Brief
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IT@Intel: Cloud Containers as a Service – Wins, Trends and Strategies

Intel embraces Containers as a Service for its enterprise cloud environment to add flexibility, drive new capabilities, accelerate development and increase efficiency

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Executive Summary

The rapid expansion of cloud-native environments presents mounting challenges for today's large digital enterprises, especially in the development, deployment and management of new applications. After a thorough assessment of our needs and available solutions, Intel IT chose a Containers as a Service (CaaS) strategy to take advantage of the many benefits it offers. Our initial success with CaaS in a few dozen cases provided us with the knowledge and experience to tailor CaaS solutions to the needs of several Intel business units. Today, CaaS applications cover a wide spectrum of solutions company-wide, ranging from modern solutions to legacy services in support of Intel's cloud-native enterprise.

This paper will discuss:

- The major industry trends in CaaS
- Our exploration and why we looked Into CaaS
- The challenges we faced in our enterprise
- Why we chose CaaS
- How we determined the best CaaS solution for our needs
- The production results and what we learned

Background

Realizing that technology changes constantly, Intel IT continually evaluates technology trends to ensure our infrastructure is efficiently meeting Intel's business needs. Like most large enterprises, we transitioned from non-virtualized infrastructure to virtual machines (VMs) in the 2000s—improving resource utilization, reducing data center footprint and achieving better scalability. As we continue to refine our enterprise private cloud, VMs still provide benefit. However, the evolution of the cloud propelled the sheer pace of innovation everywhere. Constantly changing business needs resulted in the prominence of new design patterns (such as microservices) and the ability to scale solutions quickly anywhere becoming a necessity.

In 2013, Docker was released as an open-source engine that allows developers to package applications into containers and manage them with simple commands and automations. It was a major evolution in enterprise management. We were intrigued by the possibilities of using containers to enhance scalability, portability and efficiency.

Containers provide another level of architecture abstraction through operating system (OS) virtualization. This allows multiple applications to run their own separate processes while sharing a common OS, including resources like the CPU, memory and network I/O. Containers consist of an application and all its libraries and dependencies without needing a special hypervisor or guest OS (see Figure 1). For this reason, containers offer greater density, faster boot times, and genuine portability, while consistently executing across multiple on-premises and cloud environments.

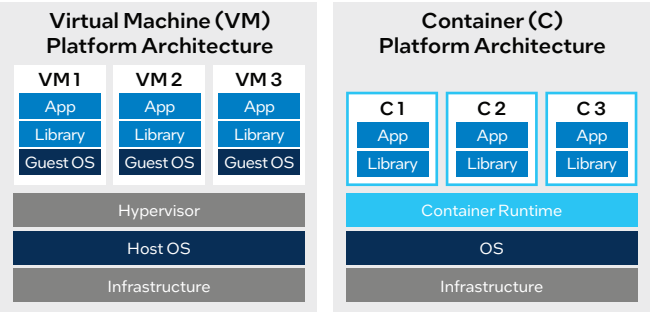


Figure 1. Containers provide OS-level virtualization with no special hypervisor or guest OS needed.

Acronyms

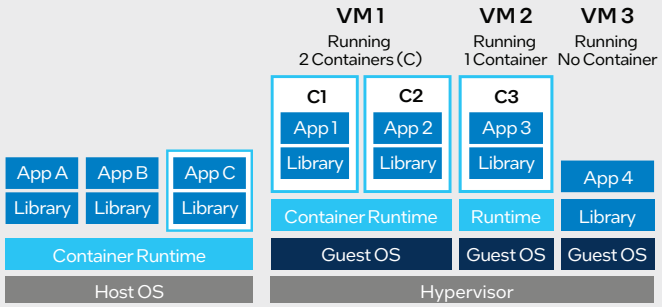
AI/ML	Artificial Intelligence/Machine Learning
CaaS	Containers as a Service
CI/CD	Continuous Integration/Continuous Deployment
OS	operating system
VMs	virtual machines

Containers and VMs

It's an evolution, not a replacement

It is important to clarify that containers and VMs are complementary rather than competing technologies. Containers provide OS-level virtualization and can be deployed on bare-metal systems or VMs, depending on data center strategy and needs. Containers are an evolutionary technology that increases density, efficiency and flexibility for enterprise clouds. Most enterprises already use VMs to provide server solutions, and containers can either reside on top of those VMs or operate solely on bare-metal systems. The question is not VMs or containers, it is VMs and containers.

Hybrid VM/Container Platform Architecture



Containers can be deployed on physical machines or VMs as needed.

Exploring Container-as-a-Service (CaaS) Benefits and Trends

Following the introduction of Docker, Intel IT organized a containers workgroup comprised of users from multiple business units to better understand their application management needs. The workgroup developed multiple detailed use cases from which we identified four major trends (see Table 1).

Table 1. Four Major Trends Impacting Intel's CaaS Strategy

Trend	Sample Workloads
#1 Hosting containerized solutions from suppliers	Automation Frameworks
	Build Automation Frameworks
	Document Management
	AI/ML Frameworks
	Microservices
	Ingestion Pipelines
#2 Enabling usage models for "as-a-service" offerings from IT	Shared CI/CD Agents
	Logging as a Service
	Build as a Service
#3 Enable software builds and CI/CD using containers	Software/Drivers Builds
	Data Science Jobs
#4 Intel offering services to external customers	AI Products

Our exploration showed the need for a CaaS capability was evident. However, for an enterprise environment the size of Intel, adopting a container strategy required a holistic approach that examined the unique needs of every business unit and offered stability, flexibility and consistency of experience across the entire enterprise. It was crucial for us to understand container technologies in detail and make pragmatic decisions regarding supplier and tool selection and to choose, prioritize and implement use cases. So, rather than embracing the new CaaS trend just for the trend's sake, we needed first to observe our internal process and challenges to ensure we identified a practical solution to meet our actual needs.

Analyzing Our Process

Before CaaS, project teams built every deployment process from scratch. Each application team had to provision the infrastructure, the container framework, and the registry; configure security and monitoring; integrate the enterprise tools; make the stack and update it regularly; run the manifest; and deploy and maintain the product. It was a cumbersome duplication of work that, at times, led to inconsistencies and confusion about tools and technologies.

Implementing CaaS greatly reduces the resources and time needed for creating and deploying applications. The platform team manages all other processes, enabling a consistency in standards and security, increasing efficiency and reducing the time to deployment (see Figure 2).

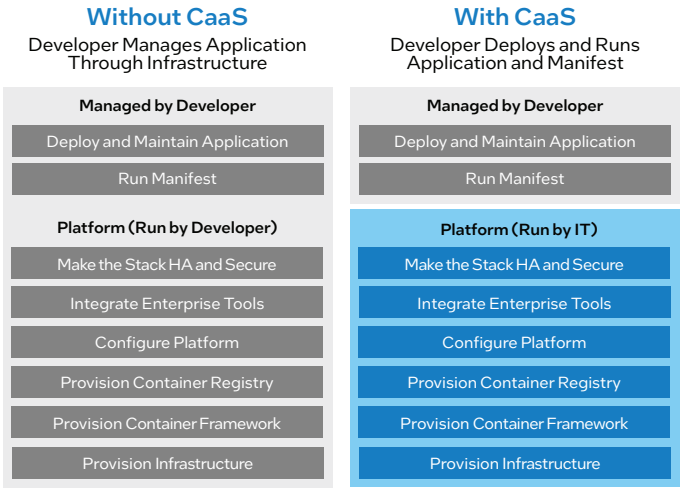


Figure 2. The CaaS platform abstracts all the complexity from the process, simplifying deployments.

Decoupling the application, with its own libraries and dependencies, allows developers to focus on the applications and leave the platform management and upkeep to the platform team.

Choosing a CaaS Solution

Once we determined CaaS was a promising technology that could potentially meet our needs, our next step was to assess which of the various CaaS platforms and solutions would best fit the broader architecture strategy of Intel's business units.

At Intel, we embrace an open-source strategy aligned to the Cloud Native Computing Foundation (CNCF). This allows us to leverage the rapid innovation taking place among the more than 100,000 contributors to meet the constantly changing needs at Intel.

Additional factors that Intel IT identified and analyzed across the technology providers included supplier maturity, market adoption, capability and innovation. We evaluated the suppliers' approach to containers as either a "pure play" solution or a pivot from an existing Platform-as-a-Service (PaaS) architecture and determined the best fit for Intel's enterprise needs. We also engaged peer IT organizations within the industry for peer-to-peer sharing and to learn about best practices and potential pitfalls.

Our CaaS Consumption Strategy

To meet the varied needs of multiple business units, we wanted our CaaS platform to support two consumption models—a shared model and a dedicated model (see Figure 3). Shared models are best for simple to medium complexity deployments where the CaaS-managed cluster supports multiple isolated tenants. Dedicated models are recommended for particular use cases with specialized hardware requirements, such as GPUs for machine learning, and for high-compute-demand applications that require dedicated resources.

The CaaS platform's agility supports both consumption models while maintaining the same roles and responsibilities for Intel IT. Application management belongs to the application/cluster owner in both models while the underlying infrastructure, software upgrades, monitoring, security, backups and training are managed by the platform team. This alleviates the infrastructure responsibilities and complexity for the application teams.

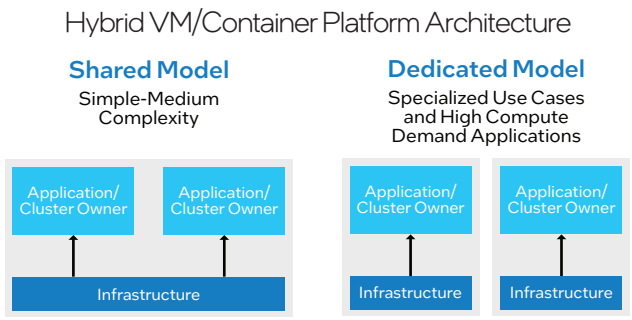


Figure 3. The CaaS platform supports both a shared model and a dedicated model of application deployment.

The CaaS platform also allows us to support both Linux and Windows platforms and our hosting strategy for private, public and hybrid cloud deployments with 100% bare-metal deployment on premises (see Figure 4).

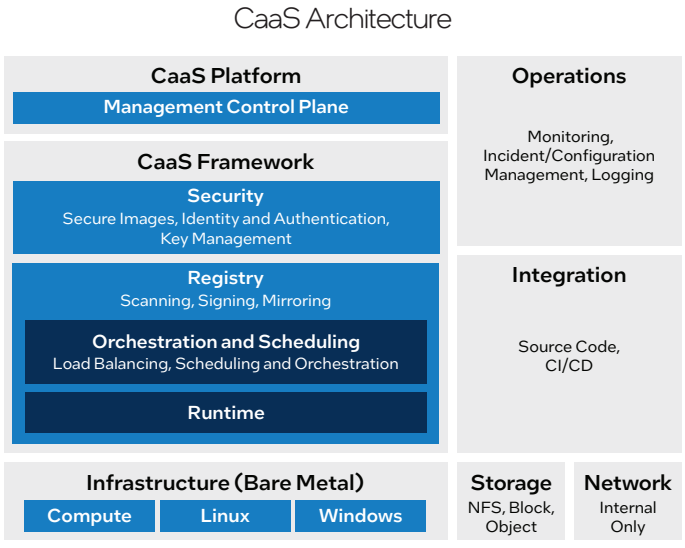


Figure 4. Our CaaS solution stack is designed to support Intel's business units.

Production Results

The benefits of a CaaS solution are real. Multiple key platforms and capabilities at Intel are now hosted on CaaS (see Figure 5), with project teams and users experiencing the benefits of increased agility, portability, efficiency, optimization and resiliency. Intel's CaaS platform growth continues to accelerate. What began as a few dozen applications has expanded to cover a wide spectrum of containerized and deployed applications across Intel's cloud enterprise.

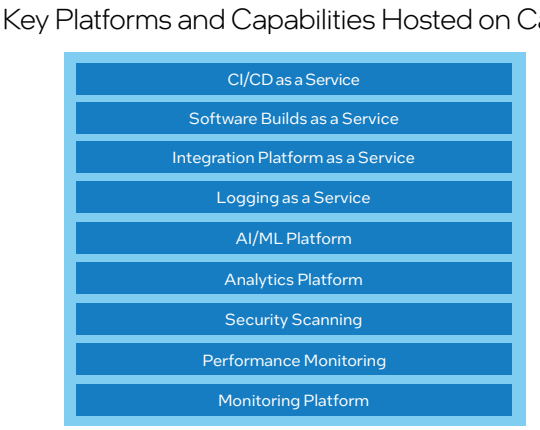


Figure 5. Intel IT's CaaS platform hosts multiple cloud-native services.

These are some of the benefits realized during this journey:

Speed

Containerizing applications enables faster testing, debugging, deployment and updates. Since containers don't include the host OS, they can be much smaller and more agile, accelerate development timelines and make it easier to automate deployment pipelines. CaaS lets project teams quickly build, test and run complex, multi-container applications throughout the cloud.

Agility

Continuous Integration/Continuous Deployment (CI/CD) jobs are ephemeral in nature, and with containers, these jobs execute and then go away, creating room for more containers that leverage the same infrastructure. Likewise, changing the underlying OS when executing CI/CD jobs was time-intensive prior to CaaS because project teams had to rebuild the servers hosting the agents. With containers, it's only a matter of changing the base images.

Portability

Application portability across platforms has always been a challenge. Since containers include an application, its libraries and all the dependencies necessary for the application to run, they can execute anywhere in exactly the same way. This creates consistency in the testing, development and production experience.

Resource Optimization

Simplifying the connection between applications and platform management allows developers to focus on creating applications to meet specific business objectives without having to manage the underlying infrastructure, reducing time to delivery and increasing productivity. The lightweight design of containers also allows for significant growth in the number of applications that can be supported using fewer hardware resources. In addition, the infrastructure abstraction enabled by CaaS has allowed us to expedite the modernization of our system without interrupting crucial tasks. CaaS optimizes hardware resources, cuts development time and increases efficiency, while offering capabilities that drive new products and services.

Key Learnings

It was clear from the start that a CaaS platform could provide many benefits for Intel's enterprise needs, but it was also obvious that forming a complete container management strategy from beginning to end was vital for selecting the best tools for long-term success. Throughout our journey, we are learning a number of important lessons:

- Working closely with the Information Security team has been key for successful implementation. Understanding what type of data the platform will hold defines which security protocols to use.
- App developers have adopted containers using a wide range of knowledge, from novice to highly adept. Training materials, self-help solutions, an active community of users and a strong CaaS team support model has been key for our success.
- In our experience, a fully allocated team supporting CaaS with agile methods and strong DevOps skillset is essential. The team should have expert-level knowledge of the CaaS platform and operations tools, possess strong customer support skills and be aware of application and workload requirements. The CaaS team needs to also stay current on industry trends and latest use cases. We found that alignment between internal governance bodies is crucial. The CaaS team needs to cultivate strong collaboration among key business units to align strategic needs.
- We found that data persistence was one of our biggest challenges arising from containerization. By engaging with our industry peers and testing multiple technologies, we were able to define short-term and long-term persistent storage strategies.

Conclusion

CaaS abstracts complexity away from the user and enables a standardized, secure and efficient solution for the development and maintenance of container-native applications. Containerized applications are quickly deployable, offer easy scalability and execute consistently across diverse environments. CaaS provides infrastructure optimization and accelerates delivery of cloud-native solutions at scale, increasing agility and efficiency. The infrastructure abstraction enabled by CaaS allows us to expedite and modernize the fabric on which our systems are running to help accelerate Intel's vision.

Intel's CaaS platform for managing containerized applications has matured tremendously. With its importance and criticality continuing to grow, more business applications are adopting containerized paths as the preferred method. Adoption of CaaS technology will continue and more use cases will evolve to fuel transformation and innovation at Intel.

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