Hype Cycle for Cloud Computing, 2019

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By Analysts David Smith, Ed Anderson

Cloud computing has reached the Slope of Enlightenment. There are emerging cloud-related technologies climbing to the Peak of Inflated Expectations, while some are maturing. This research outlines the cloud-related technologies in use and those becoming the foundation for the future of computing.

Analysis

What You Need to Know

Hype around cloud computing persists and remains high relative to other technologies, even as it has been around and on Hype Cycles for over a decade. Much of the focus has shifted from the unrealistic promises that cloud will transform everything (as well as the other extreme pessimistic view that it didn't deliver) to a more pragmatic approach that views cloud as inevitable. A major focus is now on how to do it well versus on whether to do it at all, as well as on the reality of multiple clouds and cloud providers for most organizations. Most organizations are becoming increasingly grounded in the practical benefits and risks of cloud computing. "Cloud first" is becoming a common description of enterprises' and vendors' strategies, as cloud adoption becomes mainstream (approaching "new normal" status), including support for production applications and mission-critical operations. Cloud services are heavily favored for new application development, particularly when organizations pursue digital business outcomes. Most vendor innovations are in the cloud or at least cloud-inspired. Some are moving toward "cloud-only."

Cloud computing examples range across many industries (including initially reluctant ones, such as finance and healthcare), organization sizes and geographic regions. Understanding the landscape of cloud service offerings, technologies and terminology is critical for organizations to establish viable cloud strategies and find success in their use of cloud service offerings. This research profiles key cloud computing technologies and concepts, and it provides guidance to IT leaders on how to leverage the growing capabilities of cloud computing.

Just when it appeared that cloud hype may be settling down, there is now a new set of terms — hybrid, multicloud, cloud-native, edge computing, distributed cloud and cloud repatriation. Despite the definitions being standardized, colloquial usage varies widely. IT professionals are not always using the word "cloud" to refer to the same thing. Occasionally, new terms have appeared and existing terms have been adjusted. We are now moving into a new era of the cloud (as cloud adoption is moving from the early-adopter period to the beginning of

mainstream adoption). So, we've seen the introduction (and in some cases the reintroduction) of quite a few terms that have been challenging for us to deal with, and have increased cloud hype.

CIOs, CTOs and enterprise architects should use this research to guide their strategic planning in the context of the continuing cloud-related hype and confusion.

For more information about how peer I&O leaders view the technologies aligned with this Hype Cycle, please see "2019-2021 Emerging Technology Roadmap for Large Enterprises."

The Hype Cycle

Cloud has moved beyond its initial impact — disrupting all aspects of IT — to providing the underlying basis for most future digital disruptions and innovations. Cloud exists on a spectrum (see "Four Types of Cloud Computing Define a Spectrum of Cloud Value") and enables the next-generation platforms and business solutions that organizations are increasingly reliant on. Cloud vendors and users alike continue to overuse the term "cloud" (cloudwashing), as well as misrepresent terminologies, such as "hybrid cloud," under the guise of pushing traditional on-premises infrastructure and hardware.

Most organizations believe hybrid scenarios, leveraging public and private implementations, will help address the challenges of these disparate environments. However, disillusionment is increasing for technologies associated with building out private clouds (cloud management platforms, private infrastructure as a service [IaaS] and private cloud itself), further driving workloads to public clouds as organizations seek the full benefits of cloud computing. We also see a few clusters of technologies appearing on this Hype Cycle:

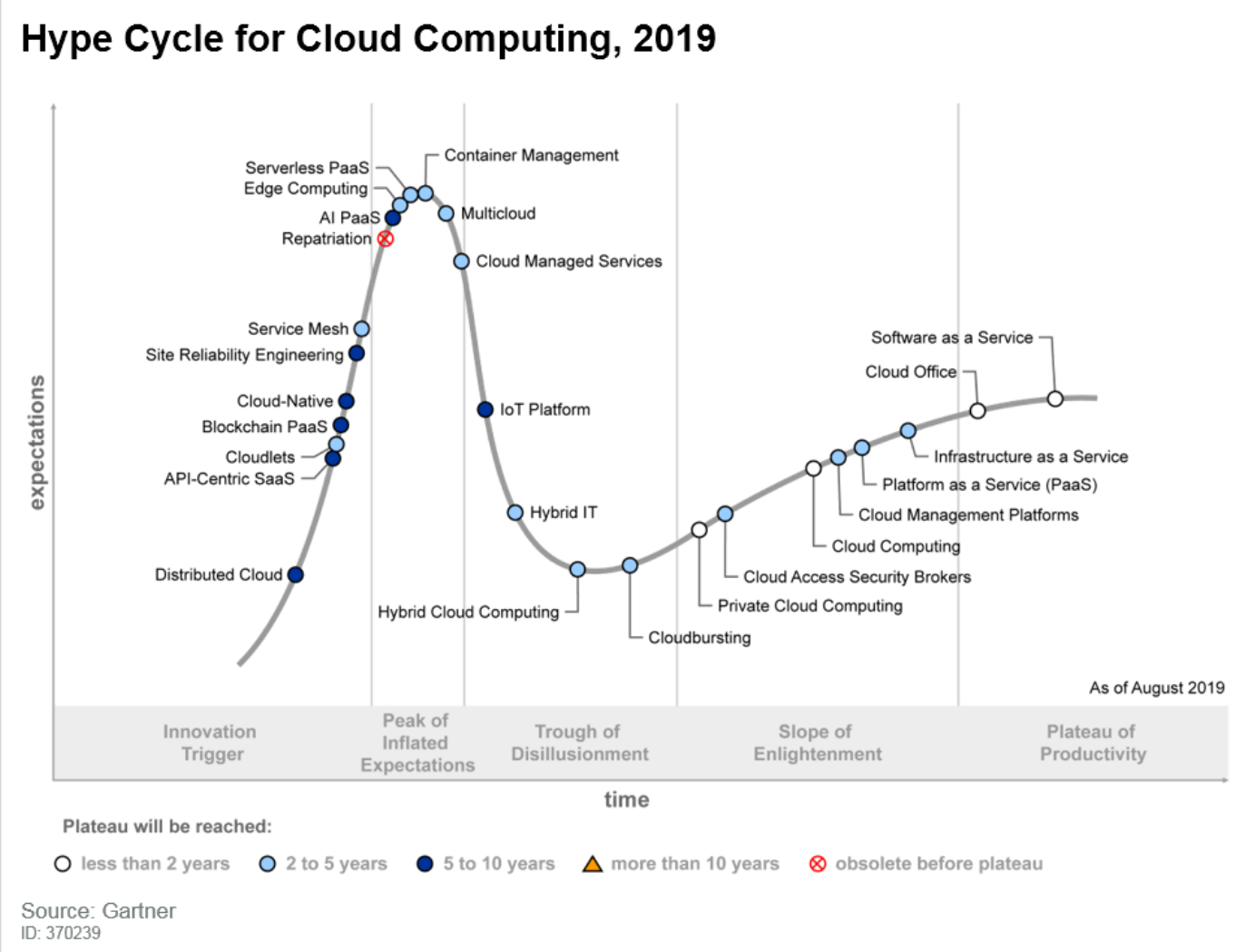
- The next wave of cloud approaches (distributed cloud, cloud-native), delivering advanced capability around technologies such as artificial intelligence (AI) and blockchain
- The most hyped of the day, currently clustered around the peak (serverless PaaS, multicloud and container management), where much of the excitement is around specific approaches that are driving innovation
- The trough (private cloud computing, cloudbursting and cloud access security brokers), where concepts that have generated significant excitement in past years are struggling with implementation challenges

This Hype Cycle includes innovation profiles describing different cloud models and deployment types, as well as the tools and services used to test, migrate, manage and secure cloud environments. We outline key technology and market areas to watch for future opportunities, particularly in cloud-based applications. Technologies to watch include distributed cloud, container management, serverless PaaS and cloud-native. Note that many of the innovation profiles in this Hype Cycle are beyond the Peak of Inflated Expectations. We have added "distributed cloud," which is a broad concept that in many ways represents the future of cloud, and "repatriation," which is unique in that it is not really happening, but is considerably hyped.

This Hype Cycle includes many new (and relatively new) innovation profiles. These include service mesh, multicloud, cloudlets and site reliability engineering. As cloud enters its second decade, it continues to evolve with new types of services and capabilities that make it the primary model for a wider range of solutions. Cloud has become the default style for just about everything in the future. If it is not cloud, it is legacy.

Organizations finding success in their use of cloud computing not only challenge cloud-related hype, but also apply practical assessments of cloud capabilities to recognize the organization's desired outcomes. Cloud (via an ever-increasing variety of SaaS) is enabling businesses to achieve their goals with less direct support by IT. Pragmatism is critical when evaluating cloud services. When applied to the right scenarios with the right management and governance, organizations can find success in realizing practical benefits, including increased agility, elasticity, scalability, innovation and, in some cases, cost savings.

Figure 1. Hype Cycle for Cloud Computing, 2019



The Priority Matrix

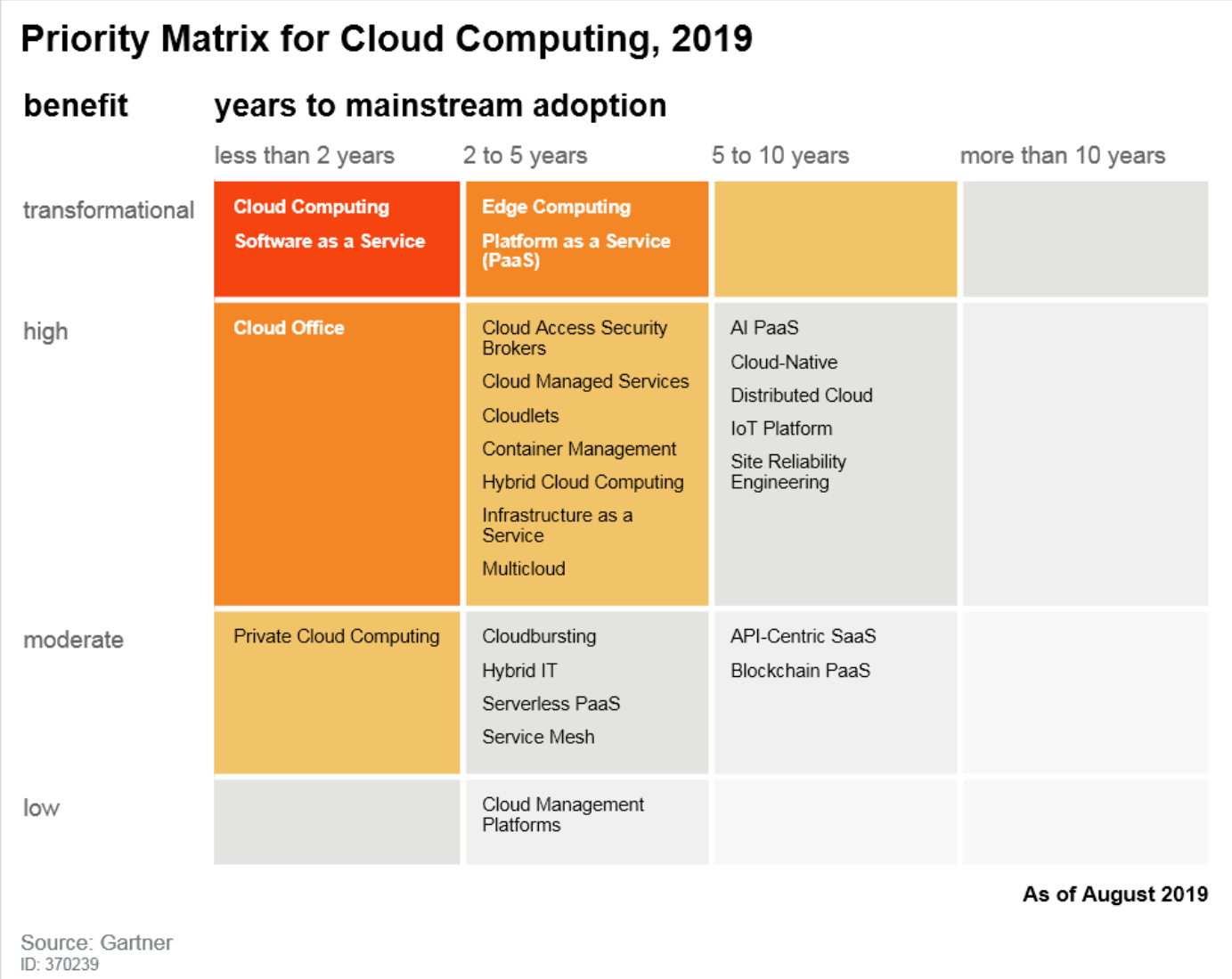
Cloud computing is a set of dynamic, high-growth markets, which causes some cloud technologies and concepts to move through the Hype Cycle at an accelerated rate. Transformational technologies and services, such as PaaS, edge computing and SaaS, are

realizing increasing usage. We are also seeing the rapidly emerging industry of managed service providers offering professional services and “cloud managed services.”

Many cloud computing technologies and concepts are two to five years away from mainstream adoption. IaaS has moved into mainstream adoption. New technologies — including serverless PaaS and edge computing — are building in hype and will grow to become important technology foundations for future cloud solutions over the next two to five years.

The relative impact of cloud and cloud-related technologies is high and often transformational. Organizations building on a cloud foundation will embrace transformational change more quickly and more effectively than organizations bound to traditional IT environments.

Figure 2. Priority Matrix for Cloud Computing, 2019



Off the Hype Cycle

The market for cloud computing is dynamic, and changes occur rapidly. Cloud technologies and offerings move steadily toward maturity, with only a few becoming obsolete before reaching the Plateau of Productivity. We endeavor to represent a broad view of cloud-related technologies and concepts, which means the Hype Cycle goes through a regular cycle of update, consolidation and focus.

To provide readers with clearer, more focused research that supports their analysis and planning, we have asked authors to include only those innovation profiles most strongly linked to the Hype Cycle and its theme. In many cases, selecting only the most salient profiles has reduced the number of innovation profiles on the Hype Cycle.

In this 2019 update, we made the following notable changes:

- Removed:
  - Immutable infrastructure
  - IaaS+
  - iPaaS
  - Application PaaS
  - Cloud tethering
  - Cloud to edge development support
  - Hyperscale computing
  - Cloud service expense management
  - Machine learning
  - API economy
  - Cloud marketplaces
  - Cloud networking
  - Software-defined infrastructure
  - Cloud service brokerage
  - Cloud migration
  - Integrated IaaS and PaaS
  - Cloud center of excellence
  - Private PaaS
  - Public cloud storage
  - SaaS administrative ERP
  - Cloud-testing tools and services

    - Cloud security assessments

- Replaced:
    - Cloud-native application architecture was replaced by cloud-native.

- Added:
    - Distributed cloud
    - API-centric SaaS
    - Cloudlets
    - Service mesh
    - Repatriation
    - AI PaaS
    - Cloud access security brokers

On the Rise

Distributed Cloud

Analysis By: David Smith; Daryl Plummer

Definition: Distributed Cloud refers to the distribution of public cloud services to different physical locations while operation, governance, updates and evolution of the services are the responsibility of the originating public cloud provider.

Position and Adoption Speed Justification: Distributed cloud computing is a style of cloud computing where the location of the cloud services is a critical component of the model. Historically, location has not been relevant to cloud computing definitions. While many people may claim that private cloud or hybrid cloud requires on-premises computing, this is a misconception. Private cloud can be done in a hosted data center or, more often, in virtual private cloud instances, which are not on-premises. Hybrid cloud likewise does not require that the private components of the hybrid are in any specific location. However, with the advent of distributed cloud, location formally enters the definition of a style of cloud services.

Distributed cloud supports tethered and untethered operation of like-for-like cloud services from the public cloud “distributed” out to specific and varied physical locations. This enables a key characteristic of distributed cloud operation — low latency compute where the compute operations for the cloud services are closer to those who need the capabilities. This can deliver major improvements in performance as well as reducing the risk of global network-related outages.

User Advice: Begin identifying scenarios where a distributed cloud model will effectively obviate the need for a hybrid cloud model and where hybrid cloud models, and connectivity and latency matter and will continue to be needed for years to come.

Business Impact: A major notion hidden within the distributed cloud concept is that the provider is responsible for all aspects of the delivery. This restores cloud value propositions that are broken when customers are responsible for a part of the delivery as is true in some hybrid cloud scenarios. It should be noted that while the cloud provider does not need to own the hardware on which the distributed cloud substation is installed, it must take full responsibility for how that hardware is managed and maintained — otherwise the value proposition of distributed cloud is compromised.

In hyperscale public cloud implementations, the public cloud is the center of the universe. However, there has been distribution of cloud services through worldwide regions in public cloud practically since its inception. The major hyperscale cloud providers now have different geographic regions around the world, all are centrally controlled and managed and provided by the public cloud provider.

Now, with distributed cloud, we are extending that distributed concept out to the edge and leverage the new offerings like Microsoft's Azure stack, Oracle's Cloud at Customer, AWS Outposts and even IBM's early attempt at distributed cloud.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Amazon; Google; IBM; Microsoft; Oracle

Recommended Reading: "The Cloud Strategy Cookbook, 2019"

API-Centric SaaS

Analysis By: Yefim Natis; Anne Thomas

Definition: API-centric ("headless") SaaS is a cloud application service that is offered for subscription, primarily or entirely, for programmatic access via APIs and/or event channels. Some minimal user experience may be provided as a starter set, but the strategic intent for API-centric SaaS is to be used as an accelerator for application development and integration tools. Although a business capability (SaaS), the API-centric SaaS acts as an extension feature, for a cloud platform (PaaS).

Position and Adoption Speed Justification: Most SaaS expose some of their functionality via APIs and/or event channels. But for most cases, API access is an additional or optional feature, typically enabling access to some, but not all the application's capabilities for extension and integration. User experience software or services that are provided with the SaaS are intended as the primary mode of user access to the application, although most modern SaaS provide

extension and modernization tools for customization of the application experience. Some types of SaaS, however, provide API and/or event access as the primary access modality, and the number of such SaaS is increasing. Mobile back-end services (Progress Kinvey), cloud communication (Twilio), artificial intelligence (IBM Watson) and numerous e-commerce services (Stripe, Snipcart, Scalefast, BigCommerce, and more) are offered as API-centric services today. New integration vendors (such as Clever, Orderful, Plaid, PokitDok) innovate around the assembly capabilities for this emerging library of building blocks. Expect vendors to offer a growing number of headless capabilities in the near future. This trend is in line with the larger trends in application design that is shifting to continuous delivery and assembly of application experiences based on libraries and ecosystems of packaged business capabilities. Next generation serverless platforms such as AWS Lambda are designed for producing exclusively API/event-centric application services and even the more traditional application platforms, capable of creating integrated user experience and back-end business logic (such as Microsoft App Service), are often used to deliver “headless” application components. The more traditional SaaS offerings will continue to offer elaborate user experience capabilities, but the trend toward increasing innovation and diversification of user experience is forcing them to also upgrade their programmatic access. Gartner expects increasing recognition and adoption of API-centric model for SaaS delivery with the associated increase in hype. Over time, most SaaS will be used, in part or in whole, in API-centric mode, gradually moving to this model as a common mainstream practice.

User Advice: CIOs and application leaders:

- Give preference to SaaS offerings that expose more of their business capabilities as API and/or event channels.
- Give preference to application development and integration tools that provide support for assembly of application capabilities utilizing API and/or event channel interfaces of SaaS.
- Plan the application design with anticipation of continuous innovation and change in user experience; therefore, separate the central business logic of the application from its model of user interaction.
- Avoid SaaS offerings that lock your organization into their user experience technology.
- Give preference to low-code and pro-code PaaS offerings that include API/event-based accelerators and are equipped for programmatic access to external API/Event channel libraries.

Business Impact: API-centric SaaS results in greater ability of the business to innovate with user experience and to create assembled multiapplication/multiprovider business experiences.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services (AWS); BigCommerce; Google (Cloud AI); IBM Watson; Microsoft (Azure AI Platform); Scalefast; Snipcart; Stripe; Twilio

Recommended Reading: "The Key Trends in PaaS and Platform Architecture, 2019"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2019"

Cloudlets

Analysis By: Thomas Bittman

Definition: A cloudlet is a small-scale data center or compute cluster that provides cloud services in close proximity to endpoints using those services. Unlike hyperscaler cloud data centers, its resources are limited and it maintains only a cache — effectively a middle tier between endpoints and back-end cloud data centers.

Position and Adoption Speed Justification: The cloudlet concept was first introduced by Mahadev Satyanarayanan of Carnegie Mellon University in 2009. It focused on the computing and latency needs of mobile users. As edge computing and IoT demand grew, the cloudlet concept became relevant to a wider array of endpoints — including things. Although content delivery networks emerged to solve the problem of latency and centralized content streaming from the cloud, cloudlets are essentially extensions of cloud services (not just data caching) made available to nearby people of things. The form factor that is used to deliver the cloudlet can vary widely, from micro data centers (most common and evolving) to edge server appliances (for specific deployment situations, much less mature) to mesh computing alternatives (sharing compute across local devices, future potential). A special form of cloudlet — tethered compute — is a type of cloudlet dedicated to a specific enterprise.

Programmable cloudlets are emerging from a variety of vendors — including hyperscale cloud providers and telecommunication providers. The hardware and software platforms for cloudlets need to mature, as do the technologies to effectively manage and integrate them effectively with back-end cloud services.

User Advice: Cloudlet technologies are diverse, immature and relatively nonstandard as a variety of vendors vie for position. Easy interoperability and consistency with primary cloud providers are critical, as are ease of access, ease of discovery, ease of management, and security and policy management (including clearing all cache of protected data). Early deployments within enterprise premises (tethered compute solutions) will mature sooner than multienterprise for mobile users and things. Hardware and platform form factors may limit use to more general-purpose edge roles. Special-purpose edge roles are better served by special-purpose edge computing solutions designed for the specific types of processing requirements, rather than general-purpose cloudlets.

Business Impact: Cloudlets will essentially extend cloud services very close to users and things, enabling enterprises and providers to extend cloud computing use cases to those

requiring low-latency, or massive data preprocessing, data security requirements and disconnected autonomy. Cloudlets will be an important part of an enterprise edge computing strategy, especially when using third-party edge computing (rather than enterprise-owned), or general-purpose edge computing capability for locations (such as retail stores, workplaces, campuses, public spaces).

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services; AT&T; Microsoft Azure; MobiledgeX; Packet; Verizon

Recommended Reading: "What Tech CEOs Must Know About Edge Computing in 2019"

"How Edge Computing Redefines Infrastructure"

Blockchain PaaS

Analysis By: Adrian Leow; Rajesh Kandaswamy; Paul Vincent

Definition: Blockchain platform as a service (bPaaS) is a set of blockchain software platform services offered to subscribers in the cloud by a vendor. Services can include some or all of the distributed ledger, node or consensus mechanisms, and other ancillary services to manage a network of distributed ledgers on the vendor's cloud infrastructure. bPaaS is separate to blockchain managed services, which include management of the solution and application stack on top of bPaaS.

Position and Adoption Speed Justification: bPaaS is a recent cloud service offering from enterprise cloud vendors such as Alibaba, Amazon Web Services (AWS) IBM, Microsoft and Oracle; also small technology startups such as BlockApps, BlockCypher and Wanxiang Blockchain Labs. Solutions in the market today are in the early stages of development and adoption, and are mostly used for performing proofs of concept (POCs). Developers seeking to implement blockchain-based applications require specific services that span compute, application, storage, network and especially integration services, both for initial implementation and ongoing operations. The cloud vendors aim to combine these services to provide enterprises with a one-stop service shop that brings the benefits of cloud elasticity and compute costs to blockchain. Each bPaaS vendor attempts to add unique elements around support for multiple blockchain platforms, security, interoperability, analytics and performance in order to differentiate their offerings in exchange for single-sourcing and centralization of public execution and ledger storage.

These offerings are new, and we expect the field of competitors to grow over time. In many cases, the cloud vendor's bPaaS supports one or a few blockchain platforms. Support for different consensus mechanisms, tools, frameworks and smart contract capabilities remains limited and continues to evolve. Interoperability for distributed ledgers across competing

platforms or clouds is extremely limited at this early stage of evolution. But relying on one vendor for all nodes of the distributed ledger negates some of the advantages of using a distributed ledger in the first place. The core value of a distributed ledger, which has fueled the hype and interest among many in the technology industry, is to enable decentralized/distributed open-source applications that avoid reliance on just one organization, server, data center or network. Most versions of bPaaS trade this core value for the convenience of vendor assistance, although this trade-off is expected to be addressed by greater interoperability and standardization in the future.

bPaaS encompasses platform services (such as AWS) or cloud-based blockchain developer toolsets. Over time, however, we expect other blockchain-based application and business services to become available in the cloud as blockchain-based SaaS. Full-stack blockchain managed services are starting to emerge and are being supported by several vendors.

Currently, in most cases the primary value of bPaaS is to “jump-start” the ability of enterprise developers to rapidly set up an initial test system or prototype — as opposed to a truly decentralized production system. Because bPaaS is dependent on a restricted perspective of blockchain, and is also affected by blockchain’s immaturity, it remains “on the ramp” toward the Peak of Inflated Expectations.

User Advice: Current bPaaS offerings can primarily help jump-start your POCs, smaller projects, or your experiments with blockchain technologies, as long as you are comfortable with limiting your experience to what bPaaS can provide. As blockchain technologies and bPaaS offerings evolve, we expect a wider range of options to be available, with additional services and increased interoperability. Be aware that cloud providers support a limited set of platforms, yet the overall landscape of choices is large and rapidly evolving. Enterprises that avail themselves of PaaS services might also consider the same vendor’s bPaaS services. There are more than 100 blockchain platform software choices, but cloud vendors currently support less than 10% of them.

Every blockchain platform will undergo major changes during the next two to five years, rendering any current choice potentially obsolete within 24 months. Some platforms, however, will keep up with evolutionary changes that keep them scalable and competitive. Enterprises should, therefore, avoid commitments to bPaaS for mission-critical initiatives until greater maturity occurs, and until platforms and services are interoperable across heterogeneous environments. Understand all aspects of the blockchain technologies you will need, and ensure they can be supported on the bPaaS offering of interest.

Business Impact: bPaaS will initially be attractive to enterprises for limited-scale experiments and POCs — until they mature, become interoperable and fully support multiple key blockchain platforms. For blockchain projects with a limited number of participants, an agreement on common bPaaS platforms and tools will be easier to attain. The list of vendors providing capabilities in this area continues to expand.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services (AWS); Blocko; IBM; Microsoft; Oracle; Wanxiang Blockchain Labs

Recommended Reading: "Market Guide for Blockchain Platforms"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2019"

"Amazon QLDB Challenges Permissioned Blockchains"

Cloud-Native

Analysis By: David Smith

Definition: Something is considered to be cloud-native if it is created to leverage cloud characteristics. Those cloud characteristics are part of the original definition of cloud computing and include capabilities delivered as a service that are scalable and elastic, metered by use, service-based, ubiquitous by means of internet technologies, and shared. The term cloud-native is used primarily as an adjective. You can have a cloud-native architecture, infrastructure, applications or operations, for example.

Position and Adoption Speed Justification: Cloud-native is particularly challenging with respect to hype because confusion amplifies hype. There are very different meanings for the cloud-native term in use already. We went to the original cloud computing definition and tried to come up with something very simple to define this. Something is cloud-native if it is created to leverage cloud characteristics. Gartner's definition of cloud-native is based on the original definition of cloud computing.

We consider something to be cloud-native if it is designed to leverage cloud characteristics. Those cloud characteristics are part of the original definition of cloud computing. It's all about capabilities delivered as a service that are scalable and elastic, metered by use, service-based, ubiquitous by means of internet technologies, and shared. Sometimes people will trade off one or more of these capabilities. For example, sharing can be problematic for some and they may accept less elasticity as a result of not enabling sharing.

Cloud-native is a concept that is not binary, meaning that something either is or isn't cloud-native. Rather, cloud-native can be expressed in degrees. The more something aligns with core cloud characteristics, the more we consider it to be cloud-native and the more cloud-native outcomes the thing will produce.

Cloud-native is a popular (hyped) concept today because many organizations using cloud have not fully realized the benefits they expected from cloud. For example, if a traditional, noncloud application is migrated to cloud using a lift-and-shift approach, the application is unlikely to leverage cloud characteristics and deliver the full benefits of cloud. This is an example of an application that is not cloud-native. In contrast, if the application is rewritten to take advantage

of the cloud capabilities through the use of cloud-native interfaces, services and operating processes, then the application is more likely to deliver the expected cloud outcomes.

User Advice: Rather than focusing purely on the definition of cloud-native, focus on the outcomes you want from using cloud. The more your use cases align with the core cloud attributes, the more likely you are to recognize the full benefits of using cloud.

Assess vendor claims about their cloud-native capabilities with skepticism. Vendors use the term “cloud-native” to promote their offerings regardless of how cloud-native their offerings may be.

When building or acquiring cloud-native applications or services, ensure that the supporting tools, processes and operations support the cloud characteristics. The value of cloud-native applications can be subverted when supporting elements are not cloud-native in their approach.

Embrace services design to bring you closer to cloud-native outcomes. This includes the use of containers, microservices architecture, serverless design, functions and many PaaS services. Use of these technologies should, however, be a means, not a goal.

Sorting out the definitions and being clear about goals are key to leveraging cloud-native.

Three contradictory definitions are in common use:

1. The first meaning is the most common. It is basically interpreting cloud-native to mean the use of the native cloud platform features. So, it could be platform as a service, availability zones or serverless, for example. So, if you’re using Amazon, you’re using the native features of AWS such as RDS, Lambda and Beanstalk.

2. The second meaning is a focus on particular technologies such as containers and Kubernetes. This is driven by an organization called the Cloud Native Computing Foundation (CNCF), which promotes these technologies.

3. The third meaning is one that is very architectural in nature. One source for this is GTP’s LIFESPAR acronym. Another example is 12-factor applications. This approach is popular with those who are very deep into architectural approaches but is in no way the most common use of the term.

Business Impact: Cloud-native, as a means to deliver cloud characteristics, has potential to enable maximum leverage of the cloud technologies and benefits. Note that the most common meanings in use are actually quite contradictory. One is all about using native features and, therefore, locking yourself into the provider. The other is all about containers, which don’t guarantee portability but are directionally consistent with the goal.

When using the term cloud-native, it is, therefore, imperative that there is clarification of which meaning is being used. It is not uncommon to find both multicloud and cloud-native as goals in a cloud strategy. Further explanation is required in that case.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Amazon; Google; IBM; Microsoft

Recommended Reading: "The Cloud Strategy Cookbook, 2019"

Site Reliability Engineering

Analysis By: George Spafford; Christopher Little; Mark Jaggers

Definition: Site reliability engineering is a collection of systems and software engineering principles used to design and operate scalable resilient systems. Site reliability engineers collaborate with developers to design and continuously improve systems that meet service-level objectives. An SRE team applies good practices and organizational standards — usually in combination with DevOps practices and tools — and applies them to responsibilities such as risk management, release engineering, monitoring, self-healing, incident and problem management.

Position and Adoption Speed Justification: Site reliability engineering (SRE) is a discipline originally created by Google, and was described in the 2016 book, "Site Reliability Engineering: How Google Runs Production Systems." Adoption interest continues to grow both by digital-native organizations as well as traditional enterprises. SRE emphasizes the engineering disciplines that lead to resilience, but individual organizations implement SRE in widely varying ways. SRE is a complementary practice for organizations seeking to scale their DevOps activities.

SRE is intended to help manage the risks of rapid change, through the use of service-level objectives (SLOs), "error budgets," monitoring automated rollback of changes and organizational learning. SRE teams are often involved in code review, looking for problems that commonly lead to operational issues (for instance, an application that does not do log cleanup and therefore may run out of storage). They also ensure that the application comes with appropriate monitoring and resilience mechanisms, and that the application meets SRE approved standards or guidelines set to achieve negotiated SLOs. SRE teams can serve as an operations function and nearly all such teams have a strong emphasis on blameless root-cause analysis. This is to decrease the probability and/or impact of future events and enable organizational learning, continual improvement and reductions in unplanned work.

SRE practices are being adopted by organizations that need to deliver digital business products reliably. These practices require a culture that supports learning and improvement, highly skilled automation practices (and usually DevOps), usage of infrastructure as code capabilities (which usually requires a cloud platform). SRE also uses automation to reduce manual processes, leverages resilient system engineering principles, and an agile development process that employs continuous integration/continuous deployment (CI/CD).

User Advice: Organizations can benefit from SRE principles even if they are not sufficiently mature, agility-focused, or large enough to adopt SRE as a primary operations model. The SRE principles for risk management, release engineering, handling service-level objectives, monitoring, automation, and self-healing can be applied to a broader range of products and platforms. SRE also represents a useful means to scale DevOps initiatives.

An SRE initiative should have an executive sponsor. The first opportunity to begin with should have the following characteristics:

- The target application must change rapidly yet maintain high availability in order to maximize business value. Stakeholders should be politically friendly.
- The pilot must demonstrate sufficient value to improve credibility and support, yet also have an acceptable level of risk, allowing the stakeholders to learn.
- The initial SRE team must have a collaborative engineering mindset, strive to continuously learn and improve, and desire to automate tasks to reduce repetitious manual work, which is known as “toil.” It is often easiest to move DevOps-skilled employees from different parts of the organization, due to the relative difficulty of hiring engineers with SRE experience. A site reliability engineer is typically a software engineer with an excellent understanding of operations, or, less frequently, an infrastructure and operations engineer with strong programming skills.
- There must be clear SLOs that can be continuously monitored and reported against.
- The SRE collaborates with developers to help them learn how to design and build their product to meet the defined SLOs — the SRE is not doing the actual development work or inspecting quality in.
- The application development team must collaborate with the SRE team to meet SLOs. Developers are responsible for a resilient architecture and reliable code. SREs should not spend more than 50% of their time on ad hoc operational activities. Any excess should go to the developers for support.

An iterative approach must be used to start and evolve SRE practices. The teams involved must share experiences and lessons learned.

Business Impact: SRE is primarily useful to fast-moving digital businesses, due to its emphasis on the balance between the ability to change rapidly, and systems stability. The SRE approach to DevOps is intended to produce systems that — despite frequent change, unpredictable customer demand and global scale — are reliable, performant and secure. For such businesses, SRE may be an essential discipline not just for achieving business objectives and maintaining operational stability, but also for controlling costs by avoiding unnecessary manual operations, and freeing up skilled personnel to work on value-added activities.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Recommended Reading: “Top SRE Practices Needed by Teams Scaling DevOps”

“Improve Operational Agility With These Top Five Methods”

“Focus on Your People and Culture to Achieve Resilient Digital Infrastructure Delivery”

Service Mesh

Analysis By: Andrew Lerner; Anne Thomas

Definition: Service mesh is a distributed computing middleware that optimizes communications between application services. It provides proxy and/or lightweight mediation for service-to-service communications, and supports functions such as authentication, authorization, encryption, service discovery, request routing, load balancing, self-healing recovery and service instrumentation.

Position and Adoption Speed Justification: Service mesh technologies are evolving rapidly, and there are multiple options available, including commercial and open-source solutions. The adoption of service mesh technologies is tied to the adoption of microservices and containers. Modern applications are increasingly distributed and containerized, which is driving both interest and the adoption of service mesh technology. We’ve observed adoption primarily in larger-scale and/or technologically forward-leaning organizations or business units.

Client interest in service mesh technology accelerated in early 2017 when Google, IBM and Lyft launched the Istio open-source project to provide a service mesh framework for microservices running in Kubernetes. Istio v1.0 was released in July 2018, and numerous vendors of Kubernetes-based platforms are releasing commercial Istio-based products.

Traditional technologies, including load balancer/ADCs and API gateway technologies, are too heavy for microservice-to-microservice communications (“east-west” traffic), and microservice teams need a lighter-weight solution. Many early adopters of microservices architecture (such as Netflix, Twitter and Lyft) developed their own service meshes. Over the past 18 months, a growing number of vendors have either joined the Istio project or started developing their own service meshes. We estimate that by 2020, all leading container management systems (delivered either as software or as a service) will include service mesh technology, up from less than 10% of generally available offerings today.

User Advice:

- Deliver secure and resilient miniservices and microservices operations by adopting a service mesh.
- Limit code dependence on any particular service mesh technology by favoring approaches that reduce vendor lock-in, such as sidecar proxies (over library-based implementations).

- Reduce cultural issues and turf wars by assigning service mesh ownership to a cross-functional PlatformOps team that solicits input and collaborates with networking, security and development teams.
- Accelerate knowledge transfer and consistent application of security policies by collaborating with I&O and security teams that manage existing application delivery controllers.

Business Impact: The biggest benefit today is that service meshes reduce the burden on developers, which can improve their productivity and help to deliver applications faster. Longer term, this should help businesses guarantee that certain standards/policies are enforced consistently across applications. These benefits are enabled because service meshes provide traffic management, which yields several additional benefits within microservice environments, including availability/resiliency, dynamism/scalability, instrumentation/visibility, and security.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Avi Networks; Buoyant; F5; HashiCorp; Istio; Microsoft; Netflix; Pivotal; VMware

Recommended Reading: “Innovation Insight for Service Mesh”

“How a Service Mesh Fits Into Your API Mediation Strategy”

At the Peak

Repatriation

Analysis By: Ed Anderson

Definition: In the context of cloud computing, repatriation is the return of an application or data that has been migrated to a public cloud back to its original, on-premises environment. Repatriation may occur when an application that has been migrated to a public cloud does not deliver the expected benefits, such as cost savings.

Position and Adoption Speed Justification: Repatriation is a topic that has recently achieved significant hype as more and more traditional workloads have been migrated to a public cloud. When a traditional application is migrated to a cloud environment there are typically specific expectations associated with the migration, such as lower costs, better performance and reliability, enhanced security, innovation and other benefits. When a cloud-hosted application fails to deliver the outcomes following a cloud migration, organizations may look for ways to address the shortcomings, including moving the application back to its original environment.

The concept of repatriation has achieved significant hype as various entities, usually with a bias toward traditional data center environments, promote the notion that public cloud services are failing to deliver on the purported benefits of public cloud. Repatriation hype indicates application workloads which have been moved to a public cloud environment are now moving back to a traditional data center. Repatriation does not include scenarios where an application or data is moved, or returned to another public cloud environment.

Gartner's position is that the concept of repatriation is mostly hype and not reality. Multiple end-user surveys on the topic have indicated that although some repatriation is occurring, the numbers are small. Most organizations when finding they are not getting the full benefits of cloud are taking other measures to remediate the shortcomings, including application modernization, operational optimization and a deeper embrace of cloud through cloud-native models and operations.

Repatriation will likely continue to be an over-hyped topic for the next year or two, but will eventually fade from the industry conversation as organizations address the shortcomings of applications that have migrated to cloud and become smarter about which applications should move to cloud in the first place.

User Advice: When confronted with the topic of repatriation:

- Consider repatriation anecdotes with skepticism, especially when delivered from entities with an interest in preserving traditional data center businesses. While there's a lot of discussion about repatriation, very little is actually occurring.
- Establish a thorough and complete cloud strategy, including a process for assessing the viability of each application migration initiative. Identify the expected benefits of moving an application to the cloud before the migration actually occurs, and then purposefully pursue those benefits. Early planning prevents the eventual need to repatriate an application.
- Employ best practices in tooling and operations to optimize workloads that have already migrated to cloud. Consider cloud-native approaches to get the greatest benefits from public cloud.

Business Impact: Repatriation has the potential to create distraction during a time when thoughtful analysis should be devoted to cloud initiatives. Public cloud environments are not well suited for every application or workload type. Therefore, employ a thorough process of due diligence before moving any workload to the cloud to avoid repatriation in the future.

Benefit Rating: Low

Market Penetration: 20% to 50% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services; Cisco; Dell; Google; Hewlett Packard Enterprise; Lenovo; Microsoft; Oracle

Recommended Reading: "Market Trends: Public Cloud Repatriation Remains the Exception, Not the Rule"

"The Cloud Strategy Cookbook, 2019"

"Three Best Practices to Prepare for Public Cloud IaaS Negotiation and Risk Mitigation"

"Forecast Analysis: IT Spending, Worldwide"

AI PaaS

Analysis By: Bern Elliot

Definition: Cloud artificial intelligence and machine learning platform services are known collectively as AI cloud services. These solutions provide AI model building tools, APIs and associated middleware that enable the building/training, deployment and consumption of machine learning models running on prebuilt infrastructure as cloud services. These cover vision, voice and general data classification and prediction models of any type.

Position and Adoption Speed Justification: Hype around AI cloud services continues to increase, with the leading cloud service providers, including Alibaba, Amazon Web Services (AWS), Baidu, Google, IBM and Microsoft, clamoring to become the platform of choice. Over the past several years, AI applications utilizing cloud services have continued to gain traction and acceptance in the market both by data scientists and developers alike. The promise of using cloud services to more quickly and easily build and deploy AI solutions will push this technology to the Peak of Inflated Expectations. However, this will be followed by some level of disillusionment as organizations experience and understand the limitations of the offerings.

AI cloud service offerings are primarily focused on the three key areas of machine learning, natural-language processing and computer vision. The AI cloud approach is continuing to disrupt the more-established on-premises data science and machine learning platform market, especially as organizations experiment and build AI prototypes. The availability of specialized hardware instances with AI-optimized chips and large amounts of data storage makes the cloud an ideal environment for organizations to build and deploy AI applications without the risks, costs and delays of conventional on-premises procurement. Cloud service providers are also offering packaged APIs and tools that make it easier for developers to integrate AI capabilities into existing applications.

User Advice: IT leaders responsible for AI-enabled applications should take these steps:

- Consider AI cloud services over on-premises options to reduce the overhead of developing and for easier deployment and elastic scalability.
- Improve the chances of success of your AI strategy by experimenting with different AI techniques and AI cloud services providers, using the exact same dataset, and then selecting

one that best addresses your requirements. Consider using an A/B testing approach.

- Increase your organization's AI project success by selecting AI cloud services that addresses your data science, developer and infrastructure requirements and skill limitations. Pretrained AI cloud services often require no (or limited) data science expertise.

Business Impact: AI cloud services offerings are focused on the three key AI services of machine learning (ML), natural-language processing and computer vision:

- Machine learning: Packaged ML services offered by the AI cloud service providers to unify the end-to-end ML workflow. Advanced solutions providing integrated access to all phases of the project — from data preparation to deployment in a managed training and execution environment accessible through APIs. Though many fail to deliver data preparation and augmentation capabilities.
- For technical professional teams with little to no data science expertise, features like automated algorithm selection and training-set creation will offload some of the complexity of the project and leverage existing expertise on operating cloud services.
- Natural-language processing: Organizations can use pretrained NLP systems to create cloud-based language solutions for a variety of use cases. Major AI cloud services vendors provide a language-processing catalog as part of their portfolio. This includes tools for developing and maintaining conversational and chatbot solutions, as would be used by simpler Q&A applications or by more-sophisticated conversational virtual assistants. Additional language services include transcription, translation, speech-to-text, text-to-speech and text analytics.
- Computer vision: This enables organizations to use pretrained visual models for generic images, though not for custom images. This may enable more rapid development of applications that process visual information. Major AI cloud services vendors provide a catalog of services for both images and video. A key capability is support for facial detection, recognition and analysis. Additional visual services include optical character recognition (OCR), handwriting recognition (HWR) label extraction, logo detection, and content moderation. Pretrained systems often require no data science expertise and allow developers to gain unique and new insight by invoking an API.

The combination of the above as cloud services will accelerate digital business technology platform viability in the short term.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Group; Amazon Web Services; Baidu Cloud; Google (Cloud AI); IBM (IBM Cloud); Microsoft (Azure AI Platform)

Recommended Reading: "Market Guide for AI Portfolio Cloud Service Providers"

Edge Computing

Analysis By: Bob Gill; Philip Dawson

Definition: Edge computing describes a distributed computing topology in which information processing is placed close to the things or people that produce and/or consume that information. Drawing from the concepts of mesh networking and distributed data centers, edge computing looks to keep traffic and processing local and off the center of the network. The goals are to reduce latency and unnecessary traffic and establish a hub for interconnection between interested peers and for the data thinning of complex media types or computational loads.

Position and Adoption Speed Justification: Most of the technology for creating the physical infrastructure of edge data centers is readily available. However, widespread application of the topology and explicit application and networking architectures are not yet common outside of vertical applications, such as retail and manufacturing. As IoT demand and use cases proliferate, the acceptance of edge computing as the topological design pattern (namely, the "where" a "thing" is placed in an overall architecture) has dramatically increased interest in edge technologies and architectures. However, the still-nascent state of non-IoT edge applications has prevented more rapid movement along the Hype Cycle since 2018.

User Advice:

- We urge enterprises to begin considering edge design patterns in their medium- to longer-term infrastructure architectures.
- Immediate actions might include simple trials using colocation and edge-specific networking capabilities, or simply placing remote location or branch office compute functions in a standardized enclosure (for example, "data center in a box").
- Some applications, such as client-facing web properties and branch office solutions, will be simpler to integrate and deploy, while data thinning and cloud interconnection will take more planning and experimentation to get right.
- We are beginning to see viable offerings from hyperscale cloud providers in extending their programming models and management systems to on-premises and edge-located devices, complementing their mostly centralized computing model with a distributed analog.
- For distributed applications requiring a consistent, global infrastructure, with less emphasis on IoT or unique physical endpoints, consider an edge infrastructure as a service provider, such as Cloudflare or NetActuate.

- Enterprises must also become familiar with an emerging application model, in which edge gateways and hubs serve as the linchpins for deploying heterogeneous, multicloud and multiendpoint applications. These are often based on open-source frameworks and technologies, such as containers and orchestration systems like Kubernetes.

Business Impact: Edge computing solves many pressing issues, such as unacceptable latency and bandwidth limitations, given a massive increase in edge-located data. The edge computing topology will enable the specifics of IoT, digital business and IT solutions well into the very near future.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

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

Recommended Reading: "The Edge Completes the Cloud"

"Top 10 Strategic Technology Trends for 2019: The Empowered Edge"

"The Future Shape of Edge Computing: Five Imperatives"

"How Edge Computing Redefines Infrastructure"

Serverless PaaS

Analysis By: Yefim Natis; Anne Thomas; Yefim Natis; Anne Thomas

Definition: A PaaS offering delivered with serverless characteristics is serverless PaaS. Serverless is a way of delivering an IT service where the underlying resources are opaque, require no preprovisioning, and are micropriced. Serverless is always a characteristic of a cloud service (public or private), it cannot be a software offering. Function PaaS (fPaaS) is the most notable example of a serverless PaaS, though databases, API management and multiple other services are also delivered serverless.

Position and Adoption Speed Justification: Serverless delivery of IT services has gained broad notice after Amazon popularized its AWS Lambda function platform as a service (fPaaS, also known as FaaS). Although some associate the notion of serverless exclusively with fPaaS, the significance of serverless, as delivered by the leading vendors (including Amazon, Google and Microsoft), extends well beyond functions. All PaaS capabilities can be delivered with serverless characteristics and many are already (for example Google App Engine or AWS DynamoDB). Majority of PaaS offerings are opaque and thus deliver some of the serverless experience. Fewer are also provisionless and micropriced to meet the full definition of a serverless PaaS.

Serverless effect can only be delivered by a cloud service that conceals and manages underlying server and container operations. It can be achieved on-premises, but it requires that a true private cloud is first established — a difficult proposition for most mainstream organizations. Deploying one of the open-source serverless frameworks, like Pivotal Function Service or Apache OpenWhisk in a private cloud context will deliver the serverless experience locally, to the subscribing part of the organization.

As the full scope of serverless delivery of fPaaS capabilities rolls out, the definition will likely be refined — relaxed in some aspects and possibly further constrained in others. For example, future fPaaS will support optional preprovisioning and autoscaling, offering lower costs to the applications with steady and predictable demand for resources (Azure Functions support it already); support for stateful operation will likely also be adopted (the serverless dbPaaS, like Amazon DynamoDB, of course, are stateful already). The current market dynamic already reflects these trends. Adoption of fPaaS is rapidly increasing with new offerings emerging or anticipated from vendors like Oracle, Red Hat and Pivotal.

The principles of serverless are also increasingly applied beyond just the fPaaS — other cloud services from various providers are delivered serverless, including databases (Cosmos DB FaunaDB, Amazon DynamoDB), API managers (Amazon API Gateway and Azure API Management), message and event brokers (Google Cloud Pub/Sub, Azure Event Grid) and other specialized xPaaS. fPaaS operational experience will become the foundation for the more general serverless PaaS. As fPaaS evolves beyond hype — through the inevitable disappointments and toward the Plateau of Productivity — serverless PaaS will follow, building on the fPaaS lessons learned, but also creating its own hype and disappointments before maturity. The market interest in “serverless” beyond just the fPaaS is bound to continue to increase, as fPaaS matures and its benefits become increasingly attractive.

User Advice: Application leaders, CIOs, CTOs, IT leaders and planners should:

- Use fPaaS offerings as representative of serverless PaaS to build in-house understanding of the trade-offs of the new platform delivery model, but with clear understanding that some of the constraints on design of functions (such as the event-driven model or duration of execution) are not attributes of the general serverless model. fPaaS is a special purpose example, but not the definition of serverless.

- When selecting platforms for cloud-native initiatives, look for platform services that closely approximate or match the serverless delivery model to achieve improved productivity, cost-efficiency and consistency of outcomes, but ensure that the cost implications and design constraints are not a counter-indication.

- Evaluate your consumption model against the serverless pricing model — although micropriced, it can still be an expensive proposition, depending on the use pattern.

- Avoid the serverless model if the project requires advanced and direct forms of control over application infrastructure operations, or where cost estimates are excessive.

- Make the cloud platform selections with an effort to minimize vendor or service lock-in; increase investment in integration technology and practices — because ongoing innovations, including the increasing adoption of serverless delivery model, will continue to compel you to consider alternative options in platforms and vendors.

Business Impact: Serverless PaaS represents the true cloud-style operations for cloud platform services. Adoption of a serverless PaaS delivery model will increase productivity and efficiency of PaaS, and help to streamline development, scale operations and reduce infrastructure costs. It will create a more consistent and manageable environment for cloud applications, but the improvements will require adjustments in the practices and strategies of planning, designing and operating the PaaS-based solutions. The adjustments, in turn, will render some current cloud applications new legacy and will require some new training and tooling. Ultimately, the business experience of the "serverless IT" will feature increased scalability, reduced costs and faster times to market for IT-supported business initiatives.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services; Google; IBM; Microsoft; Oracle

Recommended Reading: "The Key Trends in PaaS and Platform Architecture, 2019"

"Leverage Serverless Functions With Event-Driven Architecture to Create New Business Value"

"Innovation Insight for Serverless PaaS"

"Adding Serverless Computing and fPaaS to Your Cloud-Native Architecture Toolbox"

"Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2019"

Container Management

Analysis By: Dennis Smith

Definition: Container management software supports the management of containers at scale in production environments. This category of software includes container runtimes, container orchestration, job scheduling, resource management and other container management capabilities. Container management software brokers the communication between continuous integration/continuous deployment (CI/CD) pipeline and the infrastructure via APIs and aids in the life cycle management of containers.

Position and Adoption Speed Justification: Interest in containers is rising sharply due to the growing adoption of container runtimes, which have introduced common container packaging formats that are more easily consumable by, and useful to, application developers and those with a DevOps approach to IT operations. Container runtimes, frameworks and other

management software have increased the utility of containers by providing capabilities, such as, packaging, placement and deployment, and fault tolerance (e.g., cluster of nodes running the application). Container management software integrates these various elements to simplify deploying containers at scale. Many vendors enable the management capabilities across hybrid cloud or multicloud environments by providing an abstraction layer across on-premises and public clouds. Container management software can run on-premises, in public infrastructure as a service (IaaS) or simultaneously in both for that purpose.

Most common use of container is focused specifically on Linux environments, and management software follows accordingly. Windows containers still significantly lag Linux containers in every respect.

Among the functionalities that container management systems provide are orchestration and scheduling; monitoring and logging; security and governance; registry management; and links to CI/CD processes. Among the vendor offerings are hybrid container management software, public cloud infrastructure as a service (IaaS) solutions specifically designed to run containers, and PaaS frameworks that have incorporated integration with container management software. All major public cloud service providers are also looking to deploy on-premises container solutions.

There is a high degree of interest in, and awareness of, containers within global organizations though a lesser percentage of them have deployed container management software (less than 20%). Additionally, there is significant grassroots adoption from individual developers where containers will be used with increasing frequency in development and testing — particularly for Linux. Container management software has progressed from an early-adopter technology to adolescent where it will remain over the next year or two.

User Advice: Organizations should begin exploring container technology as a means for packaging and deploying Linux applications and their runtime environments. Depending on the environment, container management tools are often deployed complementarily with continuous configuration management tools. As container integration is added to existing DevOps tools and to the service offerings of cloud IaaS and PaaS providers, DevOps-oriented organizations should experiment with altering their processes and workflows to incorporate containers. An organization may be a good candidate for exploring a cloud-native container management tool in conjunction with OS containers (as an alternative to hypervisor-based cloud management platforms), if it meets the following criteria:

- It's DevOps-oriented or aspires to become DevOps-oriented
- It 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.
- It intends to use an API to automate deployment, rather than obtaining infrastructure through a self-service portal

Business Impact: Container runtimes make it easier to take advantage of container functionality, including providing integration with DevOps tooling and workflows. Containers provide productivity and/or agility benefits, including the ability to accelerate and simplify the application life cycle, enabling workload portability between different environments and improving resource utilization efficiency and more. Container management software simplifies the art of achieving scalability, production readiness and optimizing the environment to meet business SLAs.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

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

Recommended Reading: "Best Practices for Running Containers and Kubernetes in Production"

"Market Guide for Container Management Software"

"Market Guide for Public Cloud Container Services"

Multicloud

Analysis By: David Smith

Definition: Multicloud computing refers to the deliberate use of cloud services from multiple public cloud providers.

Position and Adoption Speed Justification: Multicloud computing is a deliberate strategy for an organization's use of multiple cloud services from different providers. An example of this is when multiple cloud providers are used as part of a high availability, redundancy or exit strategy in a planned manner. Multicloud is much more common in IaaS (and converged IaaS/PaaS) scenarios than SaaS. While it is possible for multi-SaaS environments in an organization, these would typically be stovepiped types of situations. Multicloud can mean very common situations such as using Amazon Web Services (AWS) for IaaS and Microsoft Office 365 for cloud office SaaS, but these are for very different purposes and not the sweet spot of multicloud.

Multicloud computing has potential to provide advantages of lowering the risk of cloud provider lock-in, can specify functional requirements that a business unit may have and can provide service resiliency and migration opportunities, in addition to the core cloud benefits of agility, scalability and elasticity.

As with many cloud-related concepts, there are many variations in real-world use and scope. In this case, they align with maturity. Many enterprises start with one provider and, as they use that solution, they become concerned about lock-in. So the first use of a multicloud strategy is often procurement-based to encourage competition. Then as multicloud providers are in use,

the need to manage and govern those services becomes important. And, eventually, some enterprises get to multicloud architectures, which rely on architectural principles and portability solutions and potentially even cloudbursting and other dynamic placement efforts.

User Advice: When using multiple cloud computing services, establish security, management, governance guidelines and standards to manage cloud service sprawl and increasing cost, and develop decision criteria to decide placement of services. Multicloud implementations will need coordination and strategy across the enterprise to identify the types of services needed and deliver the benefits of a cloud environment. IT organizations will also need training and skilled engineers, and need to be prepared for the additional expense. Use of a cloud management platform (CMP) and/or a cloud service brokerage (CSB) in a multicloud environment can enable organizations to implement governance and optimizations, but care must be taken to not just shift vendor lock-in to a CMP or CSB vendor.

Business Impact: Multicloud provides an organization with agility and the potential of some target cost optimization opportunities. It also can provide a basis to lower cloud provider lock-in and increase workload migration opportunities.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Amazon; Google; IBM; Microsoft; Oracle

Recommended Reading: “The Cloud Strategy Cookbook, 2019”

“A Guidance Framework for Architecting Portable Cloud and Multicloud Applications”

“Hybrid Architectures for Cloud Computing”

Cloud Managed Services

Analysis By: Craig Lowery; Ed Anderson

Definition: Cloud managed services are IT service offerings that provide for the day-to-day management of, and operational responsibility for, cloud service environments. Cloud managed services generally include day-to-day monitoring and management of cloud service environments, including configuration management, performance management, cost optimization, security and compliance monitoring, capacity management, financial management, and governance. Cloud service brokerage is often delivered as a cloud managed service.

Position and Adoption Speed Justification: Cloud managed services can meet many of the needs of organizations today. However, providers have varying levels of capability based on the specific technologies and personnel roles they use to deliver their services. Use of automation in delivery of cloud managed services is a significant differentiator. Like end-user organizations,

providers are faced with the challenges of sourcing tools and developing a skilled workforce to meet the demands of a growing, volatile market. Cloud service providers also typically provide consultative and implementation (professional) services, again, with varying degrees of capability across providers.

Demand for cloud managed services will continue to increase as organizations move from simple to more-complex cloud use cases, often involving hybrid cloud solutions. Strong cloud managed service providers will demonstrate cloud capabilities aligned with hyperscale IaaS+PaaS providers and will embrace new technology innovations such as artificial intelligence, automation, data services, IoT and edge computing.

User Advice: Organizations considering cloud managed service offerings must carefully assess providers to ensure the provider has sufficient current expertise and a track record of success. Providers typically offer cloud-related IT service offerings across the adoption spectrum from advisory services (design), implementation services (build) and managed services (run). Look for providers with capabilities across this continuum and a defined product roadmap. These attributes are present in the providers that are most likely to have a full understanding of cloud-specific requirements and, therefore, the most complete cloud professional and managed service capabilities.

Other factors to consider:

- Demonstrable partnerships with leading cloud providers, including partner status in cloud provider partner programs
- Proven expertise and commitment to long-term support of your strategic cloud provider(s)
- Certifications held by individual engineers, operators and deployment managers
- Customer use cases demonstrating successful delivery of managed service offerings
- Expertise in the industry, region and country associated with the target environment
- Demonstration of innovation in delivering new capabilities beyond cloud
- Integration of noncloud capabilities (such as on-premises infrastructure management) in an end-to-end visibility and management scheme
- Investment in cloud and digital technologies consistent with market trends, such as multicloud management and hybrid cloud computing

Selecting a cloud managed service provider may create a dependency on the provider that can be difficult to sever in the event the provider cannot successfully deliver the offering. Perform a careful and thorough inspection of the services prior to making long-term commitments.

Business Impact: Cloud managed services can fill a critical function in managing and operating a cloud service environment. When coupled with innovation, cloud managed services can help

an organization exploit the full capabilities of the cloud for near- and long-term benefits. Most organizations will engage cloud managed services to assist with the immediate challenges of running a complex cloud environment, usually after assisting with a mass migration from an on-premises facility. In this case, the organization will recognize only moderate benefits. However, when organizations work with their providers to unlock the uniquely disruptive potential possibilities of cloud and engage in more innovative, digital processes, the outcomes can be transformative and return greater value for the organization on its cloud computing investment.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: 2nd Watch; Accenture; Cloudreach; Deloitte; DXC Technology; Infosys; Logicworks; Rackspace; Smartronix

Recommended Reading: "Magic Quadrant for Public Cloud Infrastructure Professional and Managed Services, Worldwide"

"Critical Capabilities for Public Cloud Infrastructure Professional and Managed Services, Worldwide"

"Toolkit: RFI for Public Cloud Infrastructure Managed Service Providers"

Sliding Into the Trough

IoT Platform

Analysis By: Alfonso Velosa; Eric Goodness; Peter Havart-Simkin

Definition: An Internet of Things (IoT) platform is a software that enables development, deployment and management of solutions that connect to and capture data from IoT endpoints to drive improved business decisions. Functional capabilities include:

- Device management
- Integration
- Data management
- Analytics
- Application enablement
- Security

It may be delivered as a hybrid combination of edge software platform and/or cloud IoT platform as a service.

Position and Adoption Speed Justification: Enterprises continue adding IoT capabilities to things, seeking benefits such as asset optimization, better interactions with customers, and new opportunities such as product as a service. The sophistication, scale and business value of these interactions call for specialized technology resources, resulting in the IoT platform. The IoT platform may be deployed in a hybrid cloud or edge fashion to meet technical or business objectives. The edge software is further distributed between the endpoints and gateways.

Continued vendor hype, culture, schedule, security, integration and other challenges for IoT projects, moved IoT platforms significantly past the Peak. 2019 sees many large vendors reorganizing their IoT businesses and evolving their strategy. A further vendor selection complication are embedded solutions by OEMs not sold on a stand-alone basis. These issues also lead us to maintain the time to plateau at five to 10 years. Note that the speed of adoption will vary across the consumer, commercial and industrial verticals.

User Advice: CIOs should factor in the following for their IoT platform strategy:

- Strategy: The strategy will vary depending if the business focus is external for an OEM's connected product or internal for an owner/operator of assets. Identify the range of IoT projects for your enterprise, and segment them by their focus, complexity and business objectives. This will help you establish a flexible, multivendor architecture. Start with smaller initiatives to build momentum, test business hypothesis and acquire implementation lessons, while limiting enterprise and career risk.
- Skills: IoT projects will require new capabilities for your organization. Build an IoT capabilities gap analysis, a skills migration plan, and training program for your developers and business analysts. In parallel, perform an assessment of IoT skills within the business units. Plan to leverage a service partner to ramp up as you train internal resources.
- Platform customization: Understand that an IoT platform is a starting point. No IoT platform will work straight out of the "box." Customize the platform to build a solution (for example, third-party integration, security, device support, and/or optimized analytics).
- Vendor selection: Evaluate candidate IoT platforms in terms of their fit-to-your-business objectives and technology, but expect roadmaps to continue to evolve quickly in the fast-changing IoT market. Key criteria center on the vendor's ability to scale from proofs of concept to operational-scale deployments, vertical market expertise, partner ecosystem, and references that show business results.

Business Impact: There is a significant opportunity from IoT-enabled assets and business processes to achieve greater value. This includes making better decisions from the insights, information and data that are generated by instrumented products, people and equipment. This improves decision making and provides better control of things distributed across the enterprise and its external stakeholders. Unfortunately, this data has been largely locked in the assets — mostly due to lack of connectivity, but also because of lack of systems and governance processes to obtain and share this data systematically.

IoT platforms act as the intermediary between the “thing” and the business processes and applications. Therefore, they facilitate the introduction of a new potentially transformative wave of digital business innovation and digital transformation to enterprises. IoT platforms provide the middleware foundation to implement asset-centered business solutions — and are part of a broader technology processes to manage multiple IoT applications in an agile/flexible fashion.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Amazon Web Services (AWS); Ayla Networks; GE Digital; Hitachi Vantara; Huawei; IDbox; Microsoft Azure; Particle; Siemens; Software AG

Recommended Reading: “Magic Quadrant for Industrial IoT Platforms”

“Critical Capabilities for Industrial IoT Platforms”

“Use the IoT Platform Solution Reference Model to Help Design Your End-to-End IoT Business Solutions”

Hybrid IT

Analysis By: Thomas Bittman

Definition: Hybrid IT is the operational model for IT organizations that are trusted brokers for a broad range of services from external cloud providers and from their own enterprises. The model uses cloud computing (private, public and hybrid), traditional computing, cloud-inspired, and/or edge computing. Hybrid IT is an organizing principle for how IT departments provide IT services and add value to IT services provided by others. A hybrid IT organization manages multiple sourcing models that can change dynamically.

Position and Adoption Speed Justification: As use of cloud computing services has matured, enterprises are looking for ways to use a variety of cloud services efficiently and effectively. Inquiries from Gartner clients on effective governance of cloud services continue to increase. Technologies to enable the cloud and multicloud management are continuing to improve, but the market is still evolving. In addition, edge computing promises to add additional choices and management requirements that need to be included.

The cloud providers have little interest in making cross-service migrations or integration easy, which increases the demand for an intermediary role. As multicloud use grows, and as the edge computing trend matures, there will be a growing need for cross-service management, integration and aggregation of cloud, edge and traditional IT services. Appropriate compliance and security measures will need to be put in place. The fundamental role of the IT organization and its associated skills will need to change. In other words, there will need to be a shift from “just” a provider role to the role of provider and broker of IT services.

User Advice: Unlike hybrid cloud, which is a complex composition of multiple cloud services into one, hybrid IT adds value across multiple disparate services from different providers, as well as internal technology solutions. Hybrid IT will be very common, because most enterprises will leverage different services from multiple providers.

A successful hybrid IT effort requires the IT organization to focus on three approaches to being a broker for services:

- Accelerating time to value — Getting to the right solution quickly.
- Adding value — Customizing as needed, reducing overhead costs and effort, and managing service levels, financials, problem management
- Protecting the enterprise — In terms of security, compliance and providers that fail

Actions that help create a hybrid IT organization include:

- Creating a core competency center on provider capabilities, best practices and internal user feedback
- Offering services through a central portal that provides a fast path to services and necessary service information, including single sign-on and consolidated billing and chargeback
- Removing and reducing overhead efforts, such as managing financials, dealing with problem management and managing the overall provider relationship
- Integrating applications and data across cloud and noncloud environments

These actions will require the development of new skills and organizational structures in IT that focus on service orchestration, provider capabilities and best practices.

Business Impact: Hybrid IT can help the enterprise leverage cloud computing services faster, appropriately, more efficiently, and with managed and acceptable risk. As cloud computing use expands, the requirements for security management, cross-service coordination, data sharing, service-level management and migration paths will grow to where enterprises without hybrid IT will have serious competitive issues. These issues will include leveraging cloud providers quickly and effectively, redundant overhead costs placed on end users, inefficient use of cloud services, and cloud provider failures that directly affect the business. Some enterprises — especially smaller ones — will fill this intermediary role by outsourcing to external providers, boutique cloud integration firms and cloud system integrators (i.e., cloud service brokerages). Larger enterprises should consider this broker role as a critical core competency that enables the efficient use of IT services and drives significant top-line growth through the more-competitive use of cloud services. Organizations that do hybrid IT well will adopt new services and sourcing models faster (e.g., edge computing).

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Accenture; DXC Technology; Hewlett Packard Enterprise; IBM; VMware

Recommended Reading: "2019 Strategic Roadmap for Compute Infrastructure"

"Hype Cycle for Hybrid Infrastructure Services, 2018"

"The Future of Enterprise Data Centers — What's Next"

"2019 Planning Guide for Cloud Computing"

Hybrid Cloud Computing

Analysis By: Milind Govekar; David Smith

Definition: Hybrid cloud computing comprises public and private cloud services that operate as separate entities but are integrated. A hybrid cloud computing service is automated, scalable and, elastic. It has self-service interfaces and is delivered as a shared service using internet technologies. Hybrid cloud computing needs integration between the internal and external environments at the data, process, management or security layers.

Position and Adoption Speed Justification: 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. As a result, virtually all enterprises have a desire to augment internal IT systems with external cloud services. 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).

Hybrid cloud computing is different from multicloud computing, which is the deliberate use of cloud services from multiple public cloud providers.

A hybrid cloud computing architecture complements multicloud computing. Although most organizations are integrating applications and services across service boundaries, we estimate approximately 15% of large enterprises have implemented hybrid cloud computing beyond this basic approach — and for relatively few services. This decreases to fewer than 10% for midsize enterprises, which mostly are implementing the availability/disaster recovery use case. Most companies will use some form of hybrid cloud computing during the next two years, but more advanced approaches lack maturity and suffer from significant setup and operational complexity. Positioning on the Hype Cycle advances toward the Trough of Disillusionment as organizations continue to gain experience in designing cloud-native and optimized services, and seek to optimize their spending across on-premises and off-premises cloud services. However, this is different from hybrid IT, which is where IT organizations act as service brokers as part of a broader IT strategy and may use hybrid cloud computing. Hybrid IT services are professional

services that provide cloud service brokerage, multisourcing, service integration and management capabilities to customers building and managing an integrated hybrid IT operating model. These services are provided by vendors (such as Accenture, Wipro, Tata Consultancy Services) and other service providers and system integrators.

Microsoft's Azure Stack, Google's Anthos, VMware's Hybrid Cloud Portfolio and AWS's Direct Connect and VPC are all attempts to support hybrid cloud implementations. Red Hat's OpenShift and Pivotal's Cloud Foundry are attempts to support hybrid PaaS implementations.

User Advice: When using hybrid cloud computing services, establish security, management, and governance guidelines and standards to coordinate the use of these services with public and private 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. Coordinate hybrid cloud services with noncloud applications and infrastructure to support a hybrid IT model. Consider cloud management platforms, which implement and enforce policies related to cloud services. If your organization is implementing hybrid IT, then consider using hybrid cloud computing as the foundation for implementing a multicloud broker role and leveraging hybrid IT services and service providers to complement your own capabilities.

Business Impact: Hybrid cloud computing enables an enterprise to scale beyond its data centers to take advantage of the elasticity of the public cloud. Therefore, it is transformational when implemented because changing business requirements drive the optimum use of private and/or public cloud resources. This ideal approach offers the best possible economic model and maximum agility. It also sets the stage for new ways for enterprises to work with suppliers and partners (B2B), and customers (B2C) because these constituencies also move toward a hybrid cloud computing model.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; Amazon Web Services (AWS); Google; Hewlett Packard Enterprise (HPE); IBM; Microsoft; Oracle; Rackspace; Red Hat; VMware

Recommended Reading: "The State of Hybrid Cloud"

"Market Guide for Managed Hybrid Cloud Hosting, North America"

"Prepare for AWS Outposts to Disrupt Your Hybrid Cloud Strategy"

"Utilizing Hybrid Architectures for Cloud Computing"

“Solution Path for Developing Enterprise Hybrid Cloud Strategies”

“I&O Leaders Must Plan for Hybrid Cloud Orchestration”

“Market Guide for Cloud Management Platforms”

“Cloud Adoption Is Driving Hybrid WAN Architectures”

Cloudbursting

Analysis By: Ed Anderson

Definition: Cloudbursting is the use of an alternative set of public or private cloud-based services as a way to augment and handle peaks in IT system requirements at startup or during runtime. Cloudbursting can span between on-premises IT systems and services and the cloud, across multiple cloud providers or across multiple resource pools of a single provider.

Position and Adoption Speed Justification: Cloudbursting has been a topic of interest closely associated with cloud computing in general. Historically difficult to implement, cloudbursting is seeing a resurgence as applications move to container-based and microservices models and as organizations pursue hybrid and multicloud strategies. Cloudbursting can be implemented as a type of autoscaling, implemented across service environments. Although cloudbursting includes any scenario where cloud services are utilized in an on-demand fashion when additional capacity is required, cloudbursting could also include scenarios where less critical resources are moved to a cloud service in order to free up internal capacity for critical on-premises workloads.

Cloudbursting has historically been a manually initiated process, however with the development of more sophisticated cloud management and orchestration tools, cloudbursting is likely to become automated through the use of triggers and service governor technology for the following roles:

- A provisioning time placement role
- A runtime movement role
- A runtime expansion role

The provisioning time placement role is the easiest to implement and requires the least governance insight because services are placed based on available capacity and policy. The runtime movement role is harder, may require some downtime and will be less common because moving services between cloud environments and across different providers can be complex. The runtime expansion role requires applications to be specifically written or adapted to cloudbursting, such as scale-out web architectures or batch-computing jobs that can disperse the work in parallel across distributed data centers. If a microservices application architecture is established on the target system, runtime expansion is much easier. Most applications have storage and database architectures that cannot be easily adapted to

geographically dispersed data centers. Likewise, networking challenges, including latency, can make cloudbursting unfeasible.

Barriers to cloudbursting usage include the lack of cross-cloud provider API standards, inadequacy of application instrumentation, root cause analysis and management tools, latency between data centers, security and networking configuration and automation, and incompatible application architectures. Standardization of application models using technologies like containers can mitigate some of these cross-cloud challenges. While penetration in large organizations is 5% to 20%, the number of services that make use of actual cloudbursting is small and is focused on the more stateless web or application tiers, and less so on the more complex and often stateful data tier.

The rising interest in multicloud architectures has elevated interest in cloudbursting as a means to leverage cloud capacity and capabilities across cloud environments. Although interest in multicloud environments is growing, the challenges of implementing cloudbursting remain for most applications, particularly applications built using traditional application architecture and operating models.

User Advice: Cloudbursting is often cited as one of the primary use cases for hybrid cloud or multicloud environments. In practice, cloudbursting remains an aspirational notion for most organizations because of the difficulties in implementing cloudbursting. When considering the use of cloudbursting, it is prudent to take a pragmatic approach, recognizing the challenges associated with an operating environment that assumes cloudbursting capabilities. Select workloads and applications that are conducive to scale-out execution using parallel and distributed processing models.

- Do not assume that cloudbursting will become a broadly viable approach for cross-cloud workload portability and expansion, even when hyped technologies such as “containers” and multicloud management solutions are used.
- Determine which applications will get real value from cloudbursting and whether these applications meet the technical criteria and constraints for implementation.
- Develop a cloudbursting model before bursting applications and data to cloud. When feasible, move the entire workload, and its related data, when cloudbursting is performed.
- Account for the development and integration skills to enable cloudbursting. Use automation where possible.
- Implement robust network connectivity and reliable transport between cloud service environments where cloudbursting is expected to occur.
- Carefully evaluate the financial implications of the dynamic movement of workloads; there may be significant costs associated with storage and networking as well as usage fees related to the cloud resources utilized when cloudbursting occurs.

- Consider cloudbursting for applications that experience demand peaks on a seasonal basis.

Business Impact: Cloudbursting has the potential to reduce the overall cost of running cloud services by dynamically provisioning capacity on-demand using hybrid and multicloud resources. This is particularly true for workloads with variable resource demands. It enables the use of cloud services to address capacity overflow for on-premises and cloud-based workloads.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Amazon Web Services; Dell; Flexera (RightScale); Google; Hewlett Packard Enterprise; IBM; Microsoft; OpenStack; VMware

Recommended Reading: "Cloud Computing Primer for 2019"

"2019 Planning Guide for Cloud Computing"

"Orchestrating Container-Based Cloud and Microservice Applications"

"Comparing Approaches for Container Orchestration Across Hybrid and Multicloud Environments"

Climbing the Slope

Private Cloud Computing

Analysis By: Thomas Bittman

Definition: Private cloud computing is a form of cloud computing used by only one organization, or one that ensures an organization is completely isolated from others. As a form of cloud computing, it has full self-service, full automation behind self-service and usage metering. It does not have to be on-premises or owned or managed by the enterprise.

Position and Adoption Speed Justification: Private and public cloud computing are at opposite ends of the "isolation" spectrum. As public cloud providers have offered virtual private cloud, dedicated instances, and dedicated hosts, the gap between private and public has become a spectrum of isolation choices.

Organizations that build a private cloud service are emulating public cloud computing providers to acquire similar benefits — mainly agility, mainly for new cloud-native applications, mainly for business value and growth. This can be for infrastructure as a service (virtual machines or containers), platform as a service, or, in some situations, software as a service.

Due to cost and complexity, most successful private clouds are built and delivered by third parties.

This term is also used to describe a very different trend, where traditional infrastructures are being modernized with virtualization, some automation and some self-service. In this manner, they are leveraging only some valuable attributes of cloud computing, but are applying them to existing applications with traditional infrastructure requirements. However, because these are different trends, Gartner does not include this form of modernization in our definition of private cloud. But when the goal is IT efficiency or modernization for existing applications, these "just enough cloud" architectures can be beneficial.

User Advice:

- Evaluate third-party options first. These include hosted private cloud, managed services, virtual private cloud alternatives or public cloud.
- Choose your private cloud strategy based on the necessary return on investment or business goals. If business growth or business value for new applications is the goal, consider a true cloud architecture. If IT efficiency or IT modernization for existing applications is the goal, choose cloud-inspired technologies and methods to implement. Just-enough cloud is often enough.
- Focus on business and application needs first; don't start with the technology. One technology architecture and operational model cannot support all of the application needs of a typical enterprise. Either build multiple architectures and operational models, or leverage third parties.
- Focus on services that fit the cloud model: standard, high volume and self-service; those that require agility and horizontal scalability; and usages that might be short-lived.
- Consider the long-term roadmap for your private cloud services. Build with the potential to integrate, interoperate or migrate to public cloud alternatives at the appropriate time.
- Manage the scope of work — start small and expand based on the business case.
- Build expertise in managing multiple architectural and operational models, and multicloud — this is more valuable to an enterprise than expertise in building a single cloud architecture.

Business Impact: Cloud computing enables agility that an enterprise can use to react quickly to business requirements in functionality or scale. Due to economies of scale, cloud computing can also improve efficiency and lower costs. However, because leveraging a true cloud computing architecture requires applications and operational models designed for cloud computing, the cost of transformation for existing applications does not always justify the investment.

True private cloud computing is used when enterprises aren't able to find cloud services that meet their needs in terms of regulatory requirements, functionality or intellectual property protection. True private cloud computing is almost always purpose-built for a specific set of new applications, and its success can be measured in revenue or market share.

When the primary goal of a private cloud is IT efficiency, businesses can reduce costs and improve overall operational efficiency for their existing application portfolios by leveraging cloud technologies where appropriate. They can then add manual or custom intervention, or customized changes as needed to support those applications.

However, enterprises need to recognize that these are two different goals with different architectures, and trying to do them in a single architecture usually achieves none of the goals well. Being bimodal based on business and application needs makes the most business sense.

Benefit Rating: Moderate

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Sample Vendors: Hewlett Packard Enterprise; IBM; Microsoft; Pivotal; Red Hat; VMware

Recommended Reading: "Rethink Your Internal Private Cloud"

"Building 'Just Enough' Private Cloud With Virtualization Automation"

Cloud Access Security Brokers

Analysis By: Steve Riley

Definition: Cloud access security brokers (CASBs) provide crucial cloud governance controls for visibility, data security, threat protection, and compliance assessment in SaaS, PaaS, and IaaS. CASBs consolidate multiple types of security policy enforcement into one place. Examples of security policies include authentication, single sign-on, authorization, credential mapping, device profiling, data security, logging, alerting, and malware detection/prevention. Most CASB deployments are cloud-based; on-premises deployments are rare.

Position and Adoption Speed Justification: Vendors offer feature-rich products to increase cloud visibility, apply consistent policy across multiple providers and offer mechanisms for organizations to demonstrate that they are governing cloud use. Incumbent security vendors have acquired many of the early CASBs. Their execution has varied in product development and integration: while some have incrementally improved and added new capabilities, others have made significant investments that have contributed to the maturity of the market. While the number of independent vendors has stabilized, the most relevant independent vendors demonstrate sustained innovation and broad market reach. Differentiation among vendors is becoming difficult, and several have branched beyond SaaS governance and protection to include custom application support in IaaS clouds and cloud security posture management (CSPM) features. It's uncertain how much longer investors will fund the few remaining private vendors. The pace of client inquiry indicates that CASB is a popular choice for cloud-using organizations. Gartner's 4Q18 security forecast predicts a 46% growth rate for CASB through 2022, higher than any other information security market (see "Forecast Analysis: Information Security and Risk Management, Worldwide, 4Q18 Update").

User Advice: When evaluating CASB vendors, examine capabilities in four functionality pillars: discovery, data protection, threat detection and compliance. Some CASBs interact with cloud services only via APIs, while others use APIs plus a forward and/or reverse proxy. The combination offers a greater choice of deployment options and more visibility methods. A few vendors augment or replace their reverse proxy with browser isolation, which relocates all content inspection, policy application, and page rendering to the vendor's cloud. This is a far more secure and controllable environment than an end user's browser itself. CASB proxy implementations may or may not require endpoint agents for traffic steering outside proxied networks; factor this into your evaluation. Common deployment scenarios that deserve special scrutiny are discovery and risk assessment, DLP, adaptive access control (AAC), user and entity behavior analysis (UEBA), cloud-to-cloud traffic, and regulatory compliance:

- For discovery and risk assessment, evaluate the thoroughness of the CASB' s analysis of an organization's cloud security posture. The CASB should discover every cloud service in use and assign each one a risk score, gleaned from attributes whose weights can be modified by customers. Evaluate the CASB's CSPM capabilities for assessing risk in IaaS storage, compute, and virtual network configurations.

- For DLP, evaluate whether CASB capabilities are sufficient or require augmentation with deployed enterprise DLP product, either via ICAP or RESTful API integration. In-line CASB DLP capabilities should provide a mechanism to control the movement of sensitive information into and out of cloud services in real-time. Examine CASB support for data classification features that can link to existing enterprise DLP policies.

- For AAC, examine techniques vendors provide for altering the behavior of governed applications based on signals observed during and after login. AAC allows for shades of access (e.g., read-only access to content on unmanaged devices) that are more useful to the business than blocking access completely.

- For UEBA, evaluate how CASBs detect and isolate risky users and devices. Insider threats and compromised accounts are common attack vectors. Seek mechanisms that build baseline behavior profiles (such as typical upload/download amounts and user locations) and alert and mitigate when behavior deviates from baselines. Step-up authentication is an important capability to test with whatever IAM or IDaaS vendor is already deployed.

- For cloud-to-cloud traffic, ensure that the CASB applies policies to actions that occur as a result of one application interacting with another when no users are involved. This requires well-developed API support in the CASB, because cloud-to-cloud traffic won't pass through a CASB proxy.

- For regulatory compliance, determine whether the CASB offers sufficient visibility and control for aspects such as user privacy and data residency. Carefully scrutinize encryption mechanisms. Encrypting data before sending it to a cloud service might negatively affect certain functionality in the service. Evaluate the CASB's CSPM capabilities for comparing IaaS workload configurations to common regulatory baselines.

Business Impact: CASBs are uniquely positioned to enable organizations to achieve consistent security policies and governance across many cloud services. Unlike traditional security products, CASBs are designed to protect data that's stored in someone else's systems. CASBs are suitable for organizations of all sizes in all industries and are uniquely positioned to help demonstrate that cloud use is well-governed. Given the expected continued feature expansion and relative ease of switching, favor one-year contract terms over lengthier ones.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Bitglass; CipherCloud; Forcepoint; McAfee; Microsoft; Netskope; Oracle; Proofpoint; Saviynt; Symantec

Recommended Reading: "Magic Quadrant for Cloud Access Security Brokers"

"Critical Capabilities for Cloud Access Security Brokers"

"10 Best Practices for Successful CASB Projects"

"How to Secure Cloud Applications Using Cloud Access Security Brokers"

"Eight Ways CASBs Improve Your IAM Security Posture"

Cloud Computing

Analysis By: David Smith

Definition: Cloud computing is a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using internet technologies.

Position and Adoption Speed Justification: Cloud computing is a very visible and hyped technology, and has passed the Trough of Disillusionment. Cloud computing remains a major force in IT. Every IT vendor has a cloud strategy — although many aren't cloud-centric, and some are better described as "cloud inspired." Users are unlikely to completely abandon on-premises models, but there is continued movement toward consuming more services from the cloud and enabling capabilities not easily accessible elsewhere. Much of the focus is on agility, speed and other non-cost-related benefits.

"Cloud computing" continues to be one of the most hyped terms in the history of IT. Its hype transcends the IT industry and has entered popular culture, which has had the effect of increasing hype and confusion around the term. In fact, cloud computing hype is literally "off the charts," as Gartner's Hype Cycle does not measure amplitude of hype (meaning that a heavily hyped term such as "cloud computing" rises no higher on the Hype Cycle than anything else).

Although the peak of hype has long since passed, cloud still has more hype than many other technologies that are actually at or near the Peak of Inflated Expectations. Variations, such as private cloud computing and hybrid approaches, compound the hype and reinforce the conclusion that one dot on a Hype Cycle cannot adequately represent all that is cloud computing. Some cloud variations (such as hybrid IT and now multicloud environments) are now at the center of where the cloud hype currently is. And, of course, there are different types of cloud services such as IaaS, PaaS and SaaS.

User Advice: User organizations must demand clarity from their vendors around cloud. Gartner's definitions and descriptions of the attributes of cloud services can help with this. Users should look at specific usage scenarios and workloads, map their view of the cloud to that of potential providers, and focus more on specifics than on general cloud ideas. Understanding the service models involved is key — especially the need to understand the shared responsibility model for security.

Vendor organizations should focus their cloud strategies on more specific scenarios and unify them into high-level messages that encompass the breadth of their offerings. Differentiation in hybrid cloud strategies must be articulated. This will be challenging, as all are "talking the talk," but many are taking advantage of the even broader leeway afforded by the term. "Cloudwashing" should be minimized. Gartner's Cloud Spectrum can be helpful.

Adopting cloud for the wrong reasons can lead to disastrous results. There are many myths surrounding cloud computing as a result of the hype (see "The Top 10 Cloud Myths" for details and advice).

Business Impact: The cloud computing model is changing the way the IT industry looks at user and vendor relationships. Vendors must become providers, or partner with service providers, to deliver technologies indirectly to users. User organizations will watch portfolios of owned technologies decline as service portfolios grow.

Potential benefits of cloud include cost savings and capabilities (including concepts that go by names such as "agility," "time to market" and "innovation"). Organizations should formulate cloud strategies that align business needs with those potential benefits. Agility is the driving factor, most of the time.

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Amazon; Google; IBM; Microsoft; Oracle; Red Hat; Salesforce; SAP

Recommended Reading: "Cloud Computing Primer for 2019"

"The Cloud Strategy Cookbook, 2019"

“The Top 10 Cloud Myths”

“Four Types of Cloud Computing Define a Spectrum of Cloud Value”

Cloud Management Platforms

Analysis By: Dennis Smith

Definition: Cloud management platforms (CMPs) enable organizations to manage private, public and multicloud services and resources. Their specific functionality is a combination of provisioning and orchestration; service request management; inventory and classification; monitoring and analytics; cost management and resource optimization; cloud migration, backup and disaster recover; and identity, security and compliance. This functionality can be provided by a single product or a set of vendor offerings with some degree of integration.

Position and Adoption Speed Justification: While the CMP market is continually changing, vendors and enterprise customers are getting a better feel about where such tooling can and cannot be used. Vendors are still being challenged with evolving customer requirements (for example, interfacing with multiple public clouds and cost transparency with workload optimization to remediate cost overruns). At the same time, major market consolidation will continue during the next few years. For example, many vendors, that initially targeted cost management, have been acquired as this functionality is becoming a part of the basic CMP functionality. The same is happening with cloud migration vendors. Cloud service providers (CSPs) and management service providers (MSPs) are also entering the market. Additionally, many long-standing vendors are introducing next-generation products, often targeting holes that their previous products had. Some of the core CMP functionality is also being combined (for example, monitoring and analytics with cost management and resource optimization). The ability to serve both application developer and I&O personas is the key. This requires that CMPs be linked into the application development process without imposing a workflow that inhibits agility while also allowing infrastructure and operations (I&O) teams to enforce provisioning standards.

Organizations have an increasing need to address multicloud requirements. In some cases, they want to become internal cloud service brokers (CSBs) and manage public services that were previously acquired — often by lines of business (LOBs) outside the I&O organization — and have become difficult to manage operationally.

User Advice: As CMP market volatility increases, IT organizations must:

- Consider CMP vendor’s viability along with evaluating features.
- Consider native cloud services as an alternative or option versus CMPs if you favor depth with an individual cloud provider versus depth across different cloud providers.
- Consider functionally focused tools (e.g., cloud expense management tool) if you only require a limited set of functionalities.

- Augment, swap out or integrate additional cloud management or traditional management tools for many requirements, because no vendor provides a complete cloud management solution.
- Standardize, because deriving value from your CMP will depend heavily on the degree of standardization offered by the infrastructure, software and services.
- Set realistic expectations on deployment times, as mature organizations implement CMP in a relatively short period (one to two years); however, less mature organizations may require two or more years to design effective, repeatable, and automatable standards and processes.
- Plan for new roles, such as cloud architects and cloud service brokers (CSBs), including developing skills in the infrastructure and operations organization, financial management and capacity management.

Business Impact: Enterprises will deploy CMPs to increase agility, reduce the cost of providing services and increase the likelihood of meeting service levels. Costs are reduced and service levels are met because CMP deployments require adherence to standards, as well as increased governance and accountability. Desirable IT outcomes include:

- Policy enforcement (e.g., on reusable standard infrastructure components)
- Reduced lock-in to public cloud providers, although at the cost of CMP vendor lock-in that can slow innovation
- Enhanced ability to broker services from various cloud providers and to make informed business decisions on which providers to use
- Ongoing optimization of SLAs and costs
- Management of SLAs and enforcement of compliance requirements
- Health and performance monitoring of cloud applications

Accelerated development, enabling setup/teardown of infrastructure that mimics production, resulting in lower overall infrastructure costs and higher quality

Benefit Rating: Low

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: CloudBolt; Embotics; Flexera (RightScale); Morpheus Data; Scalr

Recommended Reading: “Magic Quadrant for Cloud Management Platforms”

"Critical Capabilities for Cloud Management Platforms"

Platform as a Service (PaaS)

Analysis By: Yefim Natis; Paul Vincent; Fabrizio Biscotti

Definition: Platform as a service (PaaS) is a type of a cloud offering that delivers application infrastructure (middleware) capabilities as a service. Gartner tracks multiple types of PaaS (xPaaS), including, among many more, application platform as a service (aPaaS), integration PaaS (iPaaS), API management PaaS (apimPaaS), function PaaS (fPaaS), business analytics PaaS (baPaaS), IoT PaaS and database PaaS (dbPaaS). PaaS capability can be delivered as a provider-managed or self-managed, multitenant or dedicated.

Position and Adoption Speed Justification: The time of rampant hype and confusion about the promise and nature of PaaS is behind us, although some confusion remains and is event accelerating, brought about by the blurring boundaries between PaaS on one hand and IaaS and SaaS on the other. Mainstream users have been gaining real value from PaaS deployments and a growing number of organizations are making long-term strategic plans for PaaS projects, replacing their reliance on on-premises or IaaS+ (deploying platform software on IaaS) initiatives. Increasing number of mainstream organizations are seeking new relationships with the megaPaaS vendors that offer integrated collections of xPaaS capabilities. The increasing maturity of the PaaS offerings overall; the fast-improving execution by IT megavendors (including Microsoft, Amazon Web Services [AWS], Google, SAP, Salesforce, IBM and Oracle); the growing market acceptance of the smaller xPaaS innovators; the momentum of SaaS and IaaS offerings that are introducing PaaS to more organizations; the emerging born-on-the-cloud xPaaS capabilities (such as fPaaS) that are inherently cloud-only — all of these trends are increasing customers' confidence and advancing adoption of PaaS overall toward the Plateau of Productivity. Some specific xPaaS categories have already reached the maturity of mainstream adoption, including aPaaS, iPaaS, dbPaaS and others.

User Advice: Application Leaders, CIOs, CTOs, and IT leaders and planners:

- Build new business software utilizing PaaS offerings to gain expertise in cloud-native experience, to take advantage of the continuous innovation common to cloud environment, to gain high quality of service, including high availability, disaster recovery and security, and to be prepared for the next wave of business and technology innovation that will mostly be cloud-native and often cloud-only.
- Look beyond just the application development using aPaaS. A mature PaaS can provide application platform, integration, event processing and stream analytics, IoT, business process management, portal, database management, in-memory data grids, business analytics, contextual data discovery, and other middleware services. The PaaS market can be as diverse in functionality as the traditional platform and middleware market, and it can support a broad variety of project types.

- When public cloud is not an acceptable option, consider the provider-managed (dedicated or local) virtual private PaaS ahead of the self-managed private. Self-managed private PaaS is often too hard to carry out, for organizational and cultural reasons. The provider-managed virtual private PaaS can be a suitable alternative.
- Choose comprehensive PaaS (megaPaaS) providers when looking to consolidate cloud business relationships but avoid exclusive commitments to retain the technical and business ability to incorporate PaaS capabilities of multiple providers.
- To build a dependable platform strategy and reduce vendor lock-in, consider PaaS for initiatives that build on your commitments to SaaS or IaaS providers — in preference to embedded platform features.

Business Impact: The relationship between the vendors and their customers changes dramatically with transition to the cloud, where the vendors shift from just the role of the manufacturers of software to that of active facilitators of their customer's platform operations. Responsibilities, costs, skills, organization and culture of enterprise IT (and business operations) undergo a transformation. IT vendors and users that delay strategic adoption of cloud platform technology, architecture and organization, are at risk of losing loyalty of their customers. Customers that delay adoption of cloud platform services (PaaS), will find themselves with expensive vendor lock-in and chaotic handling of their hybrid technology environment.

Benefit Rating: Transformational

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Amazon Web Services; Dell Boomi; Google Cloud Platform; IBM Cloud; Mendix; Microsoft Azure; Oracle Cloud Platform; OutSystems; Salesforce Platform; SAP Cloud Platform

Recommended Reading: "Platform as a Service: Definition, Taxonomy and Vendor Landscape, 2019"

"The Key Trends in PaaS and Platform Architecture, 2019"

"Innovation Insight for Platform-as-a-Service Suites (MegaPaaS)"

"Not Just PaaS: Know and Use the Cloud Platform Continuum"

Infrastructure as a Service

Analysis By: Raj Bala

Definition: Infrastructure as a service (IaaS) is a standardized, highly automated offering in which computing resources owned by a service provider, complemented by storage and

networking capabilities, are offered to customers on demand. Resources are scalable and elastic in near real time and metered by use. Self-service interfaces, including an API and a graphical user interface (GUI), are exposed directly to customers. Resources may be single tenant or multitenant, and are hosted by the service provider or on-premises in a customer's data center.

Position and Adoption Speed Justification: Cloud IaaS is a mainstream technology that can be used to host most workloads, including mission-critical enterprise applications. Customers must still pay careful attention to selecting an appropriate provider, architecture and security controls, and are responsible for proper governance.

The best use of IaaS is transformational, where it can offer significant benefits in business agility, operations quality and cost. IaaS is frequently used to improve developer productivity and agility, and can facilitate continuous integration/continuous deployment (CI/CD), and the use of "infrastructure as code," including immutable infrastructure.

IaaS is increasingly used as a general substitute for data center infrastructure, and may drive improved operations, efficiency and cost savings. In this context, it is typically used to host traditional business applications, and may even host complex enterprise applications, such as ERP.

User Advice: The cloud IaaS provider market has bifurcated. Hyperscale integrated IaaS and PaaS providers dominate the market, and a single vendor (Amazon Web Services) holds a commanding market share lead. The nonhyperscale providers have largely been relegated to specialized scenarios — primarily scenarios that require deep support for legacy technologies, or that have specific location requirements that cannot be met by a hyperscale cloud provider. In general, the hyperscale providers offer a broad range of capabilities, and can meet enterprise requirements for availability, performance, security, regulatory compliance, service and support. The other providers also generally offer high-quality services, although these services are more limited in scope.

Most enterprises have begun to adopt IaaS strategically, and have a broad range of workloads on IaaS, including production applications. Public cloud IaaS now represents more than 15% of overall workloads. Midmarket businesses are the most likely to believe that IaaS will replace nearly all their data center infrastructures during the next five years. Most businesses have at least piloted IaaS, but those that have not done so should begin with new applications.

Both public multitenant and private single-tenant offerings are available; however, the distinction between public and private cloud IaaS is blurring. The most cost-effective clouds are highly standardized and use a shared capacity pool. There are hybrid public/private cloud offerings — enabling "cloud bursting" for on-demand capacity and business continuity — but this technology is likely to remain confined to narrow niches.

In most cases, there are no technical barriers, and few contractual or business barriers, to using cloud IaaS for a virtualizable x86-based application. Instead, IT leaders should ask themselves

whether cloud IaaS is the best possible solution for an application. In many cases, organizations should consider using both IaaS and PaaS — preferably from a cloud provider that offers integrated IaaS and PaaS, rather than IaaS alone.

Business Impact: Cloud computing infrastructure services are broadly advantageous for IT organizations. The cost benefits, driven primarily by automation, are particularly significant for small and midsize businesses (SMBs). Larger enterprises benefit primarily from greater flexibility and agility, although they can potentially also achieve cost reductions.

The benefits of IaaS have been driven primarily by the developer empowerment that comes from self-service, the flexibility offered by on-demand infrastructure, and the quality and efficiency of automation. Over time, system management tasks have become increasingly automated, leading to more-efficient infrastructure management. Organizations that simply "lift and shift" workloads to the cloud will reap limited cost and efficiency benefits, compared with those that use IaaS to drive IT transformation.

The metered-by-use attribute of these services will result in more efficient use of capacity, and their self-service nature will empower employees outside of IT operations. This will improve developer productivity and make it easier for business buyers to obtain infrastructure.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Alibaba Cloud; Amazon Web Services; Google; IBM; Microsoft; Oracle; Skytap; Virtustream

Recommended Reading: "The Cloud Strategy Cookbook, 2019"

"Cloud and Edge Infrastructure Primer for 2019"

Entering the Plateau

Cloud Office

Analysis By: Jeffrey Mann

Definition: "Cloud office" refers to a collection of the most broadly-used SaaS-based personal productivity, horizontal collaboration and communication tools combined into one product. It generally includes email, IM, file sharing, conferencing, document management and editing, search and discovery, and collaboration. Microsoft Office 365 and Google G Suite are the primary examples. The broad term "cloud office" is a general term. The name "Microsoft Office" refers to a specific set of products.

Position and Adoption Speed Justification: The cloud office innovation profile continues to advance quickly along the Hype Cycle as enterprise adoption grows and the technologies

become well understood. In 2019, it has reached the Plateau of Productivity as it becomes an accepted cornerstone of most organizations' collaboration and communications infrastructure.

Enterprises have made the move because of general preference for cloud deployments and the desire to reduce costs, redeploy IT staff, drive simplicity and provide more functionality to users. Vendors provide their most attractive new features — such as mobile apps, content discovery tools and artificial intelligence — from cloud deployments only.

User Advice: Application leaders responsible for digital workplace initiatives should:

- Look beyond a "like for like" deployment that focuses only on recreating previous on-premises functionality from the cloud. Although this can be a good initial step, investigate the unique capabilities of cloud office suites to improve digital dexterity, efficiency and innovation.
- Do not assume that the chosen cloud office product will meet all collaboration and communication requirements. Look beyond cloud office to meet specific needs or user requirements.
- Monitor the cloud office vendor's roadmap and product announcements closely. The cloud model assumes almost continuous enhancement with new features and improvements coming regularly. Assess these additions for their impact on your operations and how to take advantage of them.
- Plan specific efforts to address user adoption by focusing on user change management. It is usually not obvious how to use the new capabilities to increase effectiveness. Employees will benefit from assistance and guidance, perhaps from more advanced colleagues, as a part of the digital dexterity initiative.
- Look to cloud office suites as a source for continuous innovation in a form that is relatively easy to adopt. Innovations like every day AI, cross-tool integration, and better meetings are likely to come from cloud office products.

Business Impact: Cloud office products are so widely adopted that they are becoming the basis on which other vendors innovate, through add-ons and integrations. Cloud office is an important part of the emerging new work nucleus. These products support a wide variety of styles of collaboration including video, conversational, and social as well as the more conventional email and IM. Most organizations have made the move, developed a plan or specifically decided to put off making a move, which will be difficult to avoid in the longer term.

Benefit Rating: High

Market Penetration: More than 50% of target audience

Maturity: Mature mainstream

Sample Vendors: Google; Microsoft; Zoho

Recommended Reading: "Office 365, G Suite or Other Cloud Office Initiatives Primer for 2018"

"Maximize the Value of Office 365 or G Suite by Making It Part of a Digital Dexterity Program"

"Use a People-Centered Approach to Manage Cloud Office Migration for Business Value"

"Implementing Microsoft Office 365: Gartner Survey Results and Analysis, 2018"

"Checklist for Microsoft Office 365 or Google G Suite Migration Planning"

Software as a Service

Analysis By: Jay Heiser

Definition: SaaS is an application model in which the software is owned, delivered and managed by the provider. It uses a pay-for-use or subscription model, with a consistent version of the application simultaneously offered to multiple customers. SaaS is overwhelmingly delivered through a multitenant public cloud model, although some applications are available as a single-tenant or on-premises version.

Position and Adoption Speed Justification: With almost 20 years of steadily increasing significance, SaaS has established itself as the normal delivery model for many application types, including CRM and HCM. Preferring the cash flow benefits of subscription over licensing, almost all application vendors have expressed an intent to make SaaS their primary, and usually exclusive, delivery model. Although a significant minority of enterprise customers still questions the appropriateness of a multi-tenant public cloud delivery model, virtually all organizations are making significant use of SaaS today. However, SaaS has not been established as the norm for all forms of software, including highly strategic applications such as ERP for manufacturing operations. SaaS as a concept should be considered as having reached the Plateau of Productivity, but the transition toward cloud-based application services is still arguably at its midpoint. The utilization of SaaS, and the maturity of many existing offerings, will continue to evolve rapidly for at least another 10 years.

User Advice: SaaS should be a first preference when considering new application capabilities, unless there are specific reasons not to such as concern for data residency requirements or complex integration requirements. If you want to help your organization make the most effective use of SaaS, you should use the following practices:

- Give up on the idea that the IT department will control application choice and usage. IT can no longer be fully in charge of the organization's digital destiny, and instead will increasingly be in the role of internal consultant or broker for applications that are the primary responsibility of the lines of business.
- Treat SaaS as the first and preferred option for application capabilities, but prepare your organization for changes in business processes as a result.

- Embrace standard SaaS offerings, even if it means giving up some capabilities.
- Build a culture of continuous improvement to take advantage of upgrades while minimizing negative impact. Updates of SaaS applications will occur, and you will not have control over them.
- Develop policies and processes to govern the entire SaaS application life cycle, from approval through operations to obsolescence.
- Create a SaaS competency center to centralize and share SaaS-specific knowledge and practices for procurement, negotiation, provisioning, use, support, continuity and customization.

Business Impact: The one-size-fits-all model of SaaS represents a form of discipline that is almost impossible to emulate within an IT department that is inevitably pressured into countless modifications and changes that escalate software costs. SaaS does not require a capital investment in hardware and licenses, which further reduces its initial costs. In subsequent years, however, SaaS may be more expensive than traditional software offerings because the operating expense remains consistent over time. Future demands to customize or integrate SaaS applications are usually more expensive than comparable modifications of traditional software, and may be impossible.

SaaS is a perfect choice for organizations that do not have the IT resources to deploy and maintain on-premises software. This is prevalent in small or midsize businesses, as well as in large enterprises with limited capabilities in their IT departments or business units. SaaS enables companies or business departments to get to live-deployment status more quickly, especially when deploying less complex applications. On an ongoing basis, SaaS provides more agility for making changes through self-service interfaces and greater innovation because SaaS providers deliver ongoing enhancements through the service. SaaS is also a great option for organizations to test or experiment with new ideas that may or may not be fully implemented or continued.

The downside of SaaS is that usage tends to sprawl, with organizations paying for a larger set of services and seats than are necessary. Unfortunately, the best practices for the control of SaaS, and the associated toolset, remain relatively immature.

Benefit Rating: Transformational

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Sample Vendors: Box; Dropbox; Google; Microsoft Office 365; Oracle; Salesforce; ServiceNow; Slack; Workday

Recommended Reading: “How to Plan for Resiliency in the Cloud”

“SaaS SLAs: Reduce Risk and Improve Service by Negotiating These Key Terms”

“Toolkit: Minimize SaaS Risk and Cost by Efficiently Negotiating Optimal Contract Terms and Conditions”

“Market Trends: The Transformative Impact of SaaS on the Software Market”

“Developing Your SaaS Governance Framework”

“5 Preparation Steps to Optimize SaaS Negotiations”

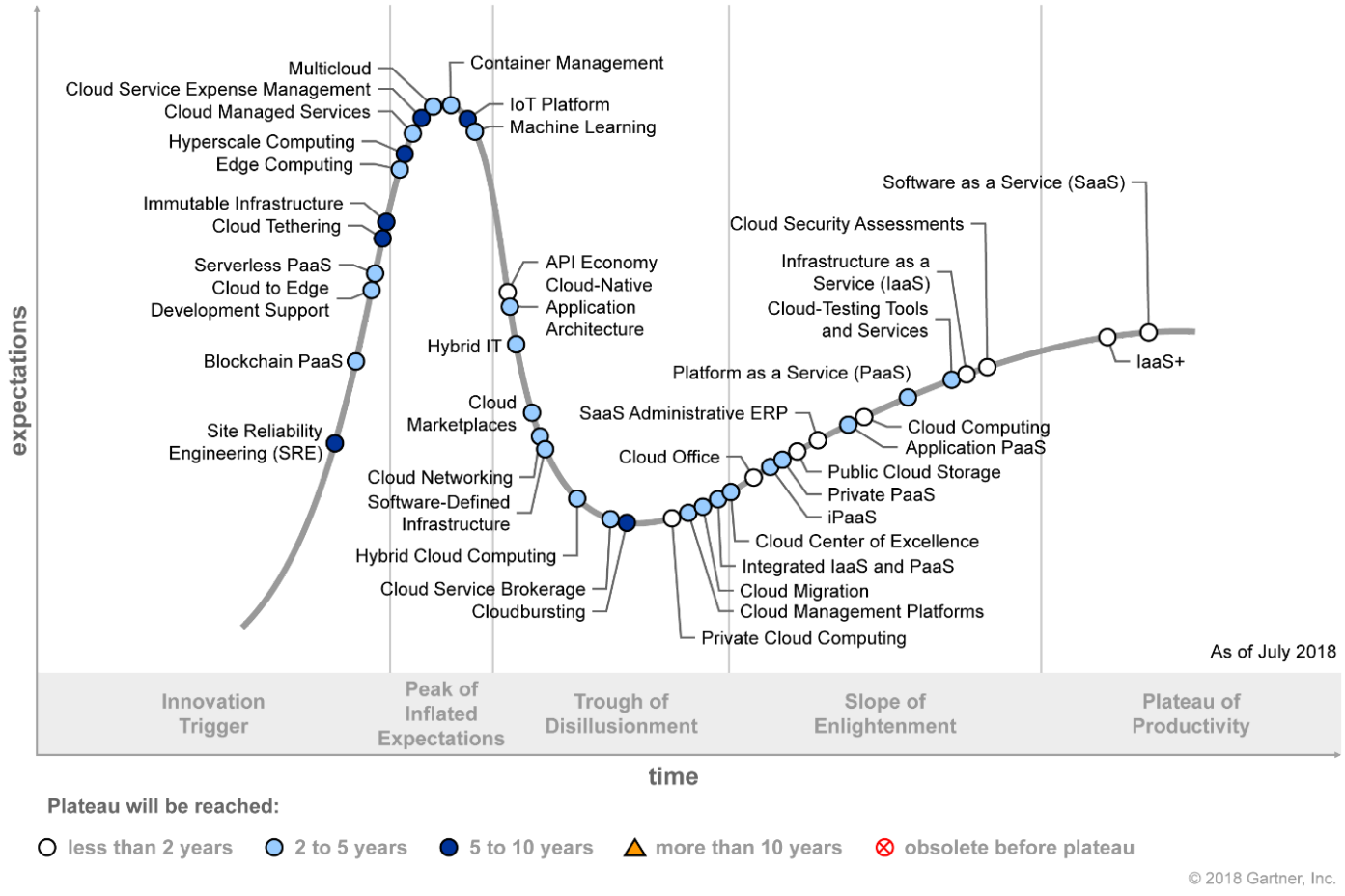
“Toolkit: Agile SaaS Acquisition Using Gartner’s Triage Methodology”

“Guide to Gartner’s Research on SaaS Security”

“Competitive Landscape: Software Asset Management Tools”

Appendixes

Figure 3. Hype Cycle for Cloud Computing, 2018



Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 1: Hype Cycle Phases

Phase ↓	Definition ↓

Phase ↓	Definition ↓
Innovation Trigger	A breakthrough, public demonstration, product launch or other event generates significant press and industry interest.
Peak of Inflated Expectations	During this phase of overenthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders results in some successes, but more failures, as the technology is pushed to its limits. The only enterprises making money are conference organizers and magazine publishers.
Trough of Disillusionment	Because the technology does not live up to its overinflated expectations, it rapidly becomes unfashionable. Media interest wanes, except for a few cautionary tales.
Slope of Enlightenment	Focused experimentation and solid hard work by an increasingly diverse range of organizations lead to a true understanding of the technology's applicability, risks and benefits. Commercial off-the-shelf methodologies and tools ease the development process.
Plateau of Productivity	The real-world benefits of the technology are demonstrated and accepted. Tools and methodologies are increasingly stable as they enter their second and third generations. Growing numbers of organizations feel comfortable with the reduced level of risk; the rapid growth phase of adoption begins. Approximately 20% of the technology's target audience has adopted or is adopting the technology as it enters this phase.
Years to Mainstream Adoption	The time required for the technology to reach the Plateau of Productivity.

Source: Gartner (August 2019)

Table 2: Benefit Ratings

Benefit Rating ↓	Definition ↓
Transformational	Enables new ways of doing business across industries that will result in major shifts in industry dynamics
High	Enables new ways of performing horizontal or vertical processes that will result in significantly increased revenue or cost savings for an enterprise
Moderate	Provides incremental improvements to established processes that will result in increased revenue or cost savings for an enterprise

Benefit Rating ↓	Definition ↓
Low	Slightly improves processes (for example, improved user experience) that will be difficult to translate into increased revenue or cost savings

Source: Gartner (August 2019)

Table 3: Maturity Levels

Maturity Level ↓	Status ↓	Products/Vendors ↓
Embryonic	■ In labs	■ None
Emerging	■ Commercialization by vendors ■ Pilots and deployments by industry leaders	■ First generation ■ High price ■ Much customization
Adolescent	■ Maturing technology capabilities and process understanding ■ Uptake beyond early adopters	■ Second generation ■ Less customization
Early mainstream	■ Proven technology ■ Vendors, technology and adoption rapidly evolving	■ Third generation ■ More out-of-box methodologies
Mature mainstream	■ Robust technology ■ Not much evolution in vendors or technology	■ Several dominant vendors
Legacy	■ Not appropriate for new developments ■ Cost of migration constrains replacement	■ Maintenance revenue focus

Maturity Level	Status	Products/Vendors
Obsolete	■ Rarely used	■ Used/resale market only

Source: Gartner (August 2019)