White Paper

Transforming Manufacturing with HPC for AI: Trends and the Path Forward

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HYPERION RESEARCH OPINION

The convergence of High-Performance Computing (HPC) and Artificial Intelligence (AI) has ignited significant breakthroughs across various sectors, with a sizeable impact in the manufacturing industry. AI, particularly advanced machine learning (ML) and deep learning (DL), has found a natural home in HPC systems, offering immense computational power to tackle complex AI workloads. This convergence of HPC and AI has not only accelerated progress in various fields but has also spurred substantial growth in the HPC-enabled AI market.

The manufacturing sector stands out with unique and very demanding characteristics, emphasizing specific use cases tailored to manufacturing processes. It requires seamless integration of AI with industrial systems, strict adherence to regulatory standards, and a focus on enhancing efficiency, reducing costs, and maintaining product quality. High-tech sectors including automotive, chip manufacturing, and fluid dynamics industries have embraced a surge in AI applications, influencing their operational and economic aspects significantly. The application of AI in these areas can offer strong competitive advantages and enhance product quality, making it an invaluable asset for manufacturing organizations.

Few organizations can deliver manufacturing oriented HPC and AI solutions on their own; collaborations are a must. The partnership between Dell Technologies, AMD, and Independent Software Vendors (ISVs) exemplifies an alliance that is positioned to address AI manufacturing challenges. The adaptability of AMD processor-based servers within Dell's validated design portfolio offers flexibility, allowing manufacturers to choose configurations that meet their specific requirements. The collaboration extends beyond hardware, with Dell actively engaging with AMD and ISVs to foster innovations and optimize performance. Furthermore, advancements in hardware have significantly bolstered the computational capabilities of manufacturing processes, shaping the future of the industry and unlocking new opportunities for innovation and productivity. This dynamic interplay of AI, HPC, and strategic partnerships marks a pivotal moment in manufacturing, offering solutions that can redefine the landscape and drive businesses forward.

SITUATION OVERVIEW

In the HPC market, the widespread integration of AI across a variety of sectors has been a notable trend. AI, particularly advanced ML and DL, require massive computational power, and more researchers and organizations have opted to use HPC systems to tackle exceedingly complex AI workloads. This convergence of HPC and AI has facilitated significant breakthroughs in a variety of fields, enabling faster, more accurate simulations and data analysis. Hyperion Research forecasts that the HPC-enabled AI market will grow robustly (22.7% CAGR) to reach $3.6 billion in 2026, and the DL subset of this market will expand even faster (32.2% CAGR) to total $1.4 billion that same year.

The HPC community has enabled and influenced the AI market, by making available advanced hardware and software, providing the ability to compute on large data sets, support parallel job operations, achieve ultrafast data movement, and take advantage of large memory and storage capacity. Recently, data-intensive AI and HPDA workloads have become a focal point for many users, sites, and vendors. In a culmination of new technology advancements and a surge of high-quality data availability, AI workloads are now a major driver of innovation and investment. Motivated vendors are answering the demand for new AI applications and facilitating a wider range of workloads from new user demographics.

Trends in AI for Manufacturing

The manufacturing sector within the HPC market has distinct characteristics that set it apart from most other commercial counterparts. Manufacturing also requires seamless integration of AI with existing industrial systems and machinery and strict compliance with industry-specific regulatory standards. These unique needs are essential for the manufacturing sector's success in AI adoption. Unlike other HPC sectors, manufacturing often centers on enhancing efficiency, reducing production costs, and maintaining product quality.

The automotive industry, chip manufacturing, and fluid dynamics disciplines of modeling and simulation have experienced a surge in the demand for AI applications. For instance, automotive manufacturers use AI for autonomous vehicle development and quality control, while chip manufacturing relies on AI to optimize designs and detect faults in semiconductor production. The application of AI in these areas has a direct impact on operational and economic aspects, making it a valuable asset for manufacturing organizations.

Potential Business Advantages

The integration of AI on HPC in the manufacturing industry can yield a multitude of business advantages, including:

- **Increase in Sales and Market Share:** AI-driven product innovation accelerates time-to-market, providing a competitive edge and enhancing market share.
- **Cost Reduction and Improved Margins:** Optimization and automation in manufacturing processes, efficient supply chain management, predictive maintenance, and quality control lead to cost reductions and improved profit margins.
- **Enhanced Efficiency:** Higher automation of tasks, traditionally requiring human supervision, improves manufacturing process continuity and product quality.

- **Data Utilization:** AI transforms accumulated data into a valuable asset, generating more value for manufacturing organizations.
- **Innovative Problem Solving:** Advanced AI, including generative AI, enables the exploration of innovative solutions to existing challenges, fostering creativity and cost-effective problem-solving.
- **Digital Twins and Rapid Prototyping:** AI-driven digital twins speed up the exploration of various scenarios, designs, materials, and use cases, allowing manufacturers to prototype and iterate quickly.

These advantages can translate into a competitive edge, as organizations that are successfully implementing AI in manufacturing can respond to market demands faster and more cost-effectively, offer with more feature-rich products, and enhance customer satisfaction and loyalty. Consequently, AI with HPC has the potential to redefine the manufacturing landscape and position companies for sustained success in a rapidly evolving business environment.

DELL/AMD PARTNERSHIP APPROACH TO AI FOR MANUFACTURING

The partnership between Dell Technologies, AMD, and key Independent Software Vendors (ISVs) in the manufacturing industry is a synergy aiming to excel in addressing AI manufacturing challenges. As stated by Chethan Neelakanta, senior solutions architect for HPC and AI at Dell Technologies, *"Dell Technologies has a long-standing partnership with AMD and major software ISVs for the manufacturing industry. The Dell PowerEdge server portfolio enables customers to use the latest generation AMD processors to solve their most complex problems quickly."* This close collaboration among Dell, AMD, and ISVs yields a combined wealth of subject expertise, technical knowledge, and software optimization that caters to the demanding needs of the manufacturing sector.

The adaptability of the AMD processor-based servers within the Dell PowerEdge portfolio is a standout feature, offering customers an array of options to suit their specific use cases and data center requirements. Whether it's dense, 1U, 2U air-cooled or liquid-cooled, both with or without accelerators, these servers provide the flexibility needed to tackle the highly diverse AI manufacturing challenges. Moreover, the collaboration goes beyond hardware, as Dell actively engages with AMD and digital manufacturing ISVs to develop and benchmark Dell validated designs. Validating designs enables customers to make informed architectural choices that align with their specific needs. This not only fosters innovation but also ensures that the systems built on the AMD processor platform are tried, tested, and optimized for peak performance, which is crucial in the realm of AI-driven manufacturing.

Another critical factor driving these advancements is the hardware improvements, especially through AMD's versions of the x86 architecture. The addition of the Milan and, most recently, the Genoa processor family series, with their advanced L3 cache technology, can significantly boost the performance capabilities of manufacturing workloads. According to Siddhartha Karkare, director of manufacturing vertical EPYC server BU at AMD, *"Both for AI as well as HPC applications in the EDA and CFD segments – the memory bandwidth per core is a performance lever which can be used on the Dell AMD server platforms which include up to 12 channels of the fastest DDR Gen5 memory."*

These hardware enhancements play a pivotal role in supporting the demanding workloads associated with AI in manufacturing. They provide the computational capability required for real-time data analysis, AI model training, and rapid decision-making, all of which are essential for optimizing

production, enhancing product quality, and ultimately improving efficiency. Thus, the synergy between AI software and advanced hardware architectures is shaping the future of manufacturing in remarkable ways, unlocking unprecedented opportunities for innovation and productivity.

The following three sections highlight recent applications of AI in the automotive industry, chip manufacturing, and computational fluid dynamics discipline, and explore the benefits of choosing the Dell and AMD validated design for AI on HPC.

Automotive Industry

AI on HPC systems offers significant advantages to the automotive manufacturing process, particularly in delivering safer and more cost-effective vehicles. As mentioned by Simone Bonino, VP of Manufacturing Solutions at Altair, *"Manufacturing engineering is an important part of the automotive industry to deliver safe, durable vehicles and reduce material and manufacturing cost."* AI plays a pivotal role in achieving these goals. One vital application is generative design, which enables engineers to find optimal designs that meet manufacturing requirements while considering trade-offs between cost and weight. By leveraging AI-driven generative design, automotive manufacturers can answer critical questions such as whether the additional cost for advanced materials is justified by the reduction in weight, or if cost savings achieved through casting are worth the trade-off of producing a heavier part. This process empowers engineers to make data-driven decisions that enhance the efficiency and cost-effectiveness of the manufacturing process.

An additional process in automotive manufacturing that benefits from AI is high-pressure die casting (HPDC). Also noted by Bonino of Altair, *"HPDC is an increasingly popular solution to manufacture large, complex components. Utilizing generative design techniques like topology optimization helps identify the most efficient design alternatives."* AI on HPC not only optimizes design but also assists in the fine-tuning process to meet specific requirements for nonlinear behavior and manufacturing, addressing complex challenges such as crack initiation that are hard to quantify. Through clustering based on deformation, expert labeling, and the training of classification models, AI empowers automotive manufacturers to streamline the design and production of large HPDC components efficiently, thus contributing to the advancement of automotive manufacturing processes.

The automotive industry also continues to develop and enhance the use and applications of Advanced Driver Assistance Systems (ADAS) and autonomous driving technology. Here, AI plays a pivotal role in advancing vehicle performance, safety, and autonomy. Manufacturers have invested heavily in HPC systems to support the development of level 5 autonomous driving, which demands immense computational power for real-time decision-making. Additionally, some startups are harnessing the capabilities of AI to train autonomous driving models in the cloud, while the vehicles themselves perform inferencing on the fly. This approach leverages cloud-based AI to continuously update and enhance the vehicle's autonomous capabilities, offering a glimpse into the future of automotive manufacturing.

Customer Success Story in the Automotive and Heavy Equipment Industry

A leading automotive and heavy equipment company needed to iterate more quickly through design and decision-making cycles and chose AI optimization on HPC to achieve these goals. This company uses many ISVs in the design and decision-making process, and it was important for the company to maintain an efficiently performing general-purpose HPC system. They chose an on-premises Dell/AMD solution to address their HPC for AI requirements.

Before choosing AI optimization, the engineering teams at this company had to manually iterate through design optimization studies, which was a very time-consuming process as it required passing different physics results between subject matter experts for each iteration. The existing process was replaced with AI optimization, accelerating decision cycles from weeks or months to just days, ultimately allowing the company to maintain a competitive advantage within the automotive and heavy equipment sector.

This company gained the following advantages by choosing the new Dell/AMD validated design:

- Faster design iterations and decision-making cycles
- Improved efficiency of the subject matter experts' time and expertise
- The ability to run over 40 different HPC applications effectively
- Competitive advantage in the automotive and heavy equipment

Chip Design

AI has emerged as a transformative force in the design and manufacturing of semiconductor chips by offering innovative solutions to complex problems. AI-driven HPC systems are enhancing chip design and manufacturing in several key ways, including chip design optimization. With the intricate and highly technical nature of semiconductor design, AI algorithms can analyze vast datasets, assess countless design possibilities, and predict the performance of different chip architectures. This allows for the creation of more efficient and powerful chips while minimizing design errors, reducing time-to-market, and lowering production costs. AI-powered HPC accelerates the optimization process, making it significantly faster and more accurate than traditional approaches.

Another crucial aspect is defect detection and quality control. AI-driven image recognition and machine learning models are employed to identify defects during the manufacturing process. These systems can analyze the microscopic details of chips and quickly identify any imperfections, ensuring that only high-quality chips are sent to market. This not only enhances the reliability of the chips but also minimizes waste and reduces production costs.

AI is also helping with supply chain optimization. It can predict demand trends, optimize inventory management, and even improve logistics and transportation. By better understanding market dynamics and streamlining the supply chain, chip manufacturers can reduce costs and improve overall operational efficiency. The combination of AI and HPC provides the computational muscle needed to process and analyze the immense amount of data required for these complex tasks.

AI on HPC will potentially shape the future of the chip design and manufacturing industry. It not only accelerates the design process, but also enhances quality control, process optimization, and supply chain management. As AI technologies continue to evolve and become more sophisticated, we can expect even greater improvements in chip design and manufacturing, leading to more powerful and reliable chips while reducing costs and waste in the semiconductor industry.

Computational Fluid Dynamics (CFD)

The integration of AI into manufacturing processes which require CFD modeling and simulation is a continually evolving endeavor, offering substantial benefits to this critical domain. As noted by Wim Slagter, director of Partner Programs at Ansys, *CFD simulations can be computationally intensive and time-consuming. AI techniques, including surrogate modeling and reduced-order modeling, have been applied to speed up simulations while maintaining accuracy. This enables quicker design iterations*

and a higher pace of innovation." AI on HPC platforms can introduce a paradigm shift by expediting CFD simulations, paving the way for more efficient and agile manufacturing processes.

One of the possible outcomes of this integration of AI into CFD simulations is the ability to conduct simulations at faster speeds while upholding precision. By harnessing ML-based flow solvers and integrating them with established CFD tools like Ansys Fluent, the industry can achieve impressive results. As noted by Slagter of Ansys, *"this enables massive training of data-driven neural networks for a variety of fluid variables."* For example, in the context of external aerodynamics for a car, this integration has demonstrated faster time-to-solution using a single CPU. Furthermore, GPUs offer the potential for an additional increase in computational speed, with the capacity for scaling up using distributed GPU architectures. These advancements hold tremendous potential for expediting manufacturing processes through ML-based methods and fostering a climate of innovation.

The evolving landscape of AI and ML in CFD is poised to enhance manufacturing processes further in the future. With ongoing advancements in these technologies, the capabilities of CFD are expected to expand even more, contributing to the continual improvement and innovation in manufacturing. As AI-driven CFD simulations continue to evolve and grow, the industry stands to benefit from improved efficiency, faster design iterations and enhanced problem-solving capabilities, all of which are critical for the dynamic and demanding world of manufacturing.

FUTURE OUTLOOK

In summary, while AI utilization in the broader HPC market is characterized by the convergence of AI and HPC capabilities and AI-driven system optimizations, the manufacturing sector's utilization of AI is marked by specific use cases and a focus on improving efficiency, compliance, and product quality. These unique requirements and applications distinguish the manufacturing sector within the HPC market and drive the adoption of AI as a transformative force in modern manufacturing.

The success of implementing AI on HPC in a manufacturing setting hinges on specific attributes and strategic considerations. A robust data-centric culture within the organization is imperative. This means having a well-established framework for data management that encompasses strategies for data collection, storage, and quality assurance. Machine learning models and AI initiatives rely heavily on data, and their effectiveness is intrinsically linked to the availability, accessibility, and quality of the data. Without a data-centric culture, AI implementations can face significant hurdles, hindering their chances of success.

Selecting the appropriate AI use cases is also important. Manufacturing companies need to focus on problems that AI is adept at solving, with a keen understanding of AI's capabilities and limitations. It's crucial to identify high-value use cases that align with business objectives. To achieve this, a comprehensive understanding of the problem at hand, the availability of high-quality data for problem characterization, and economic viability for implementing advanced AI solutions are essential. This strategic alignment ensures that AI investments are channeled into areas where they can deliver tangible benefits.

Another key consideration is the availability of talent, domain knowledge, and specialized tools, all of which play a pivotal role in the successful implementation of AI in manufacturing. Organizations require data scientists, domain experts, and a robust AI environment with the necessary software

tools. These resources are indispensable for effectively harnessing the potential of AI. In cases where such resources are costly or limited, partnering with AI vendors who offer outsourcing and consulting services can expedite the AI implementation process.

Given the complexities involved in selecting and implementing the right HPC and AI solutions, manufacturers should be judicious in their partner selection. The Dell, AMD, and ISV strategic partnership can be used as a strong model for AI on HPC collaboration for the manufacturing sector.

About Hyperion Research, LLC

Hyperion Research provides data-driven research, analysis and recommendations for technologies, applications, and markets in high performance computing and emerging technology areas to help organizations worldwide make effective decisions and seize growth opportunities. Research includes market sizing and forecasting, share tracking, segmentation, technology, and related trend analysis, and both user & vendor analysis for multi-user technical server technology used for HPC and HPDA (high performance data analysis). Hyperion Research provides thought leadership and practical guidance for users, vendors and other members of the HPC community by focusing on key market and technology trends across government, industry, commerce, and academia.

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