



Unleash the Power of the Data Economy

Huawei OceanStor All-Flash Storage Technological Innovation
Leads Industry Transformation

Gartner®

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Industry Digital transformation Demand technological innovations

Rapid data growth and real-time processing pose enormous challenges to data infrastructure and place mounting pressure on data computing, transmission, and storage. Vertical optimization of data processing and storage is putting computing power close to data sources and changing the industry landscape through stacking and consolidation.

According to Gartner analysis, "...enabling innovation through an agile, scalable and intelligent infrastructure is vital for digital organizations".¹ In this paper, technological innovations like NVMe and NVMe-oF, Next-Generation Memory are listed in top 10 for innovation leaders to rethink infrastructure strategies for next-generation workloads.

As for the storage system, which is an important part of the IT infrastructure, speed is the key to thriving in the fierce competition of the current market. All-flash storage provides that speed and is critical for the digital transformation of enterprises. It is a main focus of development in storage and has been deployed in enterprises for everything from core systems to common applications. The SSD revolution will be accelerated to completely replace HDDs before 2022. The storage industry will use memory networks, such as NVMe over Fabrics, to reshape storage and computing architecture with heterogeneous computing and SCM after 2022. These trends will drive the data economy for the next years.

As for the Financial industry: Mobile phone payments are one of the defining features of the new era of Bank 4.0 and mark a major shift away from traditional payment methods. Although each transaction is small, the high transaction frequency and need for 24/7 availability has placed a more than ten-fold increase in pressure on bank IT systems. For example, in 2010, banking payment systems processed 5.2 billion transactions. The rapid development and spread of mobile Internet and payments quickly made high-frequency payments in small amounts the new norm. As a result, the banking industry processed 223.3 billion transactions for electronic payments in 2019. Banking services, such as transactions and clearing, require high performance for data processing to handle this surge. Agile IT systems provide high performance by completing an entire digital transaction within 1 second. The IT system must also be robust and stable enough to avoid errors and support hundreds of thousands of transactions

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per second (TPS) during peak hours. This is especially important during massive sales holidays, such as Double Eleven shopping days. Its peak transaction periods last from 10 to 15 minutes. High-end all-flash storage is also crucial to efficiency and stability of A+, A, and B services of financial institutions, such as real-time transactions, e-banking, clearing, and transfers.

New generation of Huawei All-Flash Storage System with innovated Technologies

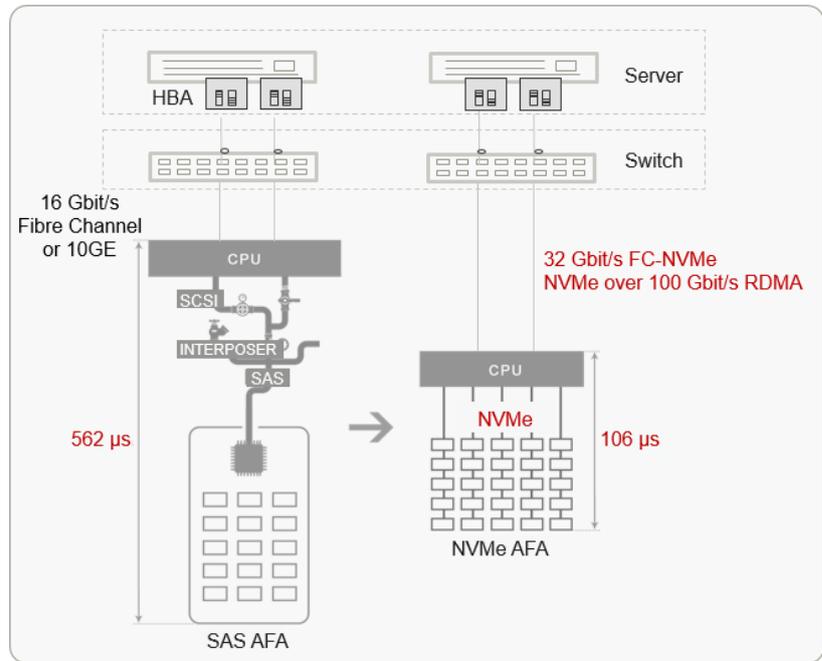
In 2019, Huawei released the latest generation of OceanStor Dorado Series, pushing the envelope of innovation with 10 cool technologies. OceanStor Dorado Series provides 20 million IOPS and a latency of 0.05 ms with the advanced E2E acceleration platform in the industry and the innovative NoF+ solution. The high reliability of its SmartMatrix architecture tolerates the failure of up to seven out of eight controllers in a single system for always-on core services. The AI architecture combines an intelligent hardware platform and software algorithm to create a machine learning algorithm for independent optimization of storage resource allocation and 20% higher cache resource utilization.

NVMe: Innovative NoF+ solution for 30% higher service efficiency

According to Gartner, "...NVMe and NVMe-oF offerings can have a dramatic impact on business use cases where low-latency requirements are critical to the bottom line. Though requiring potential infrastructure enhancements, the clear benefits these technologies can provide will immediately attract high-performance computing and OLTP use cases where clients can quickly show a positive ROI. The easiest way to consume these technologies will be through acquisition of modern solid-state arrays (SSAs) that support these."²

The mission of Huawei is to provide industry-leading products with advanced technologies for all industries. Huawei has been researching flash memory since 2005 and has developed a large number of core patents for it. Huawei has a large number of SSD patents, and has focused on NVMe protocol with comprehensive research to

FIGURE 1
Architecture: SAS vs NVMe



Source: Huawei

E2E NVMe SSDs, NVMe flash controllers, and NVMe all-flash OSs. OceanStor all-flash storage from Huawei is the series with E2E NVMe storage products with an ultra-low latency of 0.05 ms.

Non-Volatile Memory Express over Remote Direct Access Memory over Converged Ethernet (NVMe over RoCE) combines the latest NVMe and RDMA technologies for high-performance storage and computing.

While the FC storage protocol is over 30 years old, NVMe over RoCE is a new generation of storage technology with obvious advantages in performance, networking, and costs. However, it requires further optimization for link fault detection, network latency stability, and deployment usability.

Huawei has leveraged its expertise and the advantages of its extensive product lines to launch the NoF+ solution. It improves the storage and network capabilities of the industry standard solution of NVMe over RoCE.

First, NVMe over RoCE features all-IP networking for networks, servers, and

storage devices to eliminate the complexity of five protocols (FC/IP/IB/PCIe/SAS) and three networks in a data center. One protocol and one network manage the entire data center for lower maintenance costs and simplified network protocols, planning, and deployment.

Second, the intelligent lossless network and five capabilities of "transmission-compute-intelligence-storage-management" of OceanStor all-flash storage implement E2E data optimization for the entire data center. The conversion between multiple protocols is consequently eliminated for shorter data transmission paths and higher transmission rates. In addition, it reduces the bit error rate (BER) during network transmission for zero packet loss and 100% computing power. The E2E latency of the NoF+ solution during testing is only 53 μs (100% random I/Os with 100% read model and 4 KB data block). The latency is stable and 30% lower than that of the existing Fibre Channel network.

NVMe over Fabrics utilizes an IP design, so the system takes 15 seconds to detect link failures. However, 15 seconds is an intolerable delay in a

production or core transaction system. The NoF+ solution runs over the intelligent lossless network and OceanStor all-flash storage for automatic system fault inspection and fault detection in real time with front-end interface modules. As a result, faults can be proactively rectified, and the link failures are detected in less than a second. This greatly improves system reliability and provides seamless core services.

Finally, Huawei will use OceanStor all-flash storage to develop a series of automatic tools to simplify network deployment and improve usability from network planning to implementation.

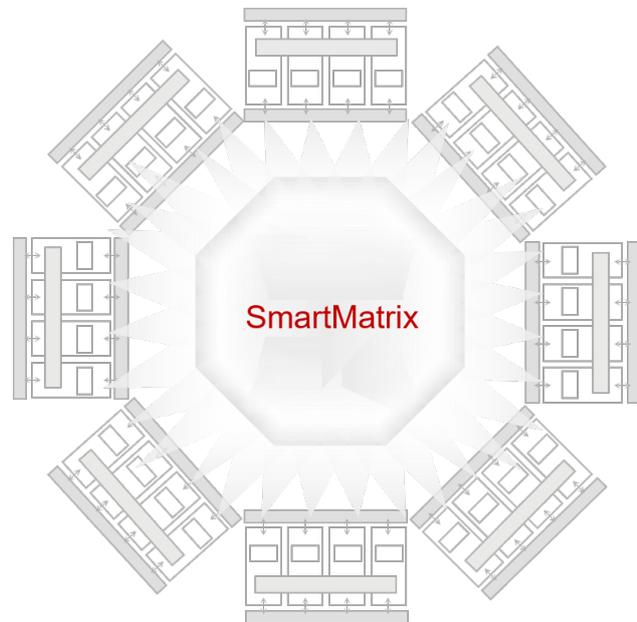
SmartMatrix: A synonym for reliability

A recent trend shows the popularity of all-flash storage being used in mission-critical service scenarios for fields that demand high reliability, such as finance and government fields. Research shows that one hour of downtime of mission-critical services can cause losses of USD 6.48 million, USD 2.8 million, and USD 2 million for the financial, energy, and telecommunications industries, respectively. Damage also extends beyond finances, as enterprises may also suffer from client loss, brand image smear, as well as other immeasurable losses.

Many industries, such as finance, manufacturing, and carriers, are promoting intelligent service system upgrades because of the need for higher reliability for diverse services and data types. At an enterprise-level, Chief Technology Officers (CTOs) looking for robust IT systems are moving toward intelligent systems, as these can consolidate multiple types of services and ensure stable service running. Designed to meet this demand, the Huawei OceanStor all-flash storage stands out from the crowd. It ensures E2E reliability at the component, product, solution, and cloud layers, and supports data consolidation at 99.9999% service availability for always-on services.

SmartMatrix is a full-mesh, balanced architecture that tolerates failure of seven out of eight controllers. The system architecture is considered the core competency of a high-end storage system. The continuous cache mirroring technology is provided so

■ FIGURE 2
SmartMatrix Architecture



Source: Huawei

that if a controller fails, the mirror controller can reconstruct cache mirror and enable the system to tolerate failure of seven out of eight controllers.

AI empowered data management in 3 layers for 5x efficiency

The first technology mentioned in the Gartner report, "Top 10 Technologies That Will Drive the Future of Infrastructure and Operations" is the "Artificial Intelligence for IT Operations (AIOps) Platforms".³ So, we believe it is obvious that how important the self-driving data management is.

Huawei Storage utilizes innovation to create new avenues of future development. The OceanStor Dorado Series differs from traditional storage in its use of the intelligent Data Management System (DMS) solution. The solution logically integrates and intelligently manages the data of devices, enterprise data centers, and clouds for seamless services across clouds. It provides enterprise users with storage resources and intelligent O&M on and off the cloud to achieve a smooth cloud evolution for data centers.

The Data Management System, or DMS, implements synergy across three layers. Device AI intelligently manages and maintains equipment. Center AI unifies the management of data centers and achieves self-tuning. Cloud AI fosters an intelligent decision process online and collaboration on and off the cloud. The Data Management Engine (DME) is the core of the DMS. The prediction engine works with the analytics and policy engines for automatic full-lifecycle management of data infrastructure, including planning, deployment, O&M, and optimization. Resources in the planning phase are automatically added to the storage pool through SLA and application templates to reduce redundant planning and initial investment. Applications of the development phase are remotely deployed, and resources are automatically provisioned for streamlined deployment in comparison to manual operations. Intelligent risk prediction, fault analysis, and fault rectification during the O&M phase automatically locate and solve problems. The optimization phase improves performance and capacity to promptly reclaim resources and improve resource utilization.

Success Story: How All-Flash Storage Helps Customers optimize their business experience

Storage devices are an essential part of any IT infrastructure, and are deployed in a wide range of industries, such as finance, carriers, and manufacturing. In particular, the financial industry has high requirements for IT infrastructure, especially storage devices, due to the sensitive nature of the services.

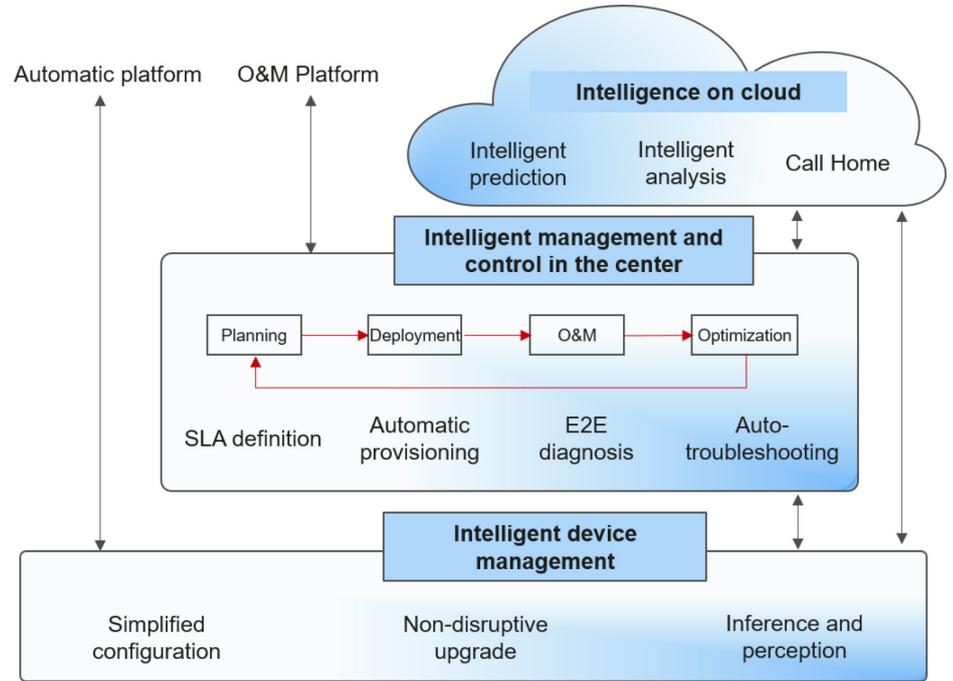
Founded in 1875, the Bombay Stock Exchange (BSE) has more than 5,500 listed companies, the most listed companies of any parents company in the world. BSE faces massive transaction requests every day, and these requirements are growing rapidly. To process them efficiently, a powerful ICT infrastructure, including storage systems, is needed.

BSE's hundreds of servers needed to meet basic high bandwidth and low latency requirements. The original storage system was outdated and had reached its end of life stage which lead to high maintenance costs. New hardware needed to be purchased to support new application rollout.

Huawei OceanStor Dorado storage, designed with native SSDs, greatly improves the performance while reducing the latency. In addition, OceanStor Dorado storage can be deployed over a geo-redundant 3DC DR solution to ensure zero Recovery Time Objective (RTO) and Recovery Point Objective (RPO). The Non-Disruptive Upgrade (NDU) solution also ensures the continuous and stable running of BSE services.

In recent years, Huawei OceanStor Dorado storage has been accelerating customer development in the financial industry. In the financial hotspots of Switzerland and Singapore, Huawei has built reliable and efficient storage infrastructure for world-famous banks. Data is the new gold in the Bank 4.0 era, which is why Huawei helps customers overcome existing business models and explore new business opportunities. In developed European economies, such as Germany, France, and Italy, Huawei provides large-scale storage consolidation solutions for leading financial institutions to improve their cross-country and -region operation efficiency,

FIGURE 3
Data Management System



Source: Huawei

reduce TCO, and improve service hosting capabilities.

Huawei OceanStor Dorado storage is not limited to the financial markets, with excellent cooperation with customers in the carriers, manufacturing, and energy industries to accelerate their digital journey. In the Asia-Pacific region, Huawei provides sustainable storage infrastructure solutions for many prestigious customers, including AIS in Thailand, Petronas in Malaysia, and Astra in Indonesia.

Forward thinking: Technology and businesses with high competitiveness

The architecture of Huawei OceanStor all-flash storage will evolve horizontally and vertically to build a competitive Composable Matrix. Horizontal evolution involves horizontal interconnection and scale-out of storage and resource pooling. Intelligent tiering and cascading achieve heterogeneous compatibility across generations and eliminate data migration. Vertical evolution uses NoF+ and RDMA

for hardware I/O passthrough, E2E high-speed networks, hundreds of millions of IOPS in data center performance, and a latency of 10 microseconds. Finally, the next generation of Huawei OceanStor all-flash storage incorporates the strategy of Five Convergences to build high competitiveness at the technical and business levels.

Glossary

Term	Definition
NVMe	A new storage access and transfer protocol for flash and the next generation of solid-state drives (SSDs)
NoF+	The enhanced Huawei solution for NVMe over Fabrics storage
SmartMatrix	The highly reliable architecture of Huawei OceanStor high-end all-flash storage

Source: Huawei

¹⁻³Gartner Inc., Top 10 Technologies That Will Drive the Future of Infrastructure and Operations, 29 October 2019, G00430091

Top 10 Technologies That Will Drive the Future of Infrastructure and Operations

Enabling innovation through an agile, scalable and intelligent infrastructure is vital for digital organizations. We highlight the 10 most compelling early-stage technologies that enterprise architecture and technology innovation leaders should use to drive infrastructure innovation through 2024.

Key Findings

- There continues to exist significant technical debt in infrastructure and operations (I&O) due to complex legacy applications and outdated processes, which cripple agility, enhance business risks and often result in bloated costs.
- There is a clear market shift in innovation — from legacy IT infrastructure vendors to cloud providers and open-source communities — that are heralding the next wave of infrastructure innovation.
- Technology innovation leaders struggle to increase their ability to absorb, deploy and scale technological innovations.

Recommendations

Enterprise architecture and technology innovation leaders driving innovation should:

- Ideate with business leaders and I&O leaders on potential use cases where these technologies can be applied to enhance business value.
- Develop a decision map on which of these technologies are relevant within their organization and a timeline for its implementation.
- Improve the scale and efficiency of innovation by identifying internal champions both within I&O and business units to lead these efforts, incentivize them, measure accurately the success/failure and iterate toward continuous improvement.
- Invest beyond technology, as technology isn't a silver bullet and needs to be complemented by process automation, skills training and cultural hacks to ensure that these projects don't fail.

Analysis

The needs of digital business are forcing technology innovation leaders to rethink infrastructure strategies for next-generation workloads. To succeed in the digital business era, innovation leaders need to drive “creative destruction,” often willing to fundamentally rethink the technology architecture, deployment environment and operating models. We have analyzed many transformative technologies and selected the 10 that we believe will have the greatest impact on I&O (see Figure 1). These technologies are all highly transformative and will mature within the next five years. As an enterprise architecture (EA) and technology innovation leader, you must assess how your organization could exploit these technologies.

In this research, we define each technology, predict its market adoption, assess why you should care and list some of the imperatives that you should be aware of. Although this research focuses on individual technologies, you should be alert for opportunities that arise when two or more of these trends combine to enable new capabilities.

Technology No. 1: Artificial Intelligence for IT Operations (AIOps) Platforms

Description: AIOps platforms combine big data and machine learning to support several primary IT operations functions. They do so through the scalable ingestion and analysis of the ever-increasing volume, variety and velocity of data that IT operations generate. These platforms enable the concurrent use of multiple data sources, data collection methods, and analytical and presentation technologies.

Why EA and Technology Innovation

Leaders Should Care: AIOps platforms bring:

- **Agility and productivity gains.** They do so by analyzing both IT and business data, yielding insights on user interaction, business activity and supporting IT system behavior.

- **Service improvement and cost reduction.** They do so by significantly cutting the time and effort required to identify the cause of uptime and performance issues. Behavior-prediction-informed forecasting can support resource optimization efforts.
- **Risk mitigation.** They do so by analyzing monitoring, configuration and service desk data. They identify anomalies from both operations and security perspectives.
- **Competitive differentiation/disruption.** They do so through superior responsiveness to market and end-user demand based on machine-based analysis of shifts.

Prediction: By 2022, at least 25% of large enterprises will be using artificial intelligence for IT operations (AIOps) platforms and digital experience monitoring (DEM) technology exclusively to monitor the nonlegacy segments of their IT estates, up from 2% in 2018.

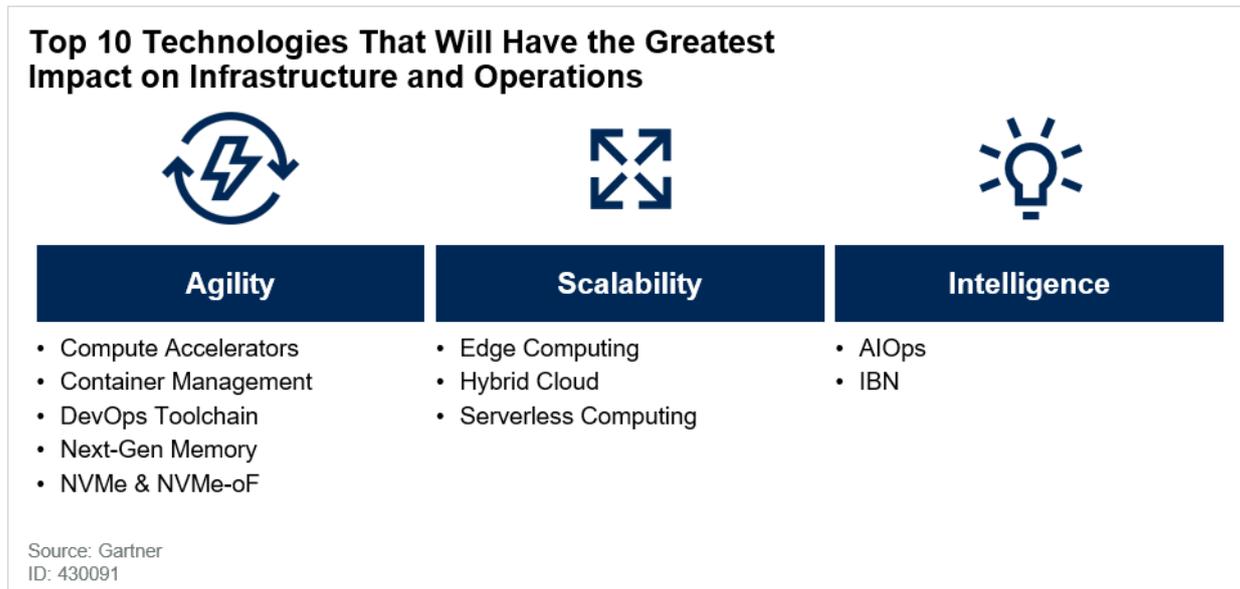
Maturity: Emerging; market adoption is 5% to 20%.

AIOps platform vendors have a broad range of capabilities, such as event correlation, anomaly detection, root cause and optimization analysis, that continues to grow. However, vendors differ in their data-ingest and out-of-the-box use cases made available with minimal configuration. Building your own AIOps platform requires a high degree of operational, analytical and data science skills.

What You Should Know: AIOps skills and IT operations maturity are the usual inhibitors in ensuring quick time to value when using these tools, followed by data quality as an emerging challenge for some of the more mature deployments. The market is experiencing broad “analytics” confusion, intentional obfuscation by vendors and rising costs associated with increasing data volumes. Cultural barriers exist and end users must acquire new skills to use AIOps platforms. Before planning to adopt an AIOps platform, decide whether a monitoring

■ FIGURE 1

Top 10 Technologies That Will Have the Greatest Impact on Infrastructure and Operations



Source: Gartner (October 2019)

tool that uses machine learning would be a sufficient alternative.

Sample Vendors: BigPanda; BMC; Devo; Elastic (Elasticsearch); Loom Systems; Moogsoft; Splunk; StackState; Sumo Logic.

Technology No. 2: Compute Accelerators

Description: Compute accelerators are composed of:

- **Graphics processing unit (GPU) accelerators.** These use a GPU to accelerate highly parallel compute-intensive portions of workloads in conjunction with a CPU.
- **Deep neural network (DNN) application-specific integrated circuits (ASICs).** These purpose-specific processors accelerate DNN computations.
- **Field-programmable gate array (FPGA) accelerators.** These server-based reconfigurable computing accelerators deliver extreme high performance by enabling programmable hardware-level application acceleration.

Why EA and Technology Innovation Leaders Should Care:

Compute accelerators bring extreme performance and power efficiency. GPU-accelerators can deliver extreme performance for highly parallel compute-intensive workloads in HPC, DNN training and inferencing. GPU computing is also available as a cloud service and may be economical for applications where utilization is low but time to market needs are high. DNN ASICs will enable neural-network-based systems to address more opportunities in your business through improved cost and performance. Use cases that can benefit from DNNs include speech-to-text, image recognition and natural-language processing.

FPGA accelerators can enable dramatic performance improvements within significantly smaller energy consumption footprints than comparable mainstream technologies. FPGA accelerators are well suited to artificial intelligence (AI) inference workloads, as they excel in low-precision processing capabilities in energy-efficient footprints.

Prediction: Through 2022, computational resources used in AI will increase by at least 4x from 2018, making AI the top category of workloads driving infrastructure decisions.

Maturity: GPUs are most mature (5% to 20% market adoption) followed by ASICs and FPGAs, which are adolescent and early mainstream, respectively (1% to 5% market adoption).

GPU subsystems are actively deployed in HPC and AI. In AI, DNN technologies are maturing quickly, and most of the DNN frameworks support GPU acceleration. Gartner describes GPU accelerators as a mature mainstream technology.

Gartner expects that the market for DNN ASICs will mature quickly, possibly within the three-year depreciation horizon of new systems. FPGAs are typically configured using hardware programming languages that are very complex to use, which has held back widespread adoption of FPGA accelerators. Gartner describes FPGA accelerators as an early mainstream technology.

What You Should Know: Widespread use of DNN ASICs will require the standardization of neural network architectures and support across diverse DNN frameworks. Choose DNN ASICs that offer or support the broadest set of DNN frameworks to deliver business value faster.

For GPU accelerators, selecting the right GPU compute platforms that offer the most mature software stack can be challenging. Optimize infrastructure costs by evaluating cloud-hosted GPU environments for proof-of-concept and prototype phases. Identify the costs associated with the skills necessary for FPGAs and with the programming challenges of FPGAs. Use cloud-based FPGA services to accelerate development.

Sample Vendors: We have broken down our list by accelerator type:

- GPU accelerators: AMD; Cray; Dell; Hewlett Packard Enterprise; IBM; Lenovo; NVIDIA; Supermicro
- DNN ASICs: Amazon; Google; Graphcore; Intel; SambaNova Systems; Wave Computing
- FPGA accelerators: Amazon Web Services; Baidu; Intel; Microsoft Azure; Xilinx

Technology No. 3: Container Management (Orchestration)

Description: Container management software supports the management of containers at scale in production environments. It includes container runtimes, container orchestration, job scheduling and resource management. Container management software brokers the communication between the continuous integration/continuous deployment pipeline and the infrastructure via APIs. It also aids in the life cycle management of containers.

Why EA and Technology Innovation Leaders

Should Care: Container runtimes make it easier to exploit container functions, such as providing integration with DevOps tools and workflows. Containers provide productivity and agility benefits, including:

- The ability to accelerate and simplify the application life cycle
- Workload portability between different environments
- Improved efficiency of resource utilization

Container management software also makes it easier to achieve scalability and production readiness, and to optimize the environment to meet business SLAs.

Prediction: By 2022, more than 75% of global organizations will be running containerized applications in production, which is a significant increase from fewer than 30% in 2018.

Maturity: Adolescent; 5%-20% market adoption.

Grassroots adoption of containers from individual developers has been significant. These developers will use containers with increasing frequency in development and testing, particularly for Linux. Gartner expects container management software to remain an adolescent technology through 2020 and possibly 2021.

What You Should Know: Explore container technology for packaging and deploying Linux applications and beware that Windows containers lag behind in maturity and ecosystem integration. Container management may be appropriate for you if your organization:

- Is DevOps-oriented or plans to become so
- Has high-volume, scale-out applications with a willingness to adopt microservices architecture or large-scale batch workloads
- Has aspirational goals of increased software velocity and immutable infrastructure
- Prioritizes provisioning and scaling time to be critical (measured in seconds, not minutes like VMs)

Sample Vendors: Amazon Web Services; D2IQ; Docker; Google Cloud Platform; IBM; Microsoft Azure; Pivotal; Rancher Labs; Red Hat; VMware.

Technology No. 4: DevOps Toolchain

Description: A DevOps toolchain is composed of tools for supporting DevOps pipeline activity and providing fast feedback as part of the software development life cycle. It typically covers six main activities: plan, create, verify, release, configure and monitor. Pipeline activities have started with discrete tools for various steps, but vendors are delivering solutions across the application development and delivery cycle.

Why EA and Technology Innovation

Leaders Should Care: A well-designed, integrated and automated DevOps toolchain enables development and operations team members to work together, with common objectives and metrics. This helps to ensure quality, on-time application delivery to the business. Of particular interest to operations teams are tools that do continuous configuration automation (such as Chef, Puppet, Ansible and SaltStack), APM/infrastructure management (such as Cisco AppDynamics, Datadog, Dynatrace, Elastic, New Relic and Splunk) and release automation tools (such as CloudBees, Microsoft and XebiaLabs).

Prediction: By 2022, at least 30% of enterprises will adopt a standard set of tools across their DevOps practices, up from less than 10% in 2018.

Maturity: Adolescent; 5%-20% market adoption.

The market is rapidly evolving through acquisitions, the emergence of open-source and new commercial products, and the continued development of cloud architecture. Competition between the largest vendors, particularly of cloud platforms, will continue to disrupt the market.

What You Should Know: DevOps toolchains can include dozens of unintegrated tools, which makes automation a technically

complex and arduous task. We recommend that IT organizations develop a toolchain strategy that establishes business objectives, identifies practices to achieve those objectives and then selects tools to support those practices. If your organization supports more than a single unified delivery platform (such as cloud, mainframe, mobile apps and packaged applications), you'll require a variety of tools from multiple vendors. The toolchain should focus on removing execution barriers and automating the development and continuous delivery process. Remember that even open-source tools aren't free. There's a cost attached to learning, integrating and (especially when they're integrated) replacing them.

Sample Vendors: Atlassian; CloudBees; GitLab; Harness; Microsoft; Red Hat; ServiceNow; XebiaLabs.

Technology No. 5: Edge Computing

Description: Edge computing is a distributed computing topology that places information processing close to the things or people that produce or consume that information. It aims to:

- Keep traffic and processing local and off the center of the network
- Reduce latency and unnecessary traffic
- Establish a hub for interconnection between interested peers
- Establish a hub for the data thinning of complex media types or computationally heavy loads

Why EA and Technology Innovation Leaders

Should Care: Edge computing solves many urgent issues, such as unacceptable latency and bandwidth and cost limitations, given a massive increase in edge-located data. Edge computing will enable aspects of the Internet of Things (IoT) and digital business well into the very near future.

Prediction: By 2022, more than 50% of enterprise-generated data will be created and processed outside the data center or cloud.

Maturity: Adolescent; 5%-20% market adoption.

Most of the technology for creating the physical infrastructure of edge is readily available. However, widespread application of the topology and explicit application and networking architectures are common only in vertical applications, such as retail and manufacturing. The increase in demand for the IoT and the proliferation of its use cases has dramatically increased interest in edge technologies and architectures. This is because edge computing is the IoT's accepted topological design pattern (namely, the "where" a "thing" is placed in an overall architecture). The still-nascent state of non-IoT edge applications has prevented wider adoption.

What You Should Know: Don't risk being left behind — begin considering edge design patterns in your medium- to longer-term infrastructure architectures. Expect to do more planning and experimentation with data thinning and cloud interconnection than with applications, such as client-facing web properties and branch office solutions. You must become familiar with an emerging application model, in which edge gateways and hubs serve as the linchpins for deploying heterogeneous, multicloud and multiendpoint applications.

Sample Vendors: Akamai; Amazon; Cisco; Cloudflare; HPE; Microsoft; Pixeom; Vapor IO; Verizon; ZEDED.

Technology No. 6: Hybrid Cloud

Description: Hybrid cloud is the integration of private and public cloud services to support parallel, integrated or complementary tasks. Hybrid cloud computing needs integration between two or more internal or external environments at the data, process, management or security layers.

Why EA and Technology Innovation

Leaders Should Care: Hybrid cloud offers enterprises the best of both worlds — the cost optimization, agility, flexibility, scalability and elasticity benefits of public cloud, in conjunction with the control, compliance,

security and reliability of private cloud. The solutions that hybrid cloud provides include service integration, availability/disaster recovery, cross-service security, policy-based workload placement and runtime optimization, and cloud service composition and dynamic execution (for example, cloudbursting).

Prediction: By 2022, more than 80% of organizations will have deployed a hybrid cloud or multicloud model for their IT needs.

Maturity: Adolescent; 5%-20% market adoption.

Organizations have started adopting foundational technologies (such as cloud management tools and continuous integration tools), but full-blown implementations still are riddled with complexity. Leading cloud IaaS providers have either released products or made announcements for hybrid and multicloud deployments in the past few years. Among the most notable of these are Azure Stack from Microsoft, VMC from AWS/VMware, Anthos from Google and Outposts from AWS. Gartner expects this to be an area of intense competition and innovation in the coming years.

What You Should Know: When using hybrid cloud computing services, establish security, management, and governance guidelines and standards to coordinate the use of these services with internal (or external) applications and services to form a hybrid environment. Approach sophisticated cloudbursting and dynamic execution cautiously because these are the least mature and most problematic hybrid approaches. To encourage experimentation and cost savings, and to prevent inappropriately risky implementations, create guidelines/policies on the appropriate use of the different hybrid cloud models.

Sample Vendors: Amazon Web Services (AWS); Google; Hewlett Packard Enterprise (HPE); IBM; Microsoft; Nutanix; OpenStack; Rackspace; Flexera (RightScale); VMware.

Technology No. 7: Intent-Based Networking

Description: An intent-based networking system (IBNS) provides:

- Translation and validation: It can take a higher-level business policy as input from end users and convert it to the required network configuration.
- Automation: It can configure appropriate network changes across existing network infrastructure.
- State awareness: The system ingests real-time network status for systems under its control.
- Assurance and dynamic optimization: The system continuously validates that business intent is being met and can take corrective action when it isn't.

Why EA and Technology Innovation Leaders Should Care:

Intent-based networking can transform network operations. IBNSs improve network agility and availability and support unified intent and policy across heterogeneous infrastructures. When the technology matures, a full IBNS implementation will reduce the time to deliver network infrastructure services to business leaders by 50% to 90%. It will also reduce the number and duration of outages by at least 50%. IBNSs also:

- Reduce operating expenditure
- Optimize performance
- Cut dedicated tooling costs
- Enhance documentation
- Improve compliance

Prediction: By 2022, more than 1,500 large enterprises will use intent-based networking systems in production, up from less than 15 today.

Maturity: Emerging; less than 1% market adoption.

Unfortunately, the technology is massively overhyped, and things such as automation and programmability are “washed” with intent. However, real-world enterprise adoption of IBNSs was nascent as of early 2019, and Gartner estimated fewer than 50 full deployments. Through 2019, early rollouts are likely to be in larger-scale environments for well-defined and specific use cases, such as spine/leaf data center networks. We don't expect the number of commercial enterprise deployments will reach the hundreds until the end of 2020. Adoption will be pragmatic, associated with new build-outs or network refresh initiatives.

What You Should Know: IBNSs require the ability to abstract and model network behavior, which has proved difficult, particularly in multivendor environments. IBNSs also require a substantial cultural shift in the design and operation of networks. This will create barriers to adoption in many risk-averse organizations. Choose an IBNS that supports multivendor network infrastructures and extends into public cloud environments to support a broader range of use cases and avoid vendor lock-in. Deploy IBNSs in phases.

Sample Vendors: Apstra; Cisco; Forward Networks; Gluware; Huawei; Intentionet; Juniper Networks; NetYCE; Veriflow Systems.

Technology No. 8: Next-Generation Memory

Description: Next-generation memory is a type of nonvolatile memory capable of displacing DRAM in servers. It has the density and manufacturing cost close to flash memory, but is fast enough to augment DRAM, or even replace it over time.

Why EA and Technology Innovation Leaders Should Care:

Next-generation memory enables a five to 10 times increase in fast, local storage capacity. This means scale-up computing systems can perform faster or handle larger analytics workloads. The nonvolatile storage will be significantly faster than any solid-state drive (SSD) but limited by PCIe interface when used as storage. Alternatively, this type of memory can provide greater consolidation, reducing costs by shrinking the data center space

required. When used as persistent memory, it has the potential to accelerate the adoption of in-memory computing architectures.

Prediction: By 2022, 20% of CPU socket servers with two or more sockets will ship with 3D XPoint NVDIMMs, up from less than 1% in 2018.

Maturity: Emerging; 1%-5% market adoption.

Gartner describes next-generation memory as an adolescent technology. Next-generation memory techniques include Hewlett Packard Enterprise's (HPE's) ion migration memristor and Intel-Micron's 3D XPoint phase change and spin-transfer torque memory. Only these three technologies have a viable opportunity between the cost, reliability and performance attributes of DRAM and flash memory. Of the three, Intel-Micron's 3D XPoint technology is the furthest along and will probably hold off the competition through 2020. Reducing the cost of keeping data in the “main memory” and simplifying high-availability architecture can accelerate the mainstream organization adoption of in-memory computing architectures.

What You Should Know: The 3D XPoint memory cell technology is shipping in less demanding Peripheral Component Interconnect Express (PCIe) and NVM Express (NVMe) solid-state storage devices, where memory management is far simpler. These devices — because of their low-write latency — exhibit high-transaction rates compared with flash-based SSDs. Fully exploiting these performance attributes requires changes to software and drivers.

Sample Vendors: Dell; Hewlett Packard Enterprise; Inspur; Intel; Lenovo; Supermicro.

Technology No. 9: NVMe and NVMe-oF

Description: Nonvolatile memory express (NVMe) and nonvolatile memory express over fabrics (NVMe-oF) are host controller and network protocols that are taking advantage of the parallel-access and low-latency features of solid-state storage and the PCIe bus. NVMe-oF extends access to nonvolatile

memory (NVM) remote storage subsystems across a network.

Why EA and Technology Innovation Leaders

Should Care: NVMe and NVMe-oF offerings can have a dramatic impact on business use cases where low-latency requirements are critical to the bottom line. Though requiring potential infrastructure enhancements, the clear benefits these technologies can provide will immediately attract high-performance computing and OLTP use cases where clients can quickly show a positive ROI. The easiest way to consume these technologies will be through acquisition of modern solid-state arrays (SSAs) that support these.

Prediction: By 2022, over 20% of new SSA shipments will utilize NVMe-oF to optimize performance, latency and effective bandwidth, up from 1% today.

Maturity: Emerging; 1%-5% market adoption.

NVMe is a fast-growing storage protocol that is being used internally within SSAs and servers. However, NVMe-oF, which requires a storage network, is still emerging and developing at different rates, depending on the network encapsulation method. There are many NVMe-oF offerings that use fifth-generation and/or sixth-generation Fibre Channel (FC) NVMe available, but adoption of NVMe-oF within 25/40/50/100 Gigabit Ethernet is slower. In November 2018, the NVMe standards body ratified NVMe/TCP as a new transport mechanism. In the future, it's likely that TCP/IP will evolve to be an important data center transport for NVMe.

What You Should Know: Buyers should clearly identify workloads where the scalability and performance of NVMe-based SSA and NVMe-oF justify the premium cost of an end-to-end NVMe-deployed SSA, such as AI/ML or transaction processing. Next, identify appropriate potential array, network interface card (NIC)/host bus adapter (HBA) and network fabric suppliers to verify that interoperability testing has been performed and that reference customers are available. During the next 12 months, most SSA vendors

will offer SSAs with internal NVMe storage, followed by support of NVMe-oF connectivity to the compute hosts.

Sample Vendors: Dell EMC; Excelfero; IBM; Kaminario; NetApp; Pavilion Data Systems; Pure Storage.

Technology No. 10: Serverless Computing

Description: Serverless computing is a model of IT service delivery. It uses the underlying enabling resources as an opaque, almost unlimited, shared pool that is continuously available without advance provisioning. The price of the pool is included in the cost of the consumed IT service. Serverless computing automatically provisions and operates the runtime environment.

Why EA and Technology Innovation

Leaders Should Care: Serverless computing enables organizations to build applications quickly and deploy them at a large scale. It's suitable when a quick response and dynamic scalability are vital. It can enable organizations to exploit new application architectures, such as microservices patterns, which can bring competitive differentiation. Serverless computing can be economical for variable workloads because it provisions and consumes infrastructure resources only when necessary. Serverless computing is transformational in terms of flexibility and reduced operating costs.

Prediction: More than 30% of global enterprises will have deployed serverless computing technologies by 2022, which is an increase from fewer than 5% today.

Maturity: Emerging; 1%-5% market adoption.

Serverless delivery of IT services has gained attention since Amazon popularized its Amazon Web Services (AWS) Lambda function platform as a service (fPaaS). However, the significance of serverless computing, as demonstrated by the leading vendors (including Amazon, Google and Microsoft), extends beyond functions. Many PaaS capabilities will be delivered with serverless characteristics, and some are already

(such as Amazon Athena). Serverless fPaaS capabilities are also starting to converge on Kubernetes, with the Knative project having potential to be the underlying abstraction to enable it. However, on-premises implementations are uncommon because of data integration and scalability challenges.

What You Should Know: Serverless computing represents a broad set of technologies, but the most transformative and widely used flavor of serverless computing is fPaaS. With fPaaS, fine-grained units of custom application logic are packaged as functions, which are executed when triggered by events. Serverless computing demands substantial transformation management. Instead of managing physical infrastructures, you'll have to:

- Take an application-centric view and understand the interdependencies between application components and whether their design enhances scalability, reliability, security and performance.
- Factor in API gateway, network egress and other costs. Exceptions such as workloads with heavy invocations can make API gateway costs high.
- Revise data classification policies and controls because objects in a content store can now also represent code, as well as data.
- Rethink IT operations from infrastructure management to application governance to ensure you can secure, monitor and debug, and meet application SLAs.

Sample Vendors: Amazon; Cloudflare; Google; IBM; Iguazio; Microsoft Azure; Oracle; Pivotal; Red Hat.

Evidence

Gartner analysts combed through hundreds of Hype Cycle profiles to select early-stage technologies that would offer significant long-term benefits to customers over the next five-year period. Detailed discussions on the list were also held within Gartner research communities with participation from a broad set of analysts.

Market adoption is expressed as a percentage of all companies that have adopted that technology.

Gartner Research Note G00430091, Arun Chandrasekaran, Andrew Lerner, 29 October 2019

Explanation of Maturity Levels:

Table 1. Maturity Level

Maturity Level	Status	Products/Vendors
Emerging	<ul style="list-style-type: none">• Commercialization by vendors• Pilots and deployments by industry leaders	<ul style="list-style-type: none">• First generation• High price• Much customization
Adolescent	<ul style="list-style-type: none">• Maturing technology capabilities and process understanding• Uptake beyond early adopters	<ul style="list-style-type: none">• Second generation• Less customization
Early mainstream	<ul style="list-style-type: none">• Proven technology• Vendors, technology and adoption rapidly evolving	<ul style="list-style-type: none">• Third generation• More out-of-box methodologies
Mature mainstream	<ul style="list-style-type: none">• Robust technology• Not much evolution in vendors or technology	<ul style="list-style-type: none">• Several dominant vendors

Source: Gartner (October 2019)



About Huawei

Founded in 1987, Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. We have more than 194,000 employees, and we operate in more than 170 countries and regions, serving more than three billion people around the world.

Huawei OceanStor storage is a part of Huawei Cloud & AI BG. Up to now, Huawei OceanStor storage systems have been deployed in more than 150 countries worldwide, serving more than 12,000 customers in various industries, such as finance, carrier, government, energy, healthcare, manufacturing, and transportation. Huawei OceanStor storage systems have become the preferred choice for data storage and processing in all industries around the world.

<https://e.huawei.com/en/products/cloud-computing-dc/storage>

