White Paper

DevOps Modernization

# Taking DevOps to the Next Level

## DevOps is accelerated on Intel® architecture.

### Overview

The rate at which IT infrastructure is evolving in the cloud has created increasingly complex challenges for DevOps teams. Cloud hyperscalers, such as Amazon Web Services (AWS) and Microsoft Azure, each provide their own DevOps-related tools to customers to help at each stage, but these tools are not designed to work across a hybrid cloud or multicloud infrastructure. As the underlying hardware foundation that is common across cloud service providers (CSPs), Intel offers a growing and consistent set of tools and technologies for DevOps teams—infused with security and performance optimizations—that can help fill this gap.

### Introduction

With the continued evolution of digital transformation, organizations are standardizing their IT spending to gain the agility that cloud platforms provide. The growth in cloud and cloud-native applications is driving a parallel rise in the role and importance of DevOps. DevOps is a cross-disciplinary practice in which application-development functions (dev) work together with IT-operations functions (ops) to improve product quality and accelerate time to market. DevOps is implemented differently in different organizations—for example, development and operations can be done by different people at one company, or as a combined team at another.

With its constant iterations, monitoring, and testing, the DevOps methodology supports desired ongoing improvement of cloud applications on a continuous integration/continuous delivery (CI/CD) cadence. But the rate at which IT infrastructure is evolving in the cloud has created increasingly complex challenges for DevOps teams.

Foremost, writing highly performant code is costly. Developing and debugging software is a time-intensive process. Finding experienced developers who can perform the work is difficult, affecting the ability to execute at speed. And cloud development brings its own set of challenges. For example, Amazon Web Services (AWS) has thousands of runtime and pricing SKUs, with an overwhelming array of configuration parameters. Many companies also use more than one public cloud, further increasing the number of choices and configurations.

Meanwhile, security must be integrated throughout the software-development process. Teams that have accelerated delivery while maintaining their reliability standards need to integrate security checks and practices without compromising their ability to deliver software quickly or reliably.

One of the key criteria for success in DevOps is the toolchain that is adopted, and its fit for the values of any organization, particularly in the deployment of hybrid and multicloud strategies. Teams need the ability to optimize for security and performance at every stage in the journey. Reflecting its own value of, and investment in, DevOps, Intel has grown and vetted an ecosystem of partners who provide a wide range of tools and technologies that help DevOps teams increase their productivity today and favorably position them for ongoing, accelerating automation in the future.

The purpose of this paper is to outline the stages within Intel's DevOps cycle, highlighting best practices, utilities, and tools that are worth examining for any team or leader who is pursuing DevOps for their own organization with intensity. With decades of experience in the enterprise, and a substantial presence in the public cloud, Intel is poised to make developers and IT organizations more successful.

## The Intel view of the DevOps cycle

DevOps teams accomplish their work in multiple stages throughout a continuous cycle.

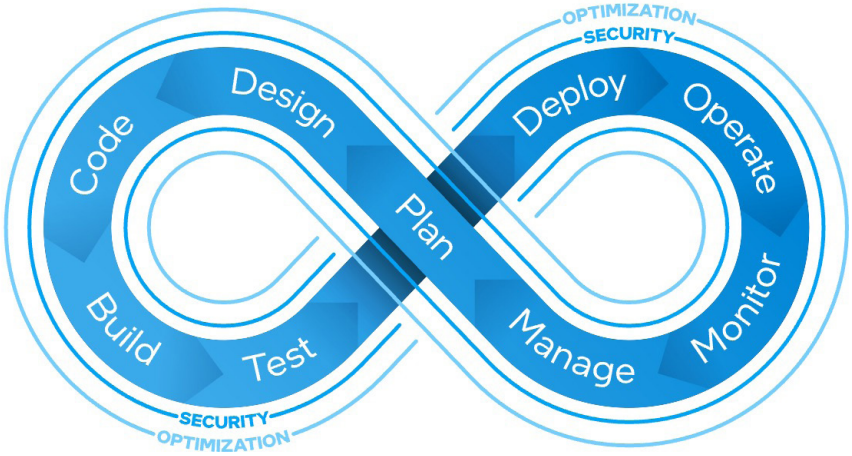


**Figure 1.** The Intel DevOps cycle is infused with security and optimizations

To underscore the influence of the DevOps movement, cloud hyperscalers, such as AWS and Microsoft Azure, each provide their own DevOps-related tools to customers to help at each stage, but these tools are not designed to work across a hybrid cloud or multicloud infrastructure, leaving practitioners with the responsibility to stitch the process together. As the underlying hardware foundation that is common across cloud service providers (CSPs), Intel offers a growing and consistent set of tools and technologies for DevOps teams that can help fill this commonly recognized gap.

Before examining each of the stages in the continuous cycle of DevOps, it's important to highlight Intel's focus on bringing security measures and performance optimizations to bear throughout the cycle. Intel supports DevOps with security and optimization capabilities from end to end.

### Enhanced security

Security threats have never been greater: the average total cost of a data breach today is more than $4 million, with 45 percent of breaches cloud-based.[1] Intel offers DevOps teams ways to achieve DevSecOps—DevOps and cybersecurity—by embedding hardware-based security in each application's lifecycle. A key security feature on the latest Intel® Xeon® Scalable processors is Intel Software Guard Extensions (Intel SGX). Intel SGX allows developers to isolate specific application code and data in private regions of memory, called enclaves, for confidential computing solutions.[2]

### Intel optimizations

Intel technologies perform their best when operating in an environment optimized for their capabilities. Intel invests significant effort to make sure that optimizations are available at the appropriate point in the DevOps lifecycle. Provisioning choices are made in DevOps every day, and not always with awareness of the available Intel optimizations designed to deliver high performance and other positive impacts.

Optimizations are made available by Intel on many fronts:

- Through optimized open source tools and libraries
- Through industry standards such as Terraform infrastructure as code (IaC) and Sentinel policy as code, which incorporate Intel optimization best practices
- Through Intel DevOps tools such as gProfiler and System Health Inspector, which evaluate running workloads for optimization opportunities
- Through industry partners such as Densify, CloudGenera, and others, who surface Intel optimization opportunities
- Through emerging FinOps (optimization of spend), where Intel is enabling partners such as Densify and Granulate to optimize cloud consumption and corresponding costs

The next section looks at each stage in the DevOps cycle to describe what it is and how Intel helps with it.

## How Intel helps optimize DevOps at every stage

Intel helps with each step of the DevOps cycle: planning, designing, coding, building, testing, deploying, operating, monitoring, and managing. This section briefly examines each stage to identify pertinent Intel offerings.

### Plan

First, DevOps teams ideate, define, and describe the features and capabilities of the applications and systems they plan to build. This is a critical project-management phase in which data and security planning is initiated and a high-level architecture framework is defined. Application lifecycle management and value stream mapping are also discussed, as are revenue models and budget allocation.

Intel Migration Advisor by CloudGenera helps teams work with a vendor-agnostic cloud-management tool that analyzes all aspects of an organization's cloud-migration plan, across CSPs and at on-premises and off-site data centers. The tool then develops a scorecard-based report that recommends workload placements and optimal configurations. The resulting migration plan and business case are grounded in live data and are generated in minutes.

### Design

Planning and design are critical precursors to software development, yet DevOps tools have generally focused more on software programming and release cycles, and less on the actual design or user experience (UX). The rise of DesignOps reflects the increasing pressure on organizations to enhance design practices and incorporate next-gen platforms for better collaboration between developers and people without formal software-development skills. This stage might include wireframes, graphic design, versioning and repository strategies, and low-code/no-code platforms.

Low-code/no-code platforms represent a new era in software development. A combination of recent advancements in artificial intelligence (AI), programming languages, and compilers makes it possible for non-developers in an organization to create high-quality, high-performance solutions in any execution environment. Intel is a leading advocate for a future in which "machine programming," or the automation of software development, replaces traditional laborious, mundane, error-prone, and time-consuming programming practices.

### Code

Teams are now actively developing software code. DevOps teams might define an integrated development environment (IDE), begin development on a low-code/no-code platform and optimized frameworks and libraries, and select mobile application-development platforms. By this stage, DevOps teams might have an established set of coding standards and version-control protocols, along with an overarching strategy for security and license compliance.

Intel has a wide range of technologies to help during code development. Intel DevCloud is a no-cost IDE that allows developers to learn, prototype, test, and run their workloads on a wide range of Intel architectures. Developers can also enroll in Intel DevCloud for preinstalled Intel-optimized frameworks, tools, and libraries. The Intel Cloud Development Tools site hosts a variety of optimization tools and open source platforms for cloud solutions, including Intel Workload Optimizer by Granulate, Intel Cloud Optimizer by Densify, containers, and Intel in Cloud Native for automated deployment, among many others.

Intel tuning guides provide guidance on BIOS, operating system, and workload/benchmark settings so development teams can get the most out of the latest Intel platforms for server workloads, including AI, high-performance computing (HPC), data analytics, databases, media, and more. Intel also offers tuning guides for WordPress, NGINX, and Java.

### Build

Dovetailing with the code stage, the build stage requires compilers and optimized frameworks and libraries, which are critical to success. Automated tools help streamline work while maintaining version control and security. Developers might also run quality assurance (QA) scripts early in the build process to help correct errors, save time, and improve product quality. Continuous integration (CI) is a part of this stage, during which new code written by multiple developers is merged into a single, centralized repository on a regular schedule.

For decades, Intel has created and shared developer tools that streamline the build stage and optimize code performance for developers. These include industry-standard compilers, optimized containers, and golden images for virtual machines (VMs). Organizations who make use of Intel's developer tools and optimized images recognize that, while the industry narrative has shifted fundamentally toward the developer, the need for achieving peak performance for the underlying processor has never been more important.

### Test

This stage could include testing in several areas: integration, API, user experience (UX), application benchmarking performance, code optimizations, load/scale testing, and security compliance testing.

Intel® VTune™ Profiler optimizes application performance, system performance, and system configuration for HPC, cloud, and more across architectures (CPUs, graphics processing units [GPU], and field-programmable gate arrays [FPGAs]). It is included in the Intel oneAPI Base Toolkit, or it can be used as part of Intel DevCloud. Intel Workload Similarity Analyzer, part of the Intel Cloud DevOps Toolkit, identifies workload similarities and offers configuration and tuning recommendations.

### Deploy

At this point, code is released into the end-user-facing production environment. With a continuous delivery approach, new features or updates to the application are released into production on an ongoing and frequent basis. Automated provisioning solutions manage and monitor both test and production environments (that is, IaC) to help verify whether tested code will work in production and to complete deployment.

Intel Terraform templates support IaC efforts with consistency, improved speed of provisioning, and reduced manual maintenance. Runtime optimization platforms such as Intel Workload Optimizer by Granulate and Intel Cloud Optimizer by Densify help with application-driven resource management. Intel-optimized cloud recipes provide teams with optimized configurations delivered as IaC, and Intel Optimized Cloud Stacks similarly provide optimized configurations delivered as images on CSP marketplaces (for example, Bitnami optimized images).

### Operate

Once an organization reaches the stage of operationalizing, it begins maintaining, monitoring, and troubleshooting applications in production environments, including hybrid clouds. DevOps teams use infrastructure-automation tools with the goals of system reliability, high availability, strong security, and zero downtime.

They have the opportunity to use Intel Inspector during a normal debug or production build to catch and debug errors quickly. Intel Inspector checks all code, including third-party libraries with unavailable sources, to locate the root cause of memory, threading, and persistence errors before release. Intel DCM supports operations by collecting and analyzing the real-time health, power, and thermals of a variety of devices in data centers. And Intel Data Center Performance Kit (Intel DC PerfKit) is an automated framework for capturing workload performance on premises and on infrastructure-as-a-service (IaaS) cloud instances that consolidates and recommends optimizations and tuning parameters.

### Monitor

Operations teams are tasked with monitoring application performance, which requires telemetry data, actionable alerting, and full visibility into applications and underlying systems. Everything should work according to UX and service-level agreement (SLA) metrics. Intel Telemetry Collector helps teams rapidly analyze and see performance visualizations for a wide range of systems. And gProfiler from Granulate continuously analyzes code performance across the entire environment, helping teams optimize the most resource-consuming parts of their code, improve application performance, and reduce costs.

### Manage

Having developed a now more mature product, teams continue to capture and track any issues, continue debugging, and assess and analyze infrastructure spending, also known as Finance DevOps (FinOps). FinOps, and how Intel Workload Optimizer by Granulate and Intel Cloud Optimizer by Densify support it, is discussed in more detail in the following section.

## Enabling DevOps now and in the future

A comprehensive DevOps practice and culture can deliver real benefits, such as faster time to market, greater customer satisfaction and loyalty, deployments at scale, faster recovery times, and built-in security. As DevOps has become more established in IT, it continues to evolve to incorporate other initiatives, such as AI and machine learning (ML). Intel is supporting DevOps teams in these corollary disciplines, including AI operations (AIOps), ML operations (MLOps), and FinOps.

### AIOps and MLOps

AIOps and MLOps platforms incorporate DevOps practices to help organizations scale AI/ML beyond experimentation to make AI a company-wide core competency and competitive advantage. Intel has acquired a number of technologies that support AIOps and MLOps. Cnvrg.io is a leading data science platform for MLOps and model management, helping DevOps build innovative ML-development solutions and build high-impact ML models in less time. SigOpt, a model-development platform, helps simplify track runs, training visualizations, and hyperparameter optimization for any type of model built with any library on any infrastructure.

Other Intel tools include optimized frameworks such as Intel Optimization of PyTorch, which enhances the performance of distributed deep learning (DL) training on Intel architecture. Intel Optimization for TensorFlow also helps boost the performance of DL applications.

Developers can get more performance for AI/ML applications through a range of Intel hardware accelerators, including Intel Advanced Vector Extensions 512 (Intel AVX-512) Vector Neural Network Instructions (VNNI) and Intel Advanced Matrix Extensions (Intel AMX). Developers can tune and optimize these built-in accelerators by using Intel oneAPI toolkits, which provide them with best-in-class compilers, performance libraries, frameworks, and analysis and debug tools. Another useful library is the open source Intel oneAPI Deep Neural Network Library (oneDNN), which provides basic building blocks for neural networks and aids developers with familiar, standardized interfaces and efficient write-once, run-anywhere code.

### FinOps

FinOps is a relatively recent discipline that helps businesses understand and control the variable nature of cloud spending. It brings together finance, IT, and leadership in a cross-company collaboration to foster innovation and adapt quickly to change while keeping costs under control. Intel Workload Optimizer by Granulate is an intuitive tool that helps organizations see where they can improve performance and utilization on Intel architecture–based instances while reducing costs. Intel Cloud Optimizer by Densify helps engineers optimize resources used by application workloads in the cloud to help manage costs.

### Low code/no code and democratization

Software engineering is moving toward simplification, and hence democratization, to allow non-developers and developers alike to design and create apps through low-code/no-code development. Rich and intuitive graphical user interfaces (GUIs) that are part of low-code/no-code platforms can make it easy for anyone to:

- Reduce development time. Seventy-two percent of ow-code developers in a recent survey created software apps two times faster than those using traditional development.[3]
- Deploy optimized code on any desired hardware target.
- Reduce execution time and costs in any execution environment.
- Maintain control and security of source code.

Machine programming can help foster democratization by utilizing AI for many aspects of software development and deployment, including correctness, translation, optimization, adaptation, and security. Machine programming also frees DevOps teams by automating these tasks so they can focus on higher-value tasks. Intel early-stage ventures such as Inteon are commercializing machine programming technology to enable new products such as performance-optimization-as-a-service and cloud-performance-analysis-as-a-service.

Today, Intel tools, automations, and accelerators presage the coming of machine programming. Ease of use, process acceleration, and automation are important improvements today and a step toward the machine programming of the future. Intel Labs, a research organization that delivers

breakthrough technologies for the tech industry, is working on novel approaches to the industry's most challenging problems. It recently released two novel software frameworks, for example, for automating the generation of super networks.

The vision of machine programming will be challenging to fulfill, taking years if not decades to come to fruition. But along the way, Intel's efforts continue to help developers take huge leaps forward.

## Conclusion

Whether your organization is comprised of sophisticated DevOps practices and toolchains that are pushing the bleeding edge of what the industry is doing, or whether you are much earlier in your journey, Intel's perspective on DevOps is meant to facilitate the spirit of experimentation that makes the movement so powerful. Consider implementing some of the utilities and tools above and in the Appendix to enhance your organization's effectiveness at every stage, and help ensure that your applications run at peak performance from boot up of the environment to desired customer outcome.

## Learn more and get started

Join the cloud insider community: intel.com/cloudinsider

Follow the Intel Cloud Developer site: intel.com/content/www/us/en/developer/topic-technology/cloud/overview.html

Go to https://bitnami.com/intel/cloud for pre-configured, validated, and optimized images.

## Appendix: Tools and technologies for DevOps

**Table 1.** A preliminary list of tools and technologies for each DevOps stage

| DevOps stage | Available tools and technologies |
|---|---|
| Plan | ▪ Intel Migration Advisor by CloudGenera<br>▪ If confidential computing is involved, plan to integrate cloud security best practices and Intel SGX.[2] |
| Design | ▪ Inteon<br>▪ Intel machine programming initiatives |
| Code | Intel Cloud Development Tools<br>**Integrated development environments (IDEs)**<br>Intel DevCloud<br>**Tuning guides**<br>▪ Intel tuning guides for AI, HPC, data analytics, databases, media, and more<br>▪ WordPress tuning guide<br>▪ NGINX tuning guide<br>▪ Java tuning guide |
| Build | ▪ Intel developer tools<br>▪ Intel oneAPI DPC++/C++ compiler<br>▪ Intel Optimized Containers (pre-defined optimized containers for specific applications and/or use cases; for example, Docker Hub container)<br>▪ Intel oneContainer portal*<br>**VMs**<br>▪ Intel Optimized Cloud Images by Bitnami |
| Test | ▪ Intel VTune Profiler<br>▪ Intel Workload Similarity Analyzer* for active benchmarking and better hardware selection |
| Deploy | Intel Endpoint Management Assistant (Intel EMA) Cloud Start Tool Terraform Scripts<br>**Runtime-optimization platforms**<br>▪ Intel Workload Optimizer by Granulate*<br>▪ Intel Cloud Optimizer by Densify<br>**Optimized recipes/stacks**<br>▪ Intel-optimized cloud recipes (optimized configurations delivered as IaC)<br>▪ Intel Optimized Cloud Stacks (optimized configurations delivered as images on CSP marketplaces; for example, Bitnami optimized images) |
| Operate | ▪ Intel System Health Inspector*<br>▪ Intel DC PerfKit*<br>▪ Intel Data Center Manager (Intel DCM) |
| Monitor | ▪ Intel Telemetry Collector*<br>▪ gProfiler from Granulate* |
| Manage | ▪ Intel Workload Optimizer by Granulate*<br>▪ Intel Cloud Optimizer by Densify |

*Available as part of the Intel Cloud DevOps Toolkit suite.

[1] IBM. "How much does a data breach cost in 2022?" 2022. ibm.com/security/data-breach.

[2] Intel. "An Ecosystem Solution for Confidential Computing." May 2022. https://networkbuilders.intel.com/solutionslibrary/anjuna-hashicorp-red-hat-openshift-using-intel-software-guard-extensions-intel-sgx.

[3] SaM Solutions. "Development Trends 2022." March 2022. sam-solutions.com/blog/software-development-trends/.



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