White Paper

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Intel IT's Multi-Cloud Strategy: Focused on the Business

Sachin Ashtikar
Principal Engineer, Intel IT

Craig Chvatal
Principal Engineer, Intel IT

Munir Ghamrawi
Principal Engineer, Intel IT

Sridhar Mahankali
Principal Engineer, Intel IT

Chris Sellers
Director, Intel Software Defined Infrastructure

Jon Slusser
Staff Technologist, Intel IT

Our transformed cloud strategy decreases application time to market and enables agile application development.

Executive Overview

Maximize the business value of the cloud. That simple statement underlies a three-year initiative to transform Intel IT's cloud strategy:

- Modernize our application stack by abstracting it from the infrastructure to enable anything-as-a-service (XaaS) capabilities.
- Focus on business and application needs not on infrastructure.
- Determine optimal workload placement to balance cost with capability requirements.
- Validate our approach through communication with fellow travelers and industry benchmarks.

We use application platforms to abstract underlying infrastructure and deployment details. We also provide internally developed, private database-as-a-service (DBaaS) capabilities, which allow developers to focus on writing the best applications possible, enable enterprise-wide development standards, and permit our applications to modernize. We are also completing an application rationalization process to help determine which applications have reached the end of their useful life and which can be migrated to a more appropriate cloud environment.

A cloud strategy that focuses on business and application needs provides the following benefits:

- Intel gains a high level of business velocity and agility, with built-in redundancy and resiliency in the XaaS capabilities.
- Developers can write code without worrying about infrastructure, allowing IT to make the "best-fit" workload placement.
- A cloud-native environment furnishes a consistent multi-cloud user experience across the enterprise.
- A simplified cloud stack provides outstanding application portability.

Our transformed cloud strategy supports fast, agile application development.

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Contributor

Glenn Rudolph
Managed Cloud Solutions Manager, Intel IT

Acronyms

CI/CD	continuous integration/ continuous delivery
CaaS	container as a service
DBaaS	database as a service
FaaS	function as a service
IaaS	infrastructure as a service
PaaS	platform as a service
SaaS	software as a service
XaaS	anything as a service

Background

Intel IT is no stranger to cloud computing. We began building our enterprise private cloud in 2010, recognizing the cloud's potential for increased agility and scalability, as well as for substantial cost savings. Over the last seven years, we have strategically used private and public cloud resources to offer choice and flexibility to Intel application owners and IT staff, helping them achieve high levels of performance, agility, scalability, and efficiency.

Our first enterprise private cloud efforts centered around offering infrastructure as a service (IaaS), which provided compute, storage, and network capabilities on demand. We then began offering platform-as-a-service (PaaS) and database-as-a-service (DBaaS) capabilities, which enable developers to run and manage applications and databases without having to build and maintain the physical or virtual infrastructure. In addition, when an application was non-differentiated for an Intel business process, we started taking advantage of software-as-a-service (SaaS) solutions provided by public service providers, for situations when commercial solutions are the best fit for the business process needs.

But as enterprise applications have evolved, we are adapting our cloud strategy to enable applications to take advantage of advances in cloud environments and cloud solutions. In particular, a focus on IaaS forces application developers to think about which compute, storage, and network resources are required to run the application, and comprehend maintenance of those infrastructure components for the application's lifecycle. This "infrastructure up" approach puts an added burden on application developers to consume and design around infrastructure components for scalability, flexibility, agility, and resiliency. We found we needed to shift our perspective of cloud to an "application down" approach—which demands an entirely different mindset. Instead of talking about compute or storage requirements, we need to think about developer and application needs; consider performance and availability requirements; align to business needs; and abstract the underlying infrastructure from the developers. We need a multi-cloud strategy that makes the application independent from the infrastructure. Such a strategy can decrease time to market and enable agile application development to allow application teams to perform continuous integration/continuous deployment (CI/CD).

Solution: Focus on the Application and Business Need, Not on the Infrastructure

The following key elements of our current cloud strategy help us maximize the value of the cloud:

- Modernize our application stack to abstract it from the infrastructure.
- Shift from an emphasis on infrastructure to an emphasis on business and application needs.
- Land each workload in the right place, based on application and business needs.
- Communicate with fellow travelers to validate our approach.

Together, these stratagems will help us implement a more robust architectural anything-as-a-service (XaaS) platform, complemented by choosing best-place cloud solutions that support that platform. In doing so, we will be able to embrace the use of multiple cloud environments, simplify our cloud stack, encourage cloud-native application development, and increase business velocity and agility (see Figure 1).

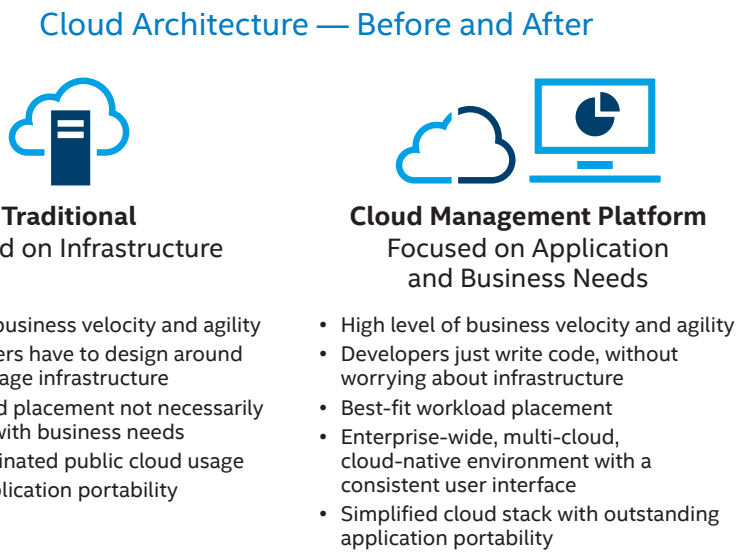


Figure 1. We are transitioning away from an infrastructure-focused cloud strategy to one that focuses more on applications and business needs, using an application platform to increase business velocity and agility.

Semantics of Cloud Computing

The **private cloud** is defined as computing services offered internally to a company on infrastructure and capabilities owned and run by the company (aka not commercially available).

The **public cloud** is defined as commercially available computing services offered by third-party providers.

Multi-cloud is the combination of the best-of-breed solutions and services from different cloud providers, including private cloud, to create the most suitable solution for a business. By providing interoperability and portability, multi-cloud gives organizations more flexibility with their cloud solution over different price-points, services offerings, capabilities, and geographical locations. A multi-cloud strategy can employ public, private, and/or hybrid cloud solutions, depending on the needs of individual companies. Done correctly, multi-cloud creates consistency across the company, independent of the services being consumed.

A **hybrid cloud** is a computing environment that combines public cloud and private cloud environments by allowing data and applications to be shared between them, enabling organizations to seamlessly scale on-premises infrastructure to off-premises infrastructure. Hybrid cloud is a subset of multi-cloud.

Modernizing the Application Stack to Abstract it from the Infrastructure

As shown in Figure 2, legacy applications—those that run on dedicated physical infrastructure, as well as those that are tightly coupled with their associated virtual compute, storage, and network resources—require developers to manage many infrastructure details. But as development standards become more mature, applications move up the XaaS stack, from IaaS to PaaS to SaaS, and then to container as a service (CaaS) and function as a service (FaaS). At each step, developers are responsible for fewer infrastructure details and can concentrate simply on writing the best code possible.

We are using application platforms to help modernize our application stack. Going beyond IaaS, an application platform is a cloud service that makes it easy to deploy and manage Web and mobile applications built using popular languages like Java*, Node.js*, Python*, HTML, ASP.NET* and others. Using a Web portal or an integrated development environment (IDE), developers upload an application to the platform, which automatically handles the details like capacity provisioning, load balancing, easy deployment to multiple cloud locations, and application health monitoring. The application platform provides developers with great flexibility as well as CI/CD and DevOps capabilities. As a result, application development is simplified and accelerated. Today, Intel IT's private cloud application platform hosts about 350 applications and 3,500 application instances. Our goal is to eventually have all enterprise applications hosted through application platforms.

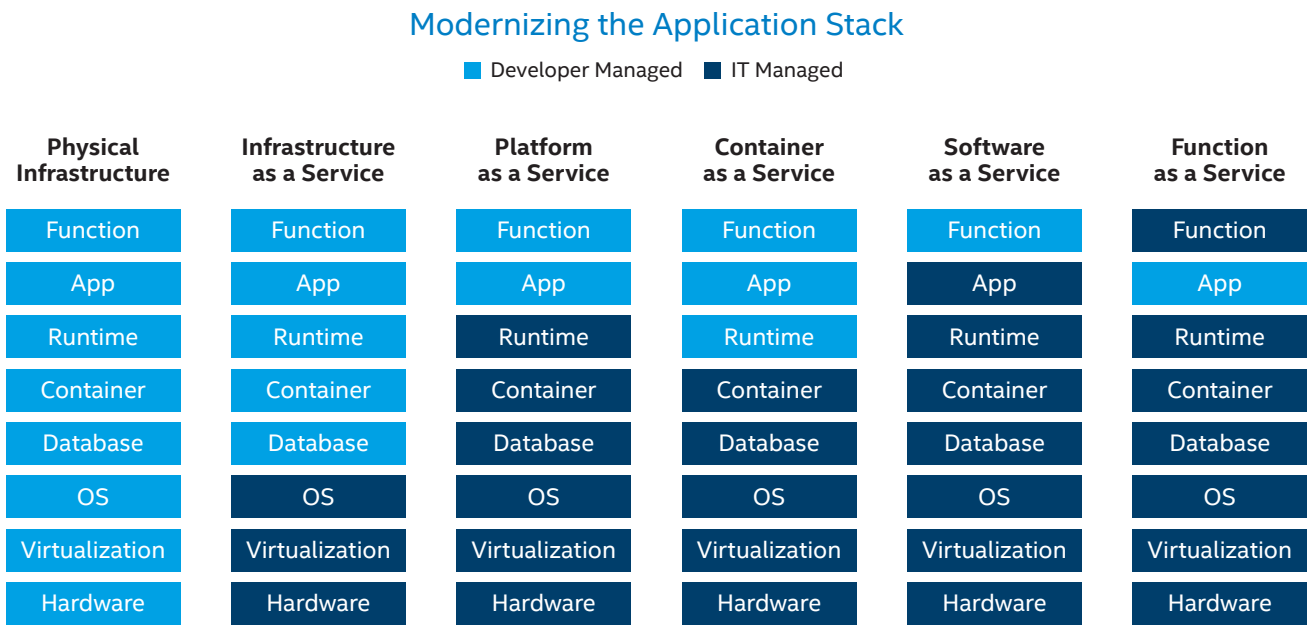
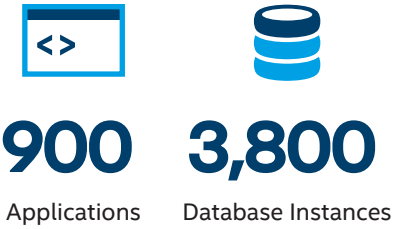


Figure 2. Moving an application up the anything-as-a-service stack abstracts the application from the infrastructure and lets developers concentrate on writing code.

Intel IT Private DBaaS



As part of our application platform suite, we also offer internally developed database-as-a-service (DBaaS) capabilities, which speed development and provide increased redundancy and resiliency through database abstraction. Developers no longer have to request infrastructure, build the database, and manage it—today they can quickly deploy a new database with a few mouse clicks. Further, developers are free from the burden of typical database administration tasks—IT maintains these tasks at a platform level. Resiliency features such as high availability and disaster recovery are also handled through DBaaS, which automates most of the administration infrastructure tasks to reduce overhead and bring consistency to the environment. Our private DBaaS supports numerous open source and commercial database products, and currently hosts over 900 applications and nearly 3,800 database instances. The databases supported as part of our DBaaS platform continue to evolve based on the demand from our application developers and use cases.

Application platforms and DBaaS are enabling us to move toward a multi-cloud environment where the user experience is consistent and our services look and act the same regardless of where they are actually hosted.

Aligning Our Cloud Strategy with Business Needs

We see the business value of the cloud reflected in the resiliency of our applications, which is a direct result of abstracting applications from the infrastructure. By encouraging the development of cloud-native applications, we can increase uptime and enhance disaster recovery capabilities. We can also better meet security needs, such as the ability to patch an application to address a vulnerability without having to worry about downtime or a system reboot.

To reach optimal return on investment, we also consider the cost of an application from an application-down perspective (as opposed to an infrastructure-up perspective). By balancing the cost of an application with the required capabilities, we can verify that an application is providing maximum value to the business. If we determine that an application is not providing maximum value, we can remove it from the application portfolio, or refactor it into a lower-cost capability tier elsewhere in the cloud.

As described in the following sections, this approach accommodates all lines of business, includes boosting necessary skills for both Intel IT staff and application developers, and is guided by a three-year roadmap.

2,000 enterprise applications

are currently in use at Intel, and they include:

- Legacy applications with dedicated infrastructure resources
- Applications utilizing virtualized infrastructure
- Cloud-native applications

Accommodating All Lines of Business with a Single Cloud Strategy

Intel IT serves all of Intel's operational domains: manufacturing, product development, office and enterprise, and product delivery and services. Therefore, our cloud strategy must encompass the business needs of each of these domains (see Figure 3).

Our cloud offerings must provide a reliable method to serve traditional enterprise applications within Intel's application inventory while delivering reliable, scalable, and automated services to enable and encourage cloud-native applications. Regardless of operational domain, we have defined strategic factors for each layer shown in Figure 3:

- **Governance.** Ideally, cloud decisions are tightly controlled and coordinated jointly between IT and the business/application owner, with self-governance capabilities.
- **Application type.** Because there are nearly 2,000 enterprise applications currently in use at Intel, we must accommodate legacy applications with dedicated infrastructure resources, applications that take advantage of virtualized infrastructure, and cloud-native applications.
- **PaaS.** Similarly, many applications are not hosted on any platform, while others can be included in generalized application groupings; modern cloud-native applications can be hosted on defined application-development platforms.
- **IaaS.** At the lowest level, all of the above factors determine whether dedicated on-premises resources are needed (that is, an application is not cloud-compatible); if an application can be hosted in a private cloud or public cloud; and if dedicated co-location is necessary.

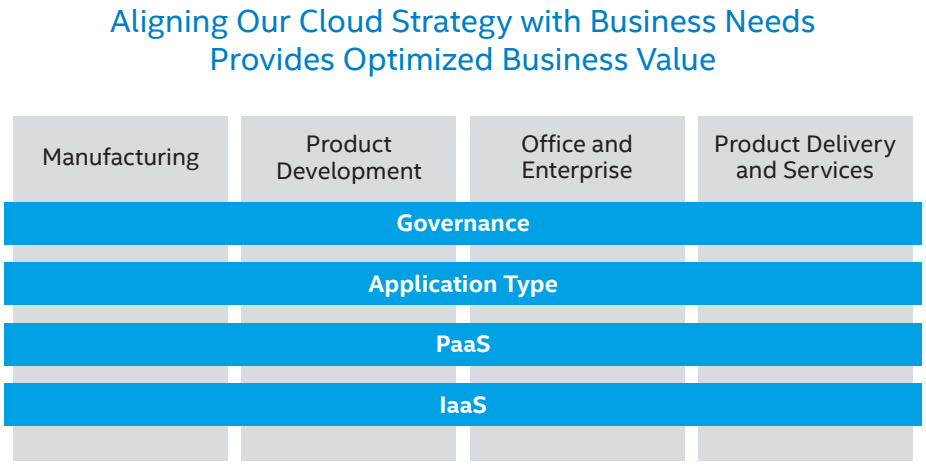


Figure 3. Our cloud strategy spans all lines of business and addresses compliance, security, and data governance requirements. Application type and platform-as-a-service (PaaS) and infrastructure-as-a-service (IaaS) needs are also considered.

Critical Skills

In addition to the technical side of our cloud strategy, we are working to increase the skill levels of our IT staff in the following critical areas to better serve our customers across all lines of business:

- Cloud security, including public, private, and hybrid security as well as controls and compliance
- Software-defined infrastructure, which includes expertise with proprietary and open source solutions, integration, and orchestration of all resources including network, storage, compute, hypervisor, and container
- Public cloud services brokerage, including design, integration, and support
- Software development using modern application development languages, cloud-native application development techniques, and CI/CD development methodologies and tools
- Big data skills, such as proficiency with in-memory databases and advanced analytics

We also reach out to application developers in the business units to educate them about modern cloud application development techniques (such as stateless applications and use of containerization technology).

Three-year Roadmap

The transformation of our cloud strategy will not happen overnight. We have defined a three-year roadmap (see Figure 4) that will provide increasing business value as our strategy matures.

We are currently in Phase 1, where we are rationalizing the approximately 2,000 applications in use within Intel IT. As part of the application rationalization process, we ask two questions:

- Is it producing business value or has it reached the end of its usefulness?
- Is an application making best use of the resources assigned to it from a business-value perspective?

Because every application has different requirements regarding security, performance, governance, and so on, there is no one single answer—as is often the case in IT, one size does not fit all.

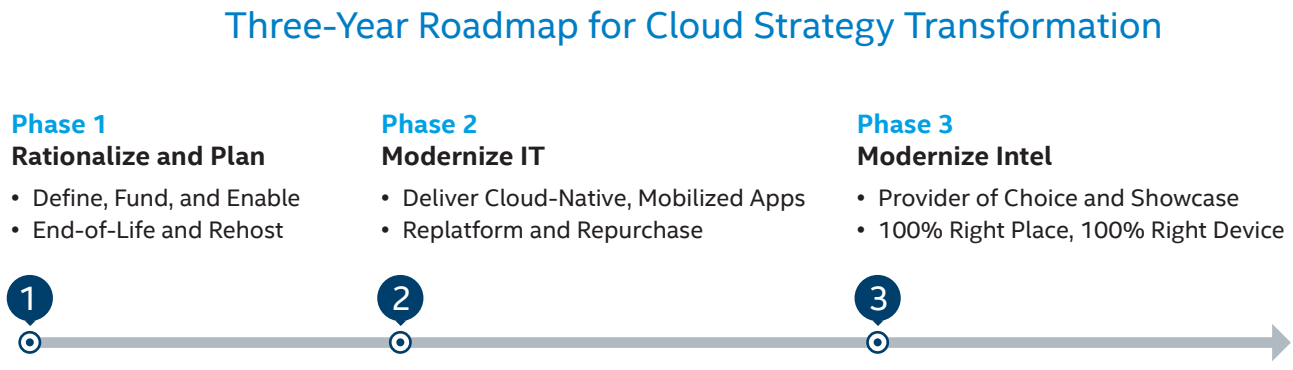


Figure 4. A three-year cloud strategy transformation roadmap will help us continue to align our cloud strategy with business needs and maximize the value of the cloud.

Figure 5 illustrates our application rationalization process, which uses the same criteria and decision tree across all four operational domains. First, we determine if an application is at end-of-life—we have found that a significant number (approximately 30 percent) of existing enterprise applications fall into this category. If an application passes that litmus test, we determine if the application is non-differentiating from an Intel business perspective; if so, we will migrate that application to a public cloud SaaS model. For applications that are strategic, we will re-architect them to take advantage of PaaS capabilities. Other applications that are constrained by return on investment issues can remain as they are, or possibly move toward PaaS. And we understand that, in certain cases, some applications are not compatible with a cloud environment and will remain as they are. We maintain a scorecard, which tracks in real time how many applications are hosted in the right place compared to how many applications remain to be rationalized and may not be hosted optimally.

As we move into Phase 2 of our cloud strategy transformation, and eventually to Phase 3, our goal is to be completely aligned with business needs using cloud-native applications that are hosted in the optimal environment to provide the greatest business value. Applications will be portable, either manually or using automation, between private and public infrastructures without direct involvement from the developer. Reliability and resiliency will be defined by application tiering and service-level agreements.

Determining Optimal Workload Placement

With a cloud-mature application stack that is abstracted from the infrastructure and that has the ability to systematically identify whether an application is providing business value, we will be well-positioned to take advantage of a multi-cloud environment. We anticipate that we will use our private enterprise cloud for some applications, such as those with strict security requirements or those that are used only internally. We will engage with different public service providers according to the provider's strengths and the application's needs. For example, one provider may have excellent identity management and security features, while another may excel at offering FaaS and CaaS capabilities. As cloud providers innovate, we have the option of moving applications from our private cloud to a public cloud, or from one public provider to another, if doing so better meets our business needs.

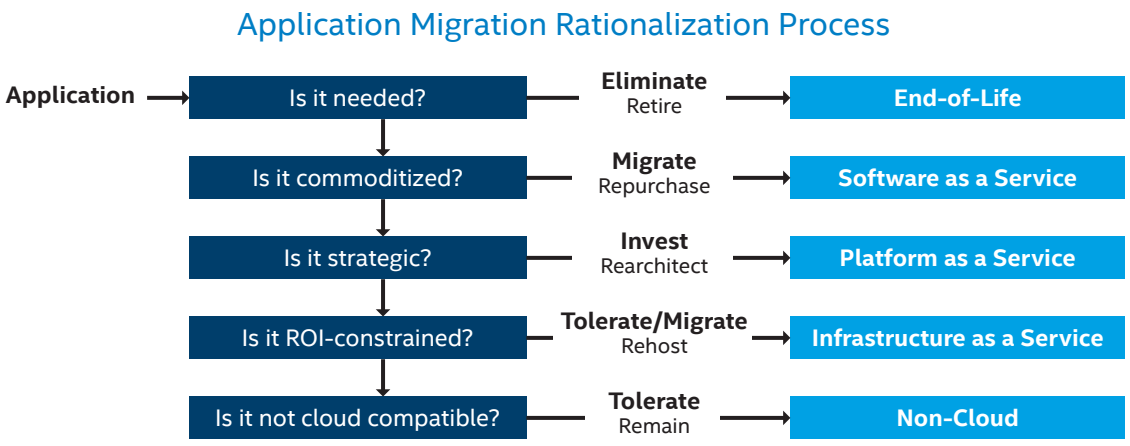


Figure 5. We use a standard application rationalization process to guide our application migration decisions.

The flexibility of being able to choose between providers, as well as easily move an application from one hosting environment to another, will enable us to maximize the value of cloud across the enterprise. The white paper, "Optimal Workload Placement for Public, Hybrid, and Private Clouds," goes into more detail about workload placement considerations.[1]

Validating Cloud Strategy through Industry Benchmarking

We are taking a benchmark-driven approach as we transform our cloud strategy. Our methodical application rationalization is one example of how we are benchmarking our progress. In addition, we have used surveys and focus groups to engage with Intel business units, and are communicating with other companies through interviews, workshops, conferences, and an analysis of industry cloud strategy trends.

Solution Architecture

As shown in Figure 6, software-defined infrastructure forms the foundation for our cloud strategy. Layered on top of the infrastructure is an application platform that provides cloud-native capabilities through a common user experience using a Web portal as well as APIs. An internal cloud brokerage service uses business rules to help identify proper placement for workloads and applications; public cloud service providers are used for discrete Internet-facing workloads, IaaS capacity, and additional failure zones.

[1] Read the Intel white paper at intel.com/content/www/us/en/cloud-computing/enterprise-cloud-computing/optimal-workload-placement-for-public-hybrid-and-private-clouds-white-paper.

Internal Public Cloud Brokerage Service

Intel IT's internal cloud brokers offer consulting, onboarding, integration, financial stewardship, and security services to business units when the public cloud is the best fit for an application or workload. Our internal cloud brokers enable us to optimize use of the public cloud to serve our core business enterprise market, where reliability and performance are priorities. We can help business units take advantage of public cloud services when appropriate to the use case, to provide elasticity or other business benefits.

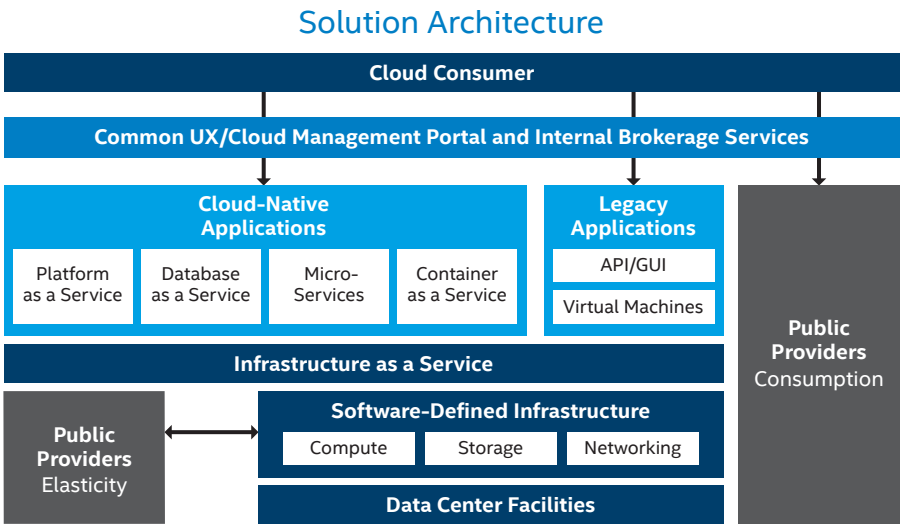


Figure 6. Our solution architecture delivers a multi-cloud environment that can serve both traditional enterprise applications and modern cloud-native applications.

Results

As Figures 7 and 8 show, developers are realizing the benefits of abstracting applications from the infrastructure. As a result, the adoption of the application platform and DBaaS is growing steadily. Since early 2015, the number of application instances hosted on our application platform has increased from virtually zero to more than 3,500. DBaaS instances have increased at about the same rate. For the applications we host on our private enterprise cloud, we constantly re-evaluate how competitive that hosting decision is, compared to public cloud. As mentioned earlier, we balance cost versus required features and functionality.

Next Steps

Our journey to a multi-cloud environment has not ended. We will continue with our application rationalization, integrating it into our overall process flow. And as enterprise applications and business needs continue to evolve, we anticipate exploring and then implementing new cloud services, including the following:

- **CaaS.** Containers offer cloud portability, eliminating the need to rewrite the code for each new OS and cloud platform.
- **Microservices.** Dissecting applications into loosely coupled components provides flexibility of deployment, scalability, reusability, and a reduced dependency on a single technology stack. Examples of microservices include messaging, object storage, logging, and authentication.
- **Serverless computing.** Further decomposition of microservices allows developers to build and run applications without thinking about servers or provisioning. The cloud provider dynamically manages the allocation of machine resources.

We also anticipate developing, delivering, and promoting a cloud-native certification program.

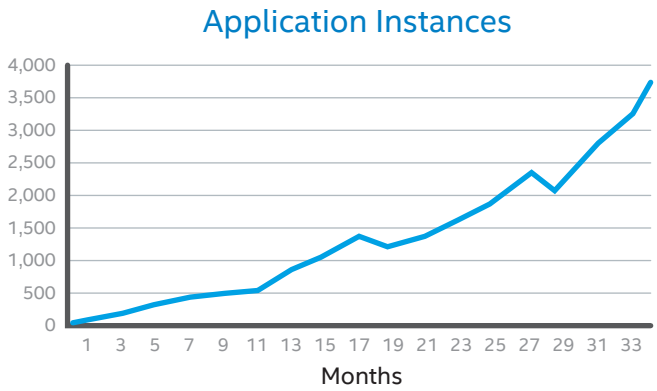


Figure 7. More than 3,500 application instances are now hosted on our application platform—meaning that our application stack is quickly maturing to be able to take best advantage of a multi-cloud environment.

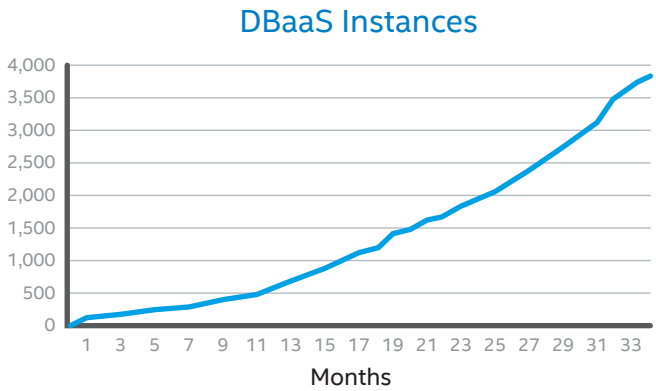


Figure 8. Application developers have eagerly adopted database as a service (DBaaS) to increase development velocity and portability, with nearly 3,800 instances now active.

Conclusion

By abstracting the application from the infrastructure using application platforms, we are gaining business velocity, flexibility, and agility as our applications move up the XaaS stack. By focusing our cloud strategy on business and application needs rather than on infrastructure, we can provide optimal business value to all of Intel's lines of business through a consistent user experience and best-fit workload placement. Overall, we have developed a model for an enterprise-wide cloud strategy that applies to both IT and Intel's business units, and can maximize the value of the cloud across the enterprise.

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