# Industrializing AI for the Enterprise with NVIDIA DGX Systems and MLOps

White Paper

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# Document History

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# Industrializing AI with MLOps

As projects leveraging artificial intelligence (AI) continue to prove their value, organizations find they have an increasing number of teams wanting to use AI to meet their business objectives. Since AI is compute intensive and working with underpowered hardware creates severe impediments to a project's success, organizations invest in accelerated computing infrastructure–including hardware and software purpose-built for AI–to shorten time-to-solution and get their models into production sooner.

Beyond good infrastructure planning, to meet the challenges of an end-to-end strategy of delivering models from prototype to production, CIOs and data science leaders need to develop cross-functional strategies that bridge the gap between traditional IT operations and AI development. These highly skilled teams share the same goal of creating successful AI-based solutions, but their pain points and daily circumstances are very different. Fortunately, a relatively new set of principles known as *MLOps* can make this process much easier, and help teams avoid many of the common pitfalls that impact unsuccessful AI initiatives.

# The Impact of Model Debt

As AI-based projects continue to proliferate, a perhaps unexpected inefficiency has now become a major concern for CIOs and data science leaders: many models, despite best efforts, simply never make it to production. There are a variety of reasons for this, ranging from the mundane such as projects being cancelled, to the more serious, where the model design or available training data doesn't lead to sufficient real-world accuracy to be useful.

These abandoned, zero-value models bring down the efficiency of an AI organization, leading to what is often called *model debt*. A bit like maintaining monetary debt, model debt is a sunk cost that must be repaid someday, dragging down the profitability of the project. Organizations are beginning to understand that avoiding model debt is a key to success using AI.

A major contributor to model debt is ineffective resource and workflow management which makes it difficult to guide a model from prototype through to successful deployment. As multiple teams work on projects on shared AI infrastructure, managing access becomes challenging. Teams find themselves using shared calendars, spreadsheets, and instant messaging to resolve scheduling conflicts. As AI teams expand, day-to-day management needs such as monitoring, reporting, and job prioritization, become even more complex. This leads to teams scrambling for time on the hardware–sometimes reserving one or more systems indefinitely even when they don't have jobs actively running just to ensure they have access when they need it. In some cases, these reservations are held inactive for long periods of time–or worse, forgotten about–effectively throwing capacity into the waste bin. There is no central clearing house where decisions on the prioritization of users and jobs for the available hardware can be made.

Another related concern is the inability to easily track data and artifacts (e.g., datasets, model versions, and experiment results) for each project. This is also often handled manually, creating massive inefficiencies in larger organizations.

At its core, this is an IT problem that needs to be solved for the entire organization, much as IT is responsible for email service, HR apps, and web infrastructure, with the AI practitioners as IT's customer. Unfortunately, the infrastructure that is used for AI is often treated as bespoke, with the management burden landing squarely on the shoulders of the data science team with little or no IT and operations involvement.

# Taking a Page from Web Application Development

More than a decade ago, web application development was in a similar situation. The number of web application projects was increasing rapidly but were divorced from the well-tested processes used by operations teams to manage deployment. These disconnects slowed organizations down, extending the development and deployment process.

The fix for this was something we now know as DevOps. In DevOps, the development processes used by developer teams and the operations processes used by IT were merged to create a cross-functional and repeatable set of practices to ensure rapid development and deployment of web applications.

While AI projects have different characteristics than web applications, something very valuable can be learned from DevOps. The key to shortening time to delivery is to make the development and operations processes peers, each with its own set of equally important aspects that can overlap. Identifying these overlapping areas and using the best practices of each discipline to ensure they fit

together harmoniously–rather than crashing into each other destructively–dramatically improves outcomes.

A similar situation exists for AI. Managing workflow is a common task spanning development and operations teams. As mentioned above, many AI projects are managed manually, which obviously isn't an operations best practice. However, by adopting operations techniques and adding workflow management software into the process, AI teams can increase their productivity significantly. This is *MLOps*, a way of automating and operationalizing end-to-end machine learning (ML) and AI pipelines across data preparation, model building, deployment, and production, and it plays a vital role in the success of AI projects.

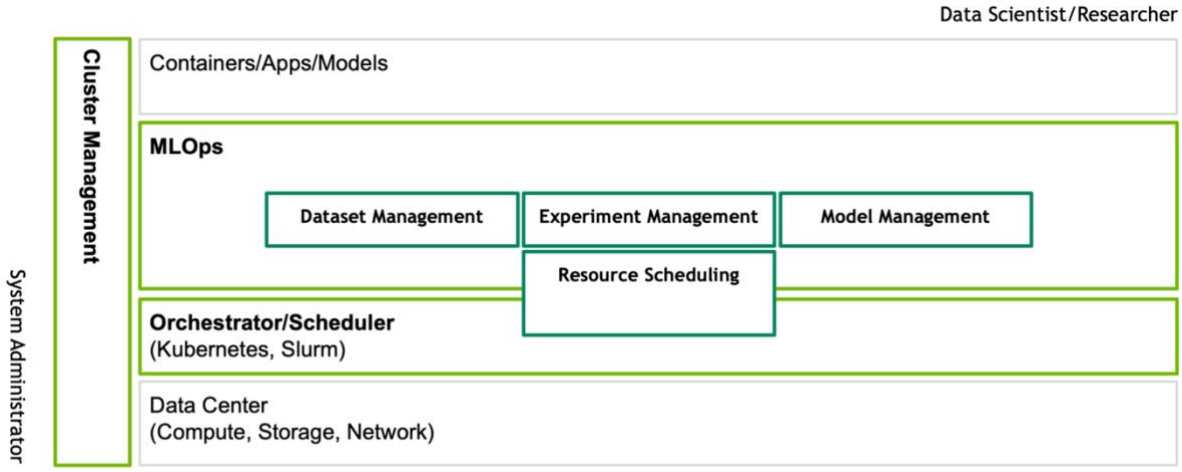
## Managing Resources, Experiments, Jobs, and Workflow

MLOps tools bring an organized, methodical discipline to AI project operation and deployment, helping to ensure AI infrastructure is well utilized. They bring together the experiments, GPU resources, and specific AI jobs into a singular management environment to:

- Improve user productivity and speed workflow - users can focus on creating their models rather than handling version control or negotiating with other teams for access to resources.
- Maximize utilization of resources - keep systems busy, run more jobs than would be possible manually.
- Allow projects to scale easily - give users instant access to 1 GPU or hundreds, right-sizing every job based on priority and need.
- Accelerate the ROI of AI - ensure models get from concept to production efficiently.

MLOps software offers capabilities such as interactive sessions, dataset and experiment management, full pipeline management with model versioning, job scheduling, reporting, and much more.

Figure 1. MLOps infrastructure stack.



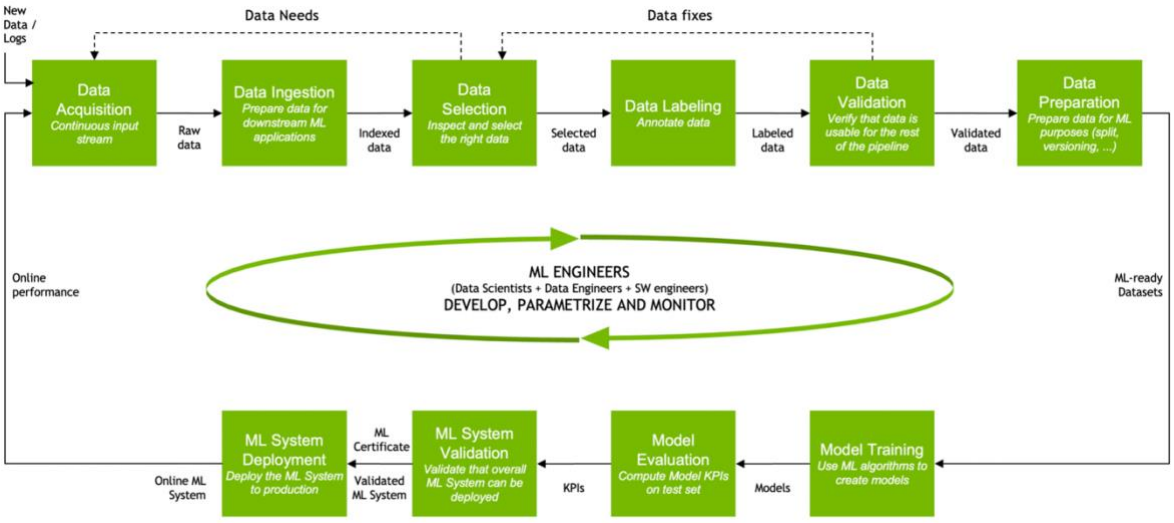

Many of these application-level MLOps tools rely on an underlying orchestration system. Two of the most common tools for this purpose are Kubernetes (K8s) and Slurm. These platforms are deployed

onto a cluster to manage the hardware resources and intelligently schedule workloads and jobs. This provides researchers a direct interface to run their experiments without needing knowledge of the underlying cluster. It also provides the MLOps engineers a tool to launch services that extend the capabilities of the base platform. For example, Kubernetes and Slurm are primarily command line driven, but MLOps tools can be deployed to give researchers a UI driven platform. There are many cloud-native products that can be easily installed onto any Kubernetes cluster and many of these are members of the NVIDIA DGX-Ready Software program discussed below.

## Speeding up the End-to-End Lifecycle of AI Development

AI development is an iterative process, where data scientists continually refine their models hundreds or thousands of times to improve their accuracy, which, in turn, increases efficacy. And due to very large datasets and algorithmic complexity, the AI development process is extremely resource intensive.

Figure 2. Typical AI development cycle.




Even with a well-planned MLOps-based approach, software can't be successful in isolation. Hardware and software need to work in harmony, each as a pillar supporting the AI development platform. Organizations need a systemized, enterprise-grade approach that supports fast prototyping, frequent iteration, and continuous feedback, as well as a robust infrastructure that can scale in an enterprise production setting.

With NVIDIA DGX™ systems, featuring NVIDIA A100 Tensor Core GPUs and NVIDIA InfiniBand networking, NVIDIA has brought together over a decade of AI experience and know-how, integrated into a full-stack platform, purpose-built for the world's most complex enterprise AI challenges. The record-breaking performance of NVIDIA DGX A100 and NVIDIA DGX SuperPOD™ and the fully accelerated DGX software stack pair perfectly with MLOps solutions, ensuring that each trip through the development cycle is fast and efficient. This results in a faster time-to-solution, as you would expect. It also results in better model accuracy, since developers can use extremely large data sets

and perform more optimizations and fine tuning. This translates directly into business value, by increasing the quality of AI models and the services built around them.

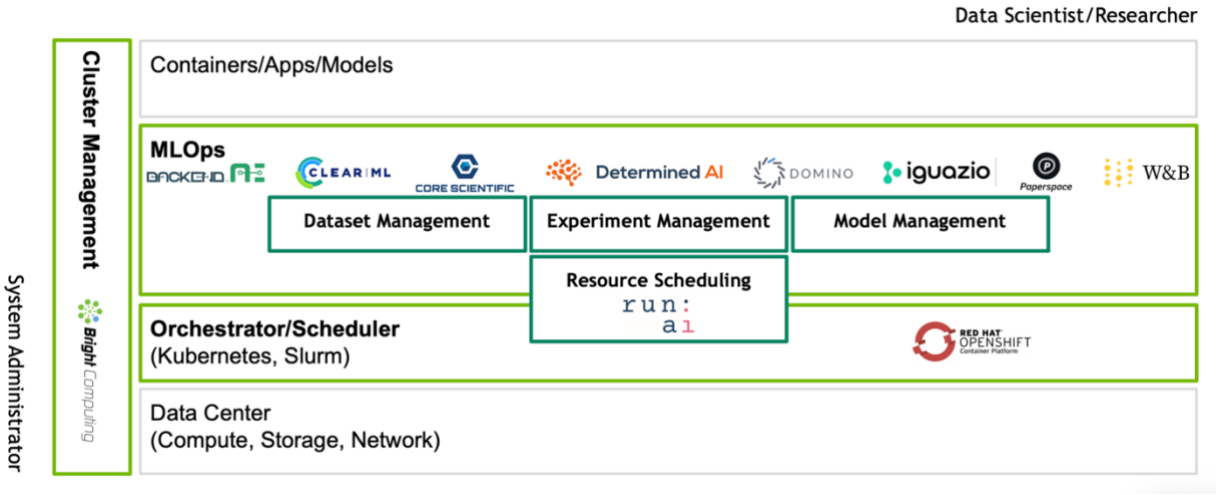
Figure 3. NVIDIA DGX systems deliver record-breaking performance for AI workloads.

Choosing the right combination of MLOps software and AI infrastructure can be the difference between projects languishing in development–with developers standing idle waiting for their jobs to complete–or successfully meeting business objectives in production. NVIDIA DGX systems speed the end-to-end lifecycle of enterprise AI across development, deployment, and on-going optimization.

## Leveraging MLOps with NVIDIA DGX-Ready Software

The NVIDIA DGX-Ready Software program is a portfolio of ISV solutions certified by NVIDIA that help organizations using NVIDIA DGX systems improve data science productivity, accelerate AI data pipeline and workflow, and improve accessibility and utilization of resources. The program features a variety of software solutions covering MLOps, cluster management, and resource scheduling and orchestration.

Figure 4. The ecosystem of NVIDIA DGX-Ready Software partners that can be used for the various parts of an AI infrastructure solution.




Since DGX-Ready Software is validated and certified with DGX systems, it takes the guesswork out of deploying this critical management layer for data science teams. The program features a large selection of MLOps software, allowing users to evaluate a variety of solutions knowing that all of them are designed to work in large, multi-node environments with DGX systems.

## Industrialization is the Key to AI Success

Now that AI is common in day-to-day operations for many organizations and projects continue to multiply, it's clear that successfully leveraging AI requires a well thought out plan to guide projects from development through to deployment. CIOs and data science leaders know that critical parts of the equation include users with AI expertise, powerful NVIDIA GPU hardware such as NVIDIA DGX A100, fast networking such as NVIDIA InfiniBand, and optimized AI software and frameworks such as those from NVIDIA NGC.

Beyond the infrastructure, organizations are turning to MLOps software to provide powerful tools to bring IT/operations and data science teams closer together, helping them to scale AI infrastructure more easily, streamline their processes, and avoid model debt. The NVIDIA DGX-Ready Software program certifies MLOps and other software solutions to ensure they run optimally on DGX systems, allowing enterprises to leverage this new breed of AI software with confidence. This combination of NVIDIA DGX infrastructure and certified MLOps software provides a clear path for enterprises to industrialize AI, unlocking the full potential of their AI initiatives.

*Learn more: www.nvidia.com/dgx-mlops*

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