generation of controller was part of an ambitious product development program, and the company did not have enough time or resources to learn the details of RapidIO optimization. Mercury developed custom middleware to allow the company's software team to develop their application code without delving into the details of fabric management and performance issues. Application development then proceeded in parallel with coding of the middleware, taking months off the process.

Successful Proof-of-Concept System

The proof-of-concept system that Mercury provided met or exceeded requirements and expectations in all five areas. The test results convinced the company's senior technical board that ATCA with RapidIO would accommodate their application requirements, and that the standards-based Ensemble ATCA platform gave them an upgradeable path that could sustain their application for years to come.

Capabilities

Mercury engineers collaborated with the company's engineering team to re-architect their system. The fielded solution was based on the Ensemble 2000 Series MPQ-101 AMC and the Ensemble 8000 Series BCC-101 carrier card. Custom AMCs were developed for the proprietary I/O, and the whole system was housed in a 5-slot Ensemble 8000 Series ATCA chassis.

Results

The new ATCA system gave the company a huge performance leap. Not only did they obtain double the performance of their bus-based architecture, but they also received some other unanticipated benefits by using ATCA:

- ATCA's built-in system management infrastructure through the IPMI network and shelf manager increased their system reliability by providing monitoring and management capabilities that resulted in reduced downtime and service costs.
- Because the RapidIO switch-fabric architecture largely decoupled the software from the hardware, application development was quicker and software maintenance was simplified. The middleware developed by Mercury was designed to ease the transition between processor families, which will reduce production costs in the future as new, more powerful processors become available.
- By moving to an open standards-based solution that incorporated off-the-shelf components, their materials management was streamlined to increase their competitiveness and provide a clearer product roadmap.

Next Step: Easy Migration to MicroTCA for Cost Reduction

The success of this ATCA migration has given the company the impetus to consider MicroTCA® as their next step. When the company moves to MicroTCA, they will be able to cut their equipment cost in half without compromising performance. The move from ATCA to MicroTCA will be straightforward, because Mercury offers compatible products for these two standards.

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