Hype Cycle for Cloud Computing, 2020

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Analyst(s): Ed Anderson, David Smith

Cloud computing is a mainstream computing model that has been validated as a dependable foundation for delivering IT capabilities. This Hype Cycle outlines the key cloud technologies in use today and the innovations that are emerging to support future needs.

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Analysis

What You Need to Know

Although cloud computing is not a new topic, industry hype surrounding cloud computing persists. Cloud computing hype has risen again recently due to the sudden shift in technology and business imperatives driven by the COVID-19 crisis. The unexpected surge in demand for cloud services pushed hyperscale cloud offerings to their limits. In most cases, the cloud services performed well in maintaining service delivery, even in the midst of unprecedented shifts in demand. The question of whether or not the cloud services model is viable has been answered. It is.

The focus on cloud computing has shifted from unrealistic beliefs that cloud will transform everything to a more pragmatic view of the true benefits of using cloud services. Cloud operational best practices are well-established, and many organizations are successfully operating cloud environments in support of their application and infrastructure requirements. New application models leverage cloud capabilities and make use of container and serverless technologies as organizations seek the pure benefits of cloud by using cloud-native architecture, applications and operating models.

Through 2019 and into 2020, we've seen an increased interest in cloud capabilities moving from central, public cloud data centers, toward diverse and distributed environments. Cloud computing and edge computing are two strong partners in delivering the power of centralized computing through cloud and dispersed computing at the edge. New distributed cloud models, and a collection of offerings from the leading cloud providers, further extend public cloud capabilities to virtually any location. Telecom providers are capitalizing on the distributed cloud model to establish new connectivity solutions using 5G services colocated with public cloud services. The future looks promising.

Terminology such as hybrid, multicloud, cloud-native, edge computing and distributed cloud describes cloud computing trends and hyped topics, and more terms are likely to follow. CIOs, CTOs and enterprise architects should use this Hype Cycle to understand the continuing evolution of cloud computing and to guide their strategic planning process in pursuit of the full benefits of cloud. As always, be wary of hype and seek out legitimate cloud technologies and solutions to realize the full benefits of the cloud value proposition.

See Gartner's "Cloud Computing Primer for 2020" as a starting point for navigating Gartner's foundational cloud computing research.

The Hype Cycle

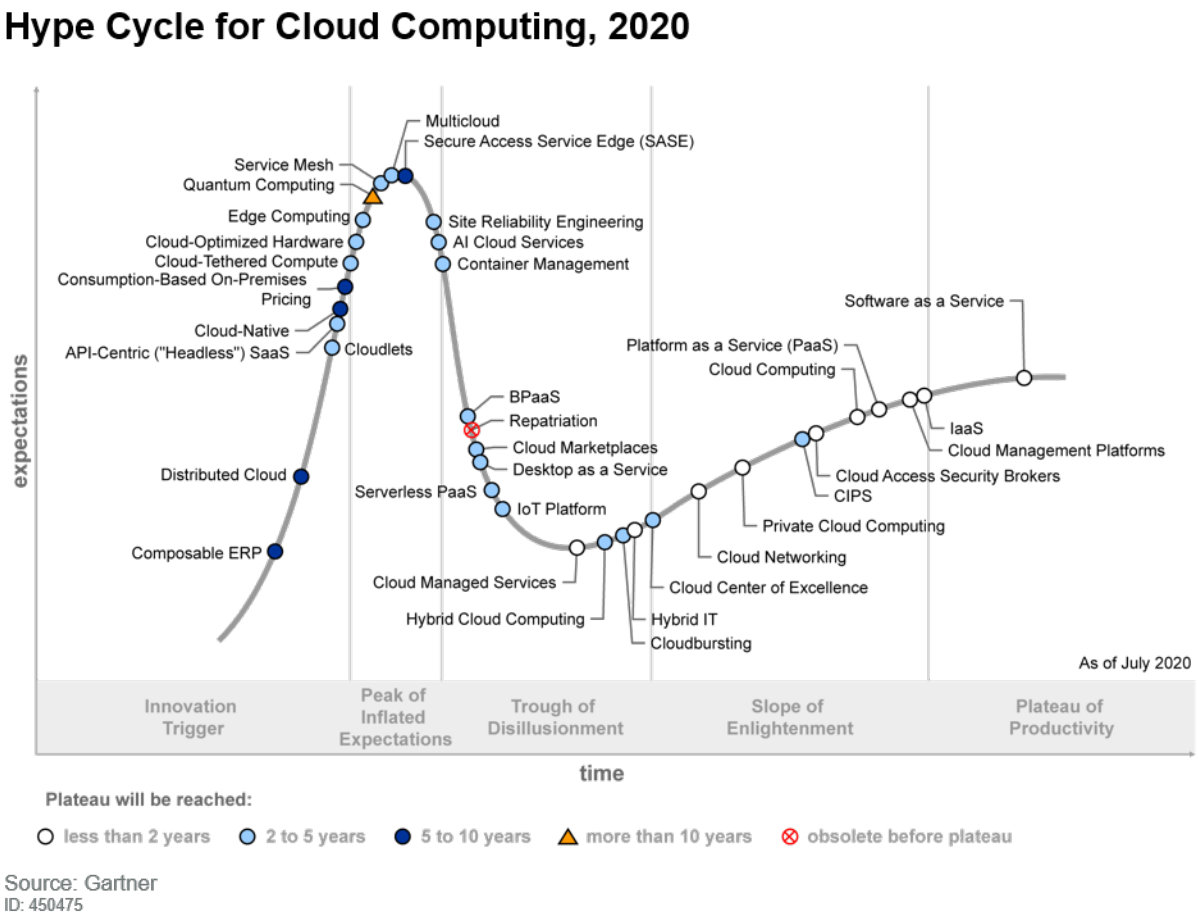
The shift from traditional IT models to cloud computing continues, as demonstrated by the seemingly endless growth of the leading cloud providers. Cloud computing is regularly used as the foundation for business-critical solutions leveraging the flexible and innovative services delivered through cloud models. Advanced capabilities in cloud management and security, as well as an ever-increasing ecosystem of cloud-based IT service providers, have helped mature cloud usage and establish cloud as a legitimate foundation for enterprise IT solutions. Cloud development tools and management frameworks compete for mind share as evidenced by the numerous container-based development and operations offerings, delivered for use both on-premises and in public cloud environments.

Hybrid scenarios, including hybrid cloud and hybrid IT (the combination of cloud and noncloud environments), are climbing out of the Trough of Disillusionment and entering the Slope of Enlightenment, illustrating the increasing maturity of hybrid solutions. Cloud managed services are becoming more common and occupy a spot in the Trough of Disillusionment as hype for cloud managed services often outpaces actual experience. Alternatively, multicloud is positioned at the top of the Peak of Inflated Expectations, reminding us that multicloud models do not solve all cloud problems, but are really just another cloud deployment option — sometimes employed intentionally, and sometimes an accidental outcome.

As mainstream cloud service offerings move into the Plateau of Productivity, cloud foundations enable and stimulate a next wave of innovations. Cloud-based solutions including the Internet of Things (IoT), artificial intelligence, quantum computing and edge computing are emerging as best-in-breed approaches to solving a new class of problems using the power of cloud computing models.

Several new innovation profiles were added this year to represent a new type of cloud-related computing approach found in on-premises systems delivered and billed on a consumption basis. Additionally, new hardware innovations, primarily driven by public cloud platform providers, are optimizing hardware platforms for the delivery of optimized and efficient cloud applications. More innovation in cloud-native application architecture and operations is likely through 2021 as organizations seek the full benefits of cloud. In fact, cloud-native approaches will be a key factor in the success of new technology initiatives as hype associated with cloud continues at its current, elevated status.

Figure 1. Hype Cycle for Cloud Computing, 2020



Source: Gartner
ID: 450475

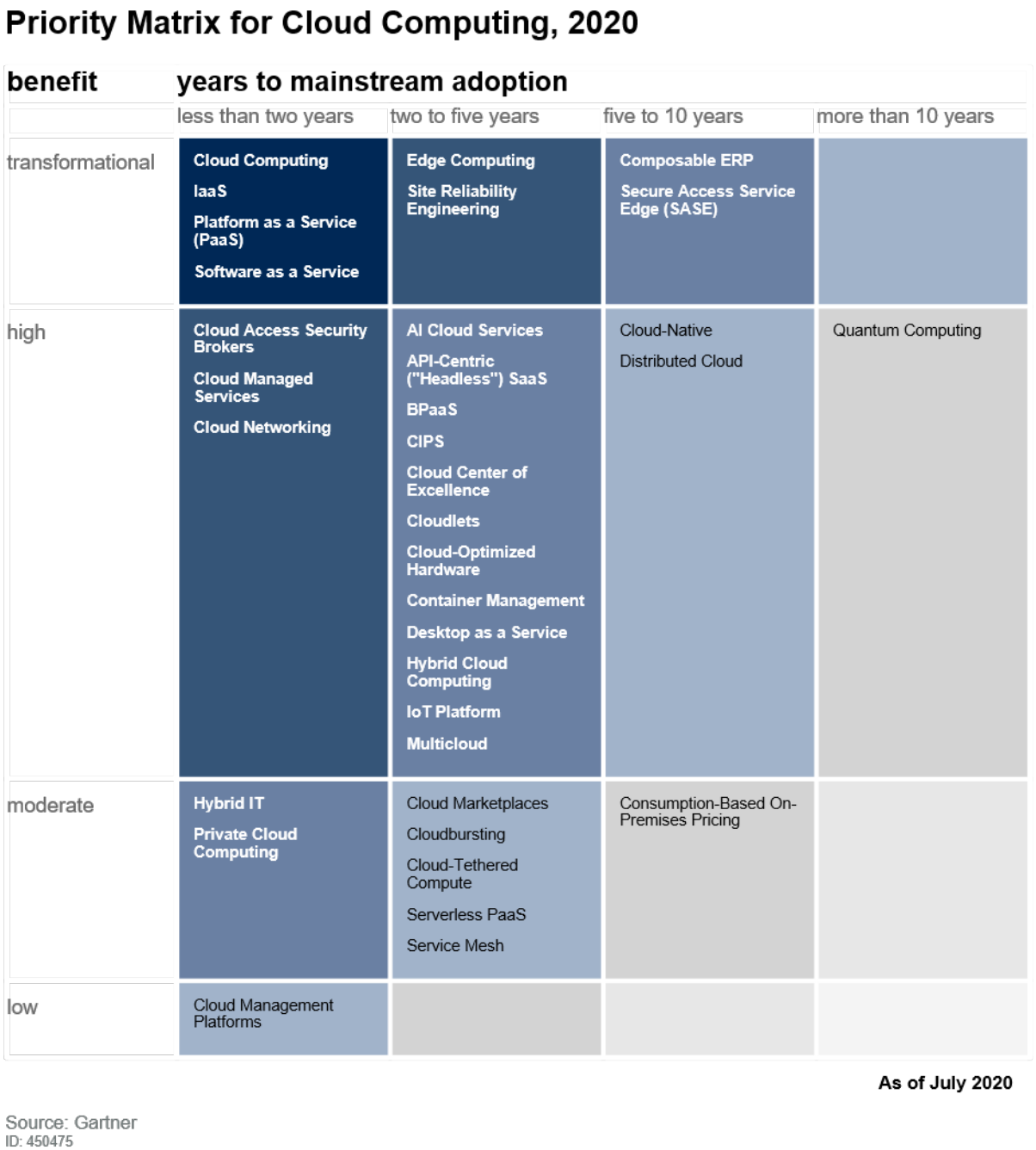
The Priority Matrix

The Hype Cycle for cloud computing represents a diverse collection of high-impact technologies driving growth and disruption across markets. The dynamic nature of cloud computing causes some cloud technologies and concepts to move through the Hype Cycle at an accelerated rate. The transformational nature of cloud-based solutions spawns an ever-increasing collection of innovations as illustrated by the innovation profiles featured on the Innovation Trigger in the Hype Cycle.

Many cloud computing technologies and concepts are two to five years away from mainstream adoption, and they will continue to be impactful. Other technologies have reached mainstream adoption and form the foundation for the next wave of innovations.

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, 2020



Source: Gartner
ID: 450475

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 those innovation profiles most strongly linked to the Hype Cycle and its theme.

In this 2020 update, we made the following notable changes:

- Removed:
  - AI PaaS
  - Blockchain PaaS
  - Cloud office (reached the Plateau of Productivity)
- Replaced:
  - API-centric SaaS with API-centric (“headless”) SaaS
- Added:
  - AI cloud services
  - Business process as a service (BPaaS)
  - Cloud infrastructure and platform services (CIPS)
  - Cloud networking
  - Cloud center of excellence
  - Cloud managed services
  - Cloud marketplaces
  - Cloud-optimized hardware
  - Cloud-tethered compute
  - Composable ERP
  - Consumption-based on-premises pricing
  - Desktop as a service
  - Quantum computing
  - Secure access service edge (SASE)

On the Rise

Composable ERP

Analysis by: Denis Torii; Duy Nguyen

Definition: Enterprise resource planning is no longer solely focused on "resources" or "planning." As a core part of the composable enterprise journey, ERP strategies need to evolve and embrace an increasingly complex technology environment. Composable ERP, a technology strategy (not a product), becomes a new and mandatory direction into a future where application and platform capabilities provide an enterprise business capabilities focus on end users.

Position and Adoption Speed Justification: Organizations are broadly disillusioned by ERP — costly, inflexible and inadequate are some of the qualifiers associated to it. What they need instead is a portfolio of connected, high-performance, highly usable solutions that can support and adapt to the fast pace of digital business environments. They want to adopt out-of-the-box standardized, commoditized processes. They seek opportunities to explore and deliver differentiated and innovative, value-creating processes. They want a platform to create innovative processes. But like all evolutionary processes, this will take time to reach mainstream — five to 10 years maybe. Right now, composable ERP is at the Innovation Trigger phase of the Hype Cycle, as organizations, software and service vendors are starting to understand the impacts and directions into this new future state. Even in its postmodern form, ERP is evolving from something more than just loosely coupled apps into a mesh of platforms and non-ERP vendors. Something new and aligned to the composable enterprise and future of applications.

User Advice: CIOs aiming to deliver flexibility and value to the enterprise must create a composable ERP strategy that focuses on these six hallmarks:

- AI-driven: AI will perform complex processes with little or no human intervention improving process outcomes throughput.
- Data-centric: Data is the lifeblood of composable ERP. Data will increasingly come from multiple applications, sources, services, and things.
- Consumable: Highly commoditized functionality offered as aggregator platforms, low-cost services.
- People-augmented: AI and automation assisting people to perform faster or to deliver better business outcomes.
- Enabling: Follows where you go, freeing the workforce from their desks and offering a seamless user experience on any device anywhere.
- Customer-facing: The name of the game is now what differentiates you to your customer, and how you can better support them with the best overall experience.

You must understand how these technologies are currently changing the shape of packaged business capabilities itself. Identify what new skills will be needed, the ongoing organizational

change impacts created, and when and where to adopt them. There is an urgent need to get your data house in order and to plan for AI adoption in the near term.

- Establish the scope of what ERP means — and should mean — for your organization by synchronizing capabilities with business plans and desired outcomes and experiences. Reimagine ERP to align with the emerging generation of applications, architectures and technologies. The old monolithic ERP mindset and practices are a dying beast.
- Exploit the emerging technologies across all pace layers based on your organization's growth, transformation or optimization goals.
- Implement an ERP strategy that includes the hallmarks of composable ERP — or lose the ability to adapt and gain efficiencies.
- Invest in enabling technologies along the core ERP journey — AI, low-code/no-code, integration capabilities, master data management, security discussions must all be part of the ERP strategy.

Business Impact: Delivering business value remains at the heart of composable ERP. However, the ability to deliver value is beginning to change radically, thanks to the influx of new technologies, mindsets, and practices. ERP is shifting toward:

- The business outcomes of the process, rather than the process execution itself. You must shift the focus from how to do it to why to do it.
- New, more-agile approaches to implementation to meet the rapidly changing digital world, resulting in quicker time to value. The days of five-year waterfall ERP implementations are over.
- What differentiates you to your customer, and how you can better support their wants and needs.
- Accepting complexity and working to manage it is a must. Don't oversimplify the challenge toward a single vendor approach across the board.

Benefit Rating: Transformational

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Recommended Reading: "ERP's Emerging Fourth Era — Moving Beyond Postmodern ERP"

"Application Leaders: Master Composable Enterprise Thinking for Your Post-COVID-19 Reset"

"Future of Applications: Delivering the Composable Enterprise"

Distributed Cloud

Analysis by: David Smith; Daryl Plummer; Milind Govekar

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. In fact, the variations on cloud (e.g., public, private, hybrid) exist because location can vary. While many people may claim that private cloud or hybrid cloud requires on-premises computing, this is a misconception. Private and hybrid cloud do not require that the private components are in any specific location. 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 an important 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 reduce 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 of 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 responsibility for how the system 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. There has been distribution of cloud services through worldwide regions in public cloud practically since its inception. The major hyperscale cloud providers 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 into next-generation hybrid environments such as Microsoft's Azure Stack Hub, Oracle's Cloud at Customer, AWS Outposts, Google Anthos and IBM's forthcoming Satellite offering.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

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

Recommended Reading: "Top 10 Strategic Technology Trends for 2020: Distributed Cloud"

"'Distributed Cloud' Fixes What 'Hybrid Cloud' Breaks"

"The Cloud Strategy Cookbook, 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 or things. The form factor used to deliver the cloudlet can vary widely. It can range from micro data centers (most common and evolving), to edge server appliances (for specific deployment situations and much less mature), to mesh computing alternatives (sharing compute across local devices, with future potential). A special form of cloudlet — tethered compute — is a type of cloudlet dedicated to a specific enterprise. Distributed cloud — distribution of public cloud services to different locations — is a form of cloudlets, but cloudlets are not always distributions of public cloud services.

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. Recent distributed cloud offerings (e.g., Microsoft Azure Stack, Amazon Web Services [AWS] Outposts, AWS Wavelength, Google Anthos) will likely become dominant and reduce the diversity in the market. 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 and public spaces).

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Amazon; AT&T; Equinix; Microsoft; MobiledgeX; Verizon

Recommended Reading: "Why and How I&O Should Lead Edge Computing"

"Cool Vendors in Edge Computing"

API-Centric ("Headless") 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 accelerating 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. Also, more traditional application platforms, capable of creating integrated user experience and back-end business logic (such as Microsoft Azure 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.
- Plan for gradual shift of development to composition and integration of API-centric packaged business capabilities
- Give preference to application development and integration tools that provide support for assembly of application capabilities utilizing API and event interfaces.
- Ensure clean separation of the back-end business logic and the front-end user experience in all applications, to maximize future benefits of the composable application experiences
- Avoid vendor applications that lock your organization into their user experience technology.
- Give preference to low-code and pro-code PaaS offerings that are well-equipped for access to external API and Event marketplaces.

Business Impact: API-centric SaaS promote the model of composable enterprise and with that — the agility, cost-efficiency and safety of application development and business innovation.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: AYLIEN; commercetools; Contentful; Elastic Path; Impala; Strapi; Stripe; Twilio

Recommended Reading: “Top 10 Trends in PaaS and Platform Innovation, 2020”

“2020 Strategic Roadmap for the Future of Applications”

Cloud-Native

Analysis by: David Smith

Definition: Something is 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 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. The original cloud computing definition helps provide 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. 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.

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 and 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 using cloud 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 can include 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.

Business Impact: Cloud-native, 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 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.

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

Three contradictory definitions are in common use:

- 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 Amazon Web Services (AWS) such as Relational Database Service (Amazon RDS), Lambda and Elastic Beanstalk. A better term to use to describe this is CSP-native (CSP means cloud service provider), or a vendor-specific term such as AWS-native.
- 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. A better term to describe this would be container-native, or Kubernetes-native.
- The third meaning is one that is very architectural in nature. One source for this is Gartner 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.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Amazon; Google; IBM; Microsoft

Recommended Reading: "The Cloud Strategy Cookbook, 2019"

"Define and Understand New Cloud Terms to Succeed in the New Cloud Era"

Consumption-Based On-Premises Pricing

Analysis by: Daniel Bowers

Definition: Consumption-based pricing for on-premises data center infrastructure is an acquisition model that includes a variable payment tied to measured usage.

Position and Adoption Speed Justification: Server and storage hardware vendors have launched or rebranded consumption-based pricing models in the last two years, positioning them as cloudlike or alternatives to public cloud. Examples include Dell Technologies' Flex on Demand, HPE's GreenLake Flex Capacity, and Pure Storage's Pure as-a-Service. These programs meet some users' desire to better align infrastructure costs with resource usage, and to shift infrastructure spending from capital expenditure to cloudlike operating expenditure. As early adopters learn financial and capacity planning lessons, vendors are evolving their offerings to offer a broader range of products and more flexible terms.

User Advice: While hardware-as-a-service offers appeal to organizations seeking to cut infrastructure costs, these programs are typically *not* cheaper than an outright purchase. Required minimum-usage commitment levels and three- to five-year contracts including mandatory services

mean consumption-based options are not strictly pay per use. Pricing often ignores market changes during the contract period, such as the long-term industry trend toward lower storage cost per GB. However, these programs enable infrastructure without large upfront capital investment. Consumption-based pricing can also be part of IT's evolution from a cost center toward a service- or product-centric delivery model. IT leaders considering these programs must address any misalignment between variable hardware usage and perpetual- or subscription-based software licensing.

Business Impact: IT leaders — jointly between infrastructure and operations, vendor management and finance — should evaluate the total cost of ownership (TCO) of a range of potential consumption-based program scenarios. For centralized IT organizations with mature chargeback processes, consumption-based programs can improve the linking of costs to specific usage. Organizations must ensure that contract terms match company requirements for categorizing capital versus operating expenses, and that contracts include appropriate end-of-term options (for example, renewals or buyouts). Consumption-based programs change hardware life cycle management, resulting in both high renewal rates and high barriers to exit because it can be difficult to resume traditional acquisition. By removing friction from new infrastructure deployment, these programs also risk allowing unchecked growth of storage resources.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Cisco; Dell Technologies; Hewlett Packard Enterprise (HPE); Hitachi Vantara; Lenovo; NetApp; Pure Storage

Recommended Reading: "How to Use Consumption-Based Procurement Models for On-Premises Infrastructure"

"Key Considerations for CSOs Moving to a Consumption-Based Subscription Model"

"Create Consumption-Based On-Premises Infrastructure Bundles for Midsize Enterprises"

Cloud-Tethered Compute

Analysis by: Tony Harvey; David Wright

Definition: Cloud-tethered compute is a model where MaaS, IaaS, or PaaS are delivered in a customer-controlled environment but managed by the vendor via a network tether from a public or private cloud. The system may require the tether to be continuously connected, for billing, or be able to operate disconnected with periodic connectivity. Updates are managed by the vendor, removing the responsibility of maintenance of the platform from the I&O team.

Position and Adoption Speed Justification: Cloud-tethered compute solutions are starting to become more common. Initially, they were developed by public cloud vendors to provide public cloud services such as IaaS and PaaS in client-controlled environments, for example, Azure Stack

Hub and AWS Outposts. Other vendors have started to develop products in this space. For example, companies like Hivecell deliver an edge-focused solution; Dell EMC delivers a VMware-based private cloud with VMware Cloud on Dell EMC; and other vendors like HPE and Lenovo deliver metal as a service and other capabilities through consumption-based models. Current adoption is relatively low, although the potential for growth due to data sovereignty, connectivity and latency issues at the edge is significant.

User Advice: Cloud-tethered compute systems are relatively new to the market and may be missing key capabilities; and some entrants do not have clear SLAs and the commercial terms are not yet fully developed. Be careful when evaluating tethered compute systems to ensure that they provide the features that the development teams require and that you clearly understand the SLAs provided, what happens at the end of the contract, and how upgrades and expansions midterm are handled.

Key areas to consider when evaluating cloud-tethered compute systems:

- Provided as a service: Some or all elements are provided as a service and remain the property of the vendor. You must have a clear understanding of who owns which element and what are the consequences of a service shutdown.
- Connectivity: Does the system require a permanent connection for the tether, or can it operate in disconnected mode? What are the limitations when operating in disconnected mode?
- Response times and hardware maintenance services: Users more used to a Tier 1 vendor service contract for on-premises maintenance may struggle to adapt to a service model that is based on next-business-day, whole-unit replacement or lower.
- Contract terms: Understand what will happen at the end of the term and how any midterm changes, upgrades or additions will affect the termination date and costs.
- Security: Cloud-tethered compute systems typically use a “shared security model,” where some responsibilities belong to the customer and some to the vendor. Although the security of the vendor may be excellent, the customer’s security team must be engaged to ensure all security risks are mutually addressed.
- Variable pricing: Similar to cloud services, monthly or other recurring charges for a cloud-tethered system could vary based on usage, making costs and budgeting less predictable than traditional infrastructure.
- Data sovereignty: Although the data is held in a location under control of the user, the system is not under user control. At a minimum, any data being used on these systems should be encrypted at rest. In addition, cloud-tethered compute vendors should be able deliver secure data deletion and even storage device retention services to ensure that sensitive data does not leave the control of the user.

Business Impact: Cloud-tethered compute represents a new form of computing in which the customer’s IT gives responsibility for and control over some of its data center assets to a cloud provider. It reduces the need to perform many of the routine tasks traditionally performed by the IT staff, especially as related to server maintenance. It will, however, create new needs for skills in

contractual analysis, security and spend management for these systems. Application- and data-level security and backup will still remain an I&O responsibility. In many cases, the I&O function may welcome the removal of basic duties related to system maintenance, which will enable it to focus on delivering higher-level services.

Benefit Rating: Moderate

Market Penetration: Less than 1% of target audience

Maturity: Emerging

Sample Vendors: AWS Outposts; Google Anthos; Hivecell; Microsoft Azure Stack; Oracle; VMware

Recommended Reading: "'Distributed Cloud' Fixes What 'Hybrid Cloud' Breaks"

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

"How to Bring the Public Cloud On-Premises With AWS Outposts, Azure Stack and Google Anthos"

"Best Practices for Tech CEOs to Manage Edge-to-Cloud Products"

"Top Emerging Trends in Cloud-Native Infrastructure"

At the Peak

Cloud-Optimized Hardware

Analysis by: Alan Priestley

Definition: Cloud-optimized hardware includes servers, networking, storage and custom silicon designed specifically for use in cloud operating environments. Optimizations include configuration via software control planes and tuning hardware functionality for specific software workloads. Cloud-optimized hardware has been developed primarily by the hyperscale cloud providers to support execution of cloud services and provide a differentiated customer experience, but is increasingly becoming available to enterprise IT for use in their infrastructure.

Position and Adoption Speed Justification: In pursuit of increased operational efficiency and lower component costs, the hyperscale cloud service providers are leveraging customized hardware products designed specifically for use in their data center infrastructure. This trend initially started with the optimization of physical data center infrastructure for cooling and power management. As infrastructure has increased in size and complexity, the focus on the use of customized products has extended to include:

- Rack and server designs, to reduce power and simplify physical installation; for example, the Open Compute Project (OCP) Foundation driven by Facebook
- Network switches and interfaces, to support and isolate multiple workloads and users on servers hosting multiple virtual instances

- Storage controllers tuned to extend flash device life cycles in SSDs
- Improved security by using custom chips to establish a hardware-based root of trust to guarantee the integrity of the hardware and firmware; for example, Amazon's Nitro Security Chip
- Function accelerators to support offload of storage and network processing from the CPU
- Custom microprocessors and ASICs for workload acceleration; for example, AWS Graviton processors and Google's Tensor Processing Units (TPUs) for AI workloads

The use of cloud-optimized hardware enables cloud service providers to enhance the efficiency of their data center operation, optimizing infrastructure for specific workloads and operations. Originally cloud-optimized hardware was the preserve of major hyperscale cloud providers. But initiatives like OCP Foundation have encouraged ODMs to productize cloud-optimized servers enabling a wider range of cloud service providers and enterprises to leverage these developments. Some of the major semiconductor vendors are also offering cloud providers custom versions of their standard chips, tuned for use in cloud infrastructure. Currently, the development of dedicated ASICs remains the preserve of major hyperscale cloud providers due to costs and resources required for chip development.

With the availability of a broad range of cloud-optimized hardware from ODMs and equipment vendors, many enterprise architects are evaluating its use within their infrastructure.

User Advice: The use of cloud-optimized hardware can enable cost and management efficiencies. However, while these benefits hold many attractions for enterprise architects planning on-premises deployments, it must be remembered that cloud-optimized hardware is designed for deployment at scale within hyperscale data centers. Consequently, enterprise architects must remain mindful that:

- The ODM business model is very different to traditional OEMs, typically having minimum delivery quantities of tens of thousands of standard units. While it is possible to specify precisely what the system configurations will be (CPU, memory, storage, network, etc.), there is no flexibility to vary. Also, ODMs provide minimal support in terms of software configurations or maintenance contract. Enterprise architects must plan to be self-sufficient in terms of support and maintenance.
- Customized hardware solutions may also leverage "nonstandard" components, focusing on price optimization and reduced functionality, with device vendors providing optimized drivers that may not support the same feature set as premium commercial products. As a result, software configurations and workload requirements must be assessed before committing to large-scale deployments.

Enterprise architects must also monitor the growing use of cloud-optimized hardware by major cloud service providers, as technologies that enable the cloud provider to improve their operational efficiency may impact enterprise workloads. This includes the growing use of proprietary CPU designs by the hyperscale cloud providers. For example, AWS Graviton processor, which enables lower-priced compute instances and services but uses an ARM-based design. For workloads based on interpreted applications (such as those running on Java Virtual Machine) and where an ARM-

based interpreter is available, these new instances can be a cost-effective solution. However, x86-based applications will need to be recompiled to run in the new environment.

Business Impact: Cloud-optimized hardware can enable enterprise architects deploying large-scale infrastructures to achieve operational efficiencies, not possible when using standard OEM equipment. These efficiencies can lower the cost of data center operations and also deliver infrastructure targeted to specific workloads. However, as cloud-optimized hardware is designed for deployment at scale, for many smaller-scale deployments, these benefits can be offset by the increase in resources and skill sets necessary to maintain the equipment and associated software stacks.

Benefit Rating: High

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Amazon Web Services (AWS); Flex; Inspur; NVIDIA; Open Compute Project Foundation

Recommended Reading: "Top 10 Strategic Technology Trends for 2020: Distributed Cloud"

"Evolve Your Infrastructure and Operations Organization to Remain Relevant in the Cloud Era"

"How to Bring the Public Cloud On-Premises With AWS Outposts, Azure Stack and Google Anthos"

"Market Trends: Emerging Opportunities for Semiconductor Vendors at the Hyperscale Cloud Service Providers"

Edge Computing

Analysis by: Bob Gill; Philip Dawson

Definition: Edge computing describes a distributed computing topology in which data storage and processing are placed close to the things or people that produce and/or consume that information. Drawing from the concepts of mesh networking and distributed computing, edge computing strives to keep traffic and processing local and off the center of the network. Edge balances latency requirement and the bandwidth required for an application, allows for autonomous operation, enables the placement of workloads and data that satisfies regulatory/security demands.

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 recommend the following:

- We urge enterprises to begin considering edge design patterns in their medium- to longer-term infrastructure architectures.
- Immediate actions 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 “Edge-IN” 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 has quickly become the decentralized complement to the largely centralized implementation of public cloud. 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 enables the specifics of IoT, digital business and distributed IT solutions, as a foundational element of next-generation applications of all kinds.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

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

Recommended Reading: “The Edge Completes the Cloud: A Gartner Trend Insight Report”

“Top 10 Strategic Technology Trends for 2019: The Empowered Edge”

“The Future Shape of Edge Computing: Five Imperatives”

“How Edge Computing Redefines Infrastructure”

Quantum Computing

Analysis by: Martin Reynolds; Matthew Brisse; Chirag Dekate

Definition: Quantum computing is a type of nonclassical computing that operates on the quantum state of subatomic particles. The particles represent information as elements denoted as quantum bits (qubits). A qubit can represent all possible values of its two dimensions (superposition) until read. Qubits can be linked with other qubits, a property known as entanglement. Quantum algorithms manipulate linked qubits in their entangled state, a process that can address problems with vast combinatorial complexity.

Position and Adoption Speed Justification: Quantum computers are not general-purpose computers. Rather, they are accelerators capable of running a limited number of algorithms with orders of magnitude of speedup over conventional computers. These problems fall into a broad category of optimization, where a traditional algorithm would take impossibly long to find a solution. Quantum computers are superior for problems with small input and output, but enormous combinatorial complexity. Quantum computers will scale using a mix of existing technology, and a combination of new algorithms and conventional computing.

Hardware based on quantum technology is unconventional, complex and leading-edge. Current qubits are good enough to demonstrate the potential of quantum computing, but quantum systems face challenges in scale, noise and connectivity that require yet unknown breakthroughs to offer business value.

The technology continues to attract significant funding, and a great deal of research is underway at many university and corporate labs. Most practitioners are working on gate-model quantum computers, which sequence the qubits through operations that prepare input data and create a solution. In such systems, input data is embodied in the program steps.

Quantum annealing is a style of quantum computing that uses entanglement and superposition in a way more akin to analog computing. D-Wave's quantum annealers, with thousands of qubits, are demonstrating practical solutions, but also face scaling and noise challenges, and do not yet deliver a business advantage.

An alternative solution, Fujitsu's Digital Annealer, offers the equivalent of 8,000 slow, but high-quality, qubits in a rack mount package. Digital Annealers may solve problems otherwise assigned to quantum computers, potentially delaying the point at which quantum computers offer business advantage.

User Advice: In the few known applications, quantum computers could operate exponentially faster than conventional computers. Quantum computers will act as accelerators to problems preprocessed and postprocessed by digital computers.

Early applications will likely be in the class of optimization, such as routing or portfolio optimization. Later applications will address organic chemistry, drug discovery, materials science and code breaking (as prime number factoring).

Quantum computers will eventually compromise today's cryptographic key exchange protocols. Quantum-safe cryptographic algorithms are in the final stages of the standardization process, and should be a midterm strategic initiative for organizations where data must be protected over decades.

If a practical quantum computer offering appears, check its usefulness across the range of applications that you require. It will probably be dedicated to a specific application, and this is likely to be too narrow to justify a purchase. For those customers interested in quantum computing, Gartner recommends the use of quantum as a service (QaaS). QaaS providers such as IBM, Rigetti Computing, Xanadu, D-Wave and others are offering application development and test tools that work with remote hardware.

Business Impact: Quantum computing could have a huge effect, especially in areas such as optimization, machine learning, cryptography, drug discovery and organic chemistry. Although outside the planning horizon of most enterprises, quantum computing could have strategic impacts in key businesses or operations.

Benefit Rating: High

Market Penetration: Less than 1% of target audience

Maturity: Embryonic

Sample Vendors: 1QBit; Alibaba Cloud; D-Wave; Google; IBM; Microsoft; QC Ware; QinetiQ; Rigetti Computing; Zapata Computing

Recommended Reading: "Strategy Guide to Navigating the Quantum Computing Hype"

"Emerging Technology Analysis: Act Now on Quantum-Safe Encryption or Risk Losing Deals"

"Quantum Computing Planning for Technology General Managers"

Service Mesh

Analysis by: 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: A service mesh addresses the lightweight middleware requirements of service-to-service communications (east-west), especially among microservices running in managed container systems. These technologies are evolving rapidly. Many commercial and open-source solutions are now generally available.

Hype surrounding service mesh technology accelerated in early 2017 when Google, IBM and Lyft launched the Istio open-source project to produce a service mesh for Kubernetes. Numerous

vendors now contribute to the project and provide commercial Istio-based products, and many people associate the service mesh market exclusively with Istio, even though it isn't the most mature product in the market.

Many clients have expressed confusion about the relationship between service meshes and other API mediation technologies, such as API gateways and application delivery controllers (ADCs.) A service mesh is lighter weight, and therefore doesn't replace traditional API mediators. (See "How a Service Mesh Fits Into Your API Mediation Strategy.") Unfortunately, management, federation and interoperability between the various API mediators and service meshes haven't been addressed by the vendor community, yet.

User Advice: Application leaders responsible for API management and microservices middleware should:

- 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 API gateways and application delivery controllers.

Business Impact: A service mesh is a powerful piece of middleware that improves development and operations of microservice-based applications. It ensures reliable, resilient and secure service-to-service communications. It provides deep visibility into the services, enabling proactive operations and faster diagnostics. It automates complex communication concerns, thereby improving developer productivity and ensuring that certain standards and policies are enforced consistently across applications.

Benefit Rating: Moderate

Market Penetration: 1% to 5% of target audience

Maturity: Adolescent

Sample Vendors: Amazon Web Services; Buoyant; F5; Google; HashiCorp; Istio; Kong; Microsoft; Netflix; VMware

Recommended Reading: "How a Service Mesh Fits Into Your API Mediation Strategy"

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, in some cases, 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 lower 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”

“Define and Understand New Cloud Terms to Succeed in the New Cloud Era”

“Technology Insight for Multicloud Computing”

Secure Access Service Edge (SASE)

Analysis by: Joe Skorupa; Neil MacDonald

Definition: Secure access service edge (SASE, pronounced “sassy”) delivers multiple capabilities such as SD-WAN, SWG, CASB, NGFW and zero trust network access (ZTNA).

SASE supports branch office and remote worker access. SASE is delivered as a service, and based upon the identity of the device/entity, combined with real-time context and security/compliance policies. Identities can be associated with people, devices, IoT or edge computing locations.

Position and Adoption Speed Justification: SASE is driven by enterprise digital business transformation: the adoption of cloud-based services by distributed and mobile workforces; edge computing and business continuity plans that must include flexible, anywhere, anytime, secure remote access. While the term originated in 2019, the architecture has been deployed by early adopters as early as 2017. By 2024, at least 40% of enterprises will have explicit strategies to adopt SASE, up from less than 1% at year-end 2018.

By 2023, 20% of enterprises will have adopted SWG, CASB, ZTNA and branch FWaaS capabilities from the same vendor, up from less than 5% in 2019. However, today most implementations involve two vendors (SD-WAN + Network Security), although single vendor solutions are appearing. Dual-vendor deployments that have deep cross-vendor integration are highly functional and largely eliminate the need to deploy anything more than an L4 stateful firewall in the branch office. This will drive a new wave of consolidation as vendors struggle to invest to compete in this highly disruptive, rapidly evolving landscape.

SASE is in the early stages of market development but is being actively marketed and developed by the vendor community. Although the term is relatively new, the architectural approach (cloud if you can, on-premises if you must) has been deployed for at least two years. The inversion of networking and network security patterns as users, devices and services leave the traditional enterprise perimeter will transform the competitive landscape for network and network security as a service over the next decade, although the winners and losers will be apparent by 2022. True SASE services are cloud-native — dynamically scalable, globally accessible, typically microservices-based and multitenant. The breadth of services required to fulfill the broad use cases means very few vendors will offer a complete solution in 2020, although many already deliver a broad set of capabilities. Multiple incumbent networking and network security vendors are developing new or enhancing existing cloud-delivery-based capabilities.

User Advice: There have been more than a dozen SASE announcements over the past 12 months by vendors seeking to stake out their position in this extremely competitive market. There will be a great deal of slideware and marketecture, especially from incumbents that are ill-prepared for the

cloud-based delivery as a service model and the investments required for distributed PoPs. This is a case where software architecture and implementation matters

When evaluating SASE offering, be sure to:

- Involve your CISO and lead network architect when evaluating offerings and roadmaps from incumbent and emerging vendors as SASE cuts across traditional technology boundaries.
- Leverage a WAN refresh, firewall refresh, VPN refresh or SD-WAN deployment to drive the redesign of your network and network security architectures.
- Strive for not more than two vendors to deliver all core services.
- Use cost-cutting initiatives in 2020 from MPLS offload to fund branch office and workforce transformation via adoption of SASE.
- Understand what capabilities you require in terms of networking and security, including latency, throughput, geographic coverage and endpoint types.
- Combine branch office and secure remote access in a single implementation, even if the transition will occur over an extended period.
- Avoid vendors that propose to deliver the broad set of services by linking a large number of products via virtual machine service chaining.
- Prioritize use cases where SASE drives measurable business value. Mobile workforce, contractor access and edge computing applications that are latency sensitive are three likely opportunities.

Some buyers will implement a well-integrated dual vendor best-of-breed strategy while others will select a single vendor approach. Expect resistance from team members that are wedded to appliance-based deployments.

Business Impact: SASE will enable I&O and security teams to deliver the rich set of secure networking and security services in a consistent and integrated manner to support the needs of digital business transformation, edge computing and workforce mobility. This will enable new digital business use cases (such as digital ecosystem and mobile workforce enablement) with increased ease of use, while at the same time reducing costs and complexity via vendor consolidation and dedicated circuit offload.

COVID-19 has highlighted the need for business continuity plans that include flexible, anywhere, anytime, secure remote access, at scale, even from untrusted devices. SASE's cloud-delivered set of services, including zero trust network access, is driving rapid adoption of SASE.

Benefit Rating: Transformational

Market Penetration: 1% to 5% of target audience

Maturity: Emerging

Sample Vendors: Akamai; Cato Networks; Cisco; Citrix; iboss; Netskope; Open Systems; Palo Alto Networks; VMware; Zscaler

Recommended Reading: "The Future of Network Security Is in the Cloud"

"Magic Quadrant for Cloud Access Security Brokers"

"Market Guide for Zero Trust Network Access"

"Market Trends: How to Win as WAN Edge and Security Converge Into the Secure Access Service Edge"

"Quick Answer: Cost-Effectively Scaling Secure Access While Preparing for a Remote Workforce"

Site Reliability Engineering

Analysis by: George Spafford; Daniel Betts

Definition: Site reliability engineering (SRE) is a collection of systems and software engineering principles used to design and operate scalable resilient systems. Site reliability engineers work with the customer or product owner to understand operational requirements and define service-level objectives (SLOs). The site reliability engineer then collaborates with IT stakeholders to design and continuously improve systems that will meet the SLOs. For products or platforms that meet SRE guidelines, the engineer may choose to provide operational support.

Position and Adoption Speed Justification: 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: The SRE approach to DevOps is intended for products and platforms that need to deliver customer value at speed at scale while managing risk. The two primary use cases are to improve reliability of existing products or platforms as well as to in creation of new products or platforms that warrant the investment in reliability.

Benefit Rating: Transformational

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Recommended Reading: "DevOps Teams Must Use Site Reliability Engineering to Maximize Customer Value"

"SRE and DevOps: End-to-End Accountability"

"Agile and DevOps Primer for 2020"

"Innovation Insight for Chaos Engineering"

"Maverick* Research: Software Testing and the Illusion of Exterminating Bugs"

AI Cloud Services

Analysis by: Van Baker; Bern Elliot

Definition: Artificial intelligence cloud services 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 services include automated machine learning, vision, and language services.

Position and Adoption Speed Justification: The use and sophistication of AI cloud services continues to increase, with the leading cloud service providers, including Alibaba, Amazon Web Services (AWS), Baidu, Google, IBM and Microsoft, competing 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 has pushed 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.

The AI cloud approach is continuing to disrupt the 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 building and deploying 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.
- Use features like automated algorithm selection and training-set creation to offload some of the complexity of the project and leverage existing expertise on operating cloud services. This will assist technical professional teams with little to no data science expertise.

Business Impact: AI cloud services offerings **will become ubiquitous** in the three key AI services of automated machine learning (ML), natural language processing and computer vision.

- **Automated Machine learning:** Packaged autoML 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. All providers offer automated model building but many fail to deliver data preparation and augmentation capabilities.
- **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 chatbot solutions or more sophisticated conversational virtual assistants. Additional language services include transcription, translation, speech-to-text, text-to-speech and text analytics. Developers can also use autoML to customize language models.
- **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 that can categorize elements of the images or video. Additional visual services include optical character recognition (OCR), handwriting recognition (HWR) label extraction. Pretrained systems often require no data science expertise and allow developers to gain unique and new insight by invoking an API. Developers can also use autoML to customize vision models.

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: "Magic Quadrant for Cloud AI Developer Services"

"Critical Capabilities for Cloud AI Developer Services"

Container Management

Analysis by: Dennis Smith

Definition: Container management supports the management of containers at scale. This category of software includes container runtimes, container orchestration and scheduling, resource management and other container management capabilities. Container management software brokers the communication between the continuous integration/continuous deployment (CI/CD) pipeline and the infrastructure via APIs, and aids in the life cycle management of containers. It can also be used to more efficiently package COTS applications.

Position and Adoption Speed Justification: Gartner surveys show that the demand for containers continues to rise. This is likely 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). The emergence of de facto standards (e.g., Kubernetes) and offerings from the public cloud providers are also driving adoption. Container management 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.

The most common use of containers is focused specifically on Linux environments, and management software follows accordingly; however, there has been a gradual adoption of Windows containers. Container-related edge computing use cases have also increased, along with deployments involving bare-metal servers and the emergence of operational control planes that support containers and VMs.

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 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 now deploying on-premises container solutions.

There is a high degree of interest in, and awareness of, containers within global organizations. Though many enterprises are planning or have recently commenced container deployments, few have containerized a significant portion of their application workloads. Additionally, there is significant grassroots adoption from individual developers who use containers with increasing frequency in development and testing — particularly for Linux. Container management software has progressed from an early-adopter technology to adolescent, where it remains.

User Advice: Organizations should begin exploring container technology as a means for packaging and deploying 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 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 has large-scale batch workloads.
- It 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.

Organizations must also factor in their desire for hybrid and/or multicloud deployments into vendor selection, as many vendors offer container management software that can be deployed in different cloud environments.

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 and production readiness, and optimizes the environment to meet business SLAs.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Adolescent

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

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

"Market Guide for Container Management"

"Best Practices to Enable Continuous Delivery With Containers and DevOps"

Sliding Into the Trough

BPaaS

Analysis by: Frances Karamouzis

Definition: Gartner defines business process as a service (BPaaS) as the delivery of business process services whose underlying construct involves the multitenancy often achieved by

leveraging cloud services. BPaaS bundles the infrastructure, application and business process layers into a combined offering. Services are often automated and the required labor pool is shared (so it's not overtly dedicated to a specific client). The pricing models are consumption-based or subscription-based commercial terms that may be gain-sharing or business outcome-based.

Position and Adoption Speed Justification: According to Gartner CEO's Study (2019), the No. 1 challenge CEOs face is "outdated work processes." The onset of the crisis added to this challenge, as the nature of required remote virtual work processes has led to a business mandate that the "default is digital" for our work processes, data and execution of functions. This has reinvigorated the focus on delivery of business and IT processes, leveraging intelligent automation for speed, scalability, repeatability and business agility at lower risk. In addition, the use of the cloud to facilitate multitenancy is a critical component in faster deployments, lower total cost of ownership (TCO), and business agility above all. This continues to fuel BPaaS, as these offerings represent the intersection of all these areas.

The positioning of BPaaS approaching the Trough of Disillusionment means that thus far, offerings that meet all the criteria of a true BPaaS offering and promise have been elusive. Additionally, there has not been a clear and definable set of vendors (either service providers, product and/or platform companies) delivering true BPaaS. However, the confluence of many forces continues to enable and fuel more vendors to construct various BPaaS offerings. However, the relative success has been unevenly distributed across different types of business processes and markets. BPaaS structures are not new; however, they are diverse and range in maturity.

User Advice: The most important advice for buyers is to seek out the primary value proposition of BPaaS, which includes multitenancy for speed, efficiency, efficacy, predictability and analytics at each layer of the business process services (people, workflow, applications and infrastructure). In order to do this, Gartner advises that buyers look for two key elements. First, look for a consistent set of standards (across people, workflow and applications) for the offering that can be industrialized and be delivered through multitenancy. Second, BPaaS requires significant R&D investments on the part of sellers, which are often driven by a commitment of scope on the part of buyers.

The biggest challenge to analyzing BPaaS vendors is that they often do not use the term "BPaaS," and there are no clear, distinct offerings within a category. Unfortunately, BPaaS comes in many shapes and sizes, because it can be available in a variety of industries and/or business functions.

Evaluating and buying BPaaS solutions can be difficult. BPaaS buyers should:

- Establish multidisciplinary functional and IT teams.
- Recognize and account for high diversity across industry BPaaS offerings. Currently, there is a lot of fragmentation across a large array of processes (and subprocesses) and a large cross-section of industry-specific services (such as banking, insurance and pharmaceuticals). Different types of BPaaS offerings are maturing at different rates.
- Watch for innovations in offerings, as BPaaS continues to evolve and new offerings emerge every year. Many leverage cloud services and smart machine platforms.

- Carefully assess the multitenancy and proven “integrated” technologies of BPaaS offerings. The value proposition and scope of specific offerings will be widely dispersed, and standards will take several years to emerge.

Business Impact: BPaaS can have a significant impact, as it drives the functional teams to recalibrate business processes to focus on deeper relationships with their customers, suppliers and partners, create more transparency, and industrialize and automate with a goal to digitize. All these demands are the root driver for seeking out BPaaS. Business is virtual and fluid, and with customer interactions from any device, anywhere and at any time. As a result, organizations are moving away from monolithic and inwardly focused concepts in favor of leveraging cloud options, including BPaaS. The most significant business impacts of BPaaS will be the ability to reduce the “run the business” cost structures, and to release resources for differentiation and innovation. The cloud-based structures that underpin BPaaS offerings bring a level of standardization, accessibility and ubiquity that drives cost reductions.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Accenture; Capgemini; EXL; Genpact; Hexaware; IBM; TCS; Teleperformance; Wipro; WNS

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 been hyped as the number of traditional workloads that have been migrated to a public cloud increases. 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 expected 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 is declining.

Repatriation refers to 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. Repatriation also doesn't include applications developed in cloud environments with the intention of deploying in another environment, including noncloud environments.

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 overhyped 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. In 2020, repatriation hype is already diminishing compared to repatriation hype noted in 2019.

User Advice: When confronted with the topic of repatriation:

- Consider repatriation anecdotes with skepticism, especially when delivered from entities with a bias toward preserving traditional data center businesses. While repatriation may be mentioned in industry discussions, 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. Proactive 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. Ongoing optimization should be part of the ongoing cloud management practices. Consider cloud-native application design, architecture and operations 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 planning and due diligence before moving any workload to the cloud to avoid the need for repatriation in the future.

Benefit Rating: Low

Market Penetration: 20% to 50% of target audience

Maturity: Legacy

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

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

“Define and Understand New Cloud Terms to Succeed in the New Cloud Era”

“Revisiting the Top 10 Cloud Myths for 2020”

“The Cloud Strategy Cookbook, 2019”

Cloud Marketplaces

Analysis by: Ed Anderson

Definition: Cloud marketplaces are online storefronts through which customers can find and subscribe to cloud service offerings, including IaaS, PaaS and SaaS. Cloud-related IT services offerings, such as consulting or migration services, are now appearing in some marketplaces. Cloud marketplaces are a type of cloud service brokerage, where the marketplace provider aggregates disparate cloud service offerings (often curated) and presents them as a collection of service offerings, usually through a portal, and sometimes referred to as “cloud app stores.”

Position and Adoption Speed Justification: Cloud marketplaces are growing in influence as a destination to find and procure cloud services, applications and service components. Cloud service providers, technology distributors, resellers, cloud service brokerage (CSB) providers and even internal IT organizations are building and delivering cloud marketplaces to their constituents. Cloud app stores, cloud service catalogs and portals are also types of cloud marketplaces, but they are typically built for consumption by a closed community of users. Cloud marketplaces may be public (open to anyone) or private.

Cloud service providers (CSPs) use cloud marketplaces to highlight their own cloud service offerings and their partners’ offerings. CSPs also use marketplaces to strengthen their ecosystem of solutions, which in turn reinforces the importance of the supporting cloud platform. Cloud marketplace offerings are typically built and supported by third-party independent software vendors (ISVs) and are most often delivered as software as a service (SaaS) offerings.

Cloud service subscribers use cloud marketplaces as a means to simplify the process of finding, purchasing and using cloud services. Marketplaces can also be used to highlight validated or sanctioned services, which can complement cloud governance policies for approved cloud service usage. Cloud service aggregation features, such as unified billing, are often included.

User Advice: The cloud marketplaces currently in market and in use by organizations have very different capabilities and serve different purposes. Most, including those offered by cloud service providers, are basic in their capabilities, although more sophisticated offerings have emerged in the market. The most fundamental type of marketplace is nothing more than a directory of cloud service offerings, with no value-added capabilities beyond the catalog. More sophisticated cloud marketplaces include additional services, such as authentication and authorization, metering, aggregated billing and reporting, provisioning, data management and integration, compliance, and security. More recently, marketplaces are including unified contracting to facilitate cross-solution procurement.

Organizations should use marketplaces to expedite the discovery and delivery of solutions that meet both their business requirements and technology preferences. Marketplaces offered by providers serve specific purposes and are represented by different types of marketplaces:

- Marketplaces of cloud services built to enhance or extend a specific cloud service offering (example: Salesforce AppExchange).
- General-purpose marketplaces, with cloud services from different providers (example: Ingram Micro Cloud Marketplace).
- Vertical industry marketplaces, with cloud services designed for specific vertical industry needs or use cases (example: government cloud marketplaces).
- Internal cloud marketplaces designed for internal discovery and deployment of preapproved cloud services. Internal marketplaces are usually delivered as a service catalog accessed through an internal portal.
- Marketplaces of solutions designed for a specific cloud platform. These marketplaces are effectively software catalogs, with purchasing and delivery capabilities (example: Amazon's AWS Marketplace).

Organizations should assess the benefits of value-added services offered through cloud marketplaces. Value-added services may be available as business services (such as billing, compliance, vertical industry specialization and managed services) or technology services (such as integration, monitoring, service delivering, security and customization). Internal cloud marketplaces can deliver similar benefits when enhanced with internal or external IT services. Conversely, cloud marketplaces may provide a level of intermediation that may make it more difficult for the organization to interact with the cloud service or the cloud service provider.

Business Impact: Third-party cloud marketplaces will be most popular with smaller organizations that benefit from the value-added capabilities of cloud marketplaces, or business units within large organizations. Larger organizations will also make use of cloud marketplaces associated with their chosen cloud platform(s). Organizations with sophisticated IT capabilities may establish a cloud marketplace as part of an internal IT organization, designed to facilitate usage of internal and external cloud services, and to provide management and control over the organization's collection of cloud services.

Benefit Rating: Moderate

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Alibaba Cloud; Amazon Web Services; CDW; Cloud28+; Google; IBM; Ingram Micro; Microsoft; Salesforce

Recommended Reading: "Navigating Online Marketplaces: Executive-Level Guide"

"Predicts 2020: Negotiate Software and Cloud Contracts to Manage Marketplace Growth and Reduce Legacy Costs"

"Top Emerging Trends in Cloud-Native Infrastructure"

Desktop as a Service

Analysis by: Nathan Hill; Michael Silver

Definition: Desktop as a service (DaaS) is a service offering that provides users with an on-demand, virtualized desktop experience delivered from a remotely hosted location. It includes provisioning, patching and maintenance of the management plane and resources to host workloads.

Position and Adoption Speed Justification: Organizations have long been interested in adopting virtual desktop infrastructure (VDI), but complexity and capital investment have made VDI implementations difficult. Relying on a service provider to take on the risk of platform build-out and to provide high-volume computing services is an attractive alternative for organizations that want to deliver applications on a device-neutral basis.

DaaS vendors originate from a software, cloud or hosting backgrounds. Some own the complete platform (such as Amazon WorkSpaces and Microsoft Windows Virtual Desktop), while others leverage hyperscale platforms, especially from Amazon and Microsoft, to bring a service-brokered offering to market.

The adoption of cloud office and SaaS increases the viability of a DaaS solution as an organization's data and services become increasingly externalized, especially when supporting highly geographically dispersed workers. This, coupled with the entry of Microsoft into the market, has injected a significant amount of hype back into DaaS. Microsoft isn't the only DaaS choice, but it heavily influences digital workplace I&O leaders' thinking, due to Microsoft's control points in the ecosystem. DaaS is moving toward the Trough of Disillusionment partly because of greater understanding of its long-term cost implications, but also as knowledge of all strengths and weaknesses become more widely understood.

COVID-19 has highlighted the value and business continuity strength of DaaS in its ability to rapidly enable remote work where on-premises options have stalled due to issues with data center access and infrastructure supply chains. COVID-19 is likely to accelerate adoption of DaaS, and may perpetuate as a delivery architecture even when employees return to the office.

User Advice: Enterprises should consider DaaS for use cases related to transient access requirements, business continuity needs or accelerating business goals. The typically high total cost of ownership (TCO) makes it hard to justify DaaS, but COVID-19 has highlighted it as a very strong solution for remote working and work-from-home scenarios. Organizations should not hesitate to conduct a proof of concept (POC) to gain a better understanding of how this service can benefit their organization.

Use DaaS for:

- Short-term employees, such as seasonal workers, where user volumes spike, or for workspace provisioning to third parties and contractors. The per-user/per-month common billing approach

makes this ideal to avoid asset-loss risk and to reduce the provisioning lead time associated with notebooks.

- Merger and acquisition (M&A). As with short-term employees, VDI can help with M&As, but the lead time for infrastructure procurement and underutilized capacity may make DaaS a better fit to accelerate the M&A process, even if only temporarily.
- Remote workers. DaaS can extend the workspace to remote users, especially with hyperscale solutions that have deep global penetration, and may be preferable to expanding an existing data center or colocation footprint.
- Business continuity. DaaS can be used as a workspace recovery solution and has proven a successful solution during COVID-19, enabling organizations to securely extend work from home.

Graphics-enabled DaaS extends the service to designer use cases. However, the cost differential compared with on-premises VDI and the performance sensitivity can be even greater here. Organizations must test functionality and performance thoroughly. Look to combine DaaS with other services provided from the same cloud provider to improve network connectivity to the cloud (such as SLA-backed, dedicated links) to optimize performance.

For smaller organizations that are aggressively migrating to cloud services and have fewer legacy integration challenges, the adoption of DaaS as a complete workforce solution is likely to be more viable. Typically, these organizations do not want to invest capital expenditure (capex) in data center infrastructures and operating expenditure (opex) in associated administration staff, if this distracts them from their core business goals.

Business Impact: DaaS has suffered from the challenges associated with the technologies that power it, namely server-based computing (SBC) and VDI. Cost, complexity and connectivity have all been inhibitors. However, with more organizations looking to deliver user-centric services across different devices and locations with an ever-increasing consumption of cloud services (SaaS, storage and productivity tools), DaaS is considered a strategic solution. The benefits of the “pay-per-use” utility of the DaaS opex model have gained mind share, as has the entry of Microsoft into the market. However, the service needs to be able to deliver a complete workspace solution for it to be viable as a primary business platform. Growth in adoption through the COVID-19 pandemic is helping to accelerate maturity in the service, but hype still remains.

Many DaaS vendors are expanding their service portfolio beyond simple OS hosting to deliver a complete workspace management life cycle solution. However, organizations that are totally reliant on browser-agnostic web applications will question the need for a Windows OS-based workspace intermediary.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

Sample Vendors: Amazon; Citrix; Diso; Dizzion; Evolve IP; Microsoft; Nutanix; Tehama; VMware; Workspot

Recommended Reading: "Market Guide for Desktop as a Service"

"Forecast Analysis: Desktop as a Service, Worldwide"

"Microsoft's WVD Will Accelerate Virtual Desktop Maturity but May Not Lower Total Cost of Ownership Enough"

"Physical, Virtual and Cloud Desktops: Is a Hybrid Approach Inevitable?"

"How to Keep End Users Connected to the Digital Workplace During Disruptions"

Serverless PaaS

Analysis by: Yefim Natis; Anne Thomas

Definition: A PaaS offering delivered with serverless characteristics is serverless PaaS. Serverless is a way of delivering a cloud service where the underlying resources are opaque, do not require 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 Alibaba, Amazon, Google, IBM, Microsoft and Oracle), extends well beyond functions. All PaaS capabilities can be delivered with serverless characteristics and many are already (for example, Google App Engine or AWS Fargate). Majority of PaaS offerings are opaque and thus deliver some of the serverless experience. Fewer are also provisionless and fewer yet 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 Apache OpenWhisk, Knative or OpenFaaS 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 respects 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 (as in Microsoft Azure Functions); 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 steadily increasing with new use cases and supporting technologies. But at the same time the limits of this architecture is also settling in and few expect fPaaS to become a replacement of the more traditional container-centric application platforms.

The principles of serverless are also increasingly applied beyond just the fPaaS — other cloud services from various providers are delivered serverless, including databases (Azure 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 and use cases become increasingly recognized.

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 duration or scale of execution of an instance of a function) 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.

Business Impact: Serverless PaaS represents the true cloud-style operations for cloud platform services. Adoption of a serverless PaaS delivery model increases productivity and efficiency of PaaS, and helps to streamline development, scale operations and reduce infrastructure costs. It will create a more consistent and manageable environment for new cloud applications and put pressure on modernizing the older ones. Because serverless effect is exclusive to the cloud — adoption of serverless also translates to a strategic adoption of cloud. Ultimately, the business experience of the "serverless IT" will feature increased scalability, reduced costs and faster application times to market.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; Amazon Web Services; Google Cloud Platform; IBM Cloud; Microsoft Azure; Oracle; SAP Cloud Platform

Recommended Reading: "Top 10 Trends in PaaS and Platform Innovation, 2020"

"A CIO's Guide to Serverless Computing"

"Top Emerging Trends in Cloud-Native Infrastructure"

"Security Considerations and Best Practices for Securing Serverless PaaS"

"Evolution of Virtualization: VMs, Containers, Serverless — Which to Use When?"

"Decision Point for Selecting Virtualized Compute: VMs, Containers or Serverless"

"Innovation Insight for Serverless PaaS"

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

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

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

IoT Platform

Analysis by: Alfonso Velosa; Eric Goodness; Scot Kim

Definition: An Internet of Things (IoT) platform is a software that enables development, deployment and management of business solutions that connect to and capture data from IoT endpoints to improve operations such as monitoring remote assets or optimizing maintenance. Capabilities include:

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

It may be delivered as edge or on-premises software, or cloud IoT platform as a service, or a hybrid combination.

Position and Adoption Speed Justification: Enterprises continue adding IoT capabilities to assets and products, seeking benefits such as cost optimization, process 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, most often implemented as an IoT platform. While enterprises across all verticals are deploying IoT, the strongest impetus comes from asset intensive industries such as manufacturing or oil and gas.

Continued integration, culture, and security challenges, and schedule delays for IoT projects, as well as excess vendor hype has moved IoT platforms closer to the Trough of Disillusionment. 2020 sees many vendors struggling to maintain business and technology viability as end users delay deployments due to economic uncertainty and employee safety concerns. Further, most large vendors have yet to develop a clear IoT platform strategy that will drive scale. Yet there is increased vendor and enterprise focus on application enablement and solutions that deliver clear business results and shorter project payback. These trends lead us to shorten the time to plateau down to two to five years. Note that the speed of adoption continues to across the consumer, commercial and industrial verticals.

User Advice: CIOs should factor in the following issues:

- Deployments: Start with smaller IoT projects, identify IoT platform technology strengths and weaknesses, acquire implementation lessons, and verify alignment to business KPIs and project payback requirements.
- Architecture: IoT platform strategies should be aligned to either external business foci, such as for an OEM's connected product, or internal foci, such as 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. Use these insights to establish a distributed deployment and a platform of platforms architecture for using multiple IoT platforms for different enterprise needs. Be aware that while this drives scalability and mitigates your vendor risk it increases your complexity and cost risk.
- Skills: IoT projects using IoT platforms require new skills. Improve team's capabilities such as integration, based on a skills gap analysis. Develop a plan for how IT personnel can complement the IoT platform skills within the business units, and drive IT-OT alignment. Plan to leverage a service partner to support critical initiatives.
- Customization: While no IoT platform will work straight out of the box, push your technology vendors to deliver vertical market modules and solutions optimized for your vertical.
- Vendor selection: Prioritize vendors you already work with, for their IoT platform. Evaluate candidate vendors on their fit-to-your-business objectives and technology. 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, long term support capabilities, and references that show business results.

Business Impact: There is a significant opportunity for enterprise stakeholders to leverage IoT-enabled assets and business processes to achieve greater value. This includes making better decisions from the data and information generated by connected products, people and equipment. This improves decision making and provides better decisions about assets 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 business process transformation.

Benefit Rating: High

Market Penetration: 5% to 20% of target audience

Maturity: Adolescent

Sample Vendors: Alibaba Cloud; AWS; Eurotech; Flutura; Kaa; Litmus Automation; Microsoft Azure; PTC (ThingWorx); ROOTCLOUD; Samsung SDS

Recommended Reading: "Magic Quadrant for Industrial IoT Platforms"

"Critical Capabilities for Industrial IoT Platforms"

"Survey Analysis: As More Companies Deploy IoT, They Increasingly Focus on Best Practices and Payback"

"Competitive Landscape: IoT Platform Vendors"

Cloud Managed Services

Analysis by: Craig Lowery

Definition: Cloud managed services are IT service offerings that provide for the day-to-day management of, and operational responsibility for, cloud service environments. A select set of professional services are typically offered and highly coordinated with the managed services to assist with cloud strategy, workload migration, solutions architecture, and ongoing transformation efforts. Cloud service brokerage is often delivered as a cloud managed service.

Position and Adoption Speed Justification: Cloud managed services providers (MSPs) have varying levels of capability based on the specific technologies and personnel roles they use to deliver their services. MSPs differentiate from each other in how they automate the delivery of their professional and managed services. Providers develop an integrated combination of proprietary, open source and partner technologies to serve their targeted use cases and customer sets. Providers also face the same challenges as end users in developing and retaining a skilled workforce but are generally better positioned to attract and cultivate those resources.

Demand for cloud managed services has grown steadily, tracking the increase in adoption of public cloud. The move to more cloud-native solutions and complex deployment scenarios such as hybrid cloud and multicloud have substantially emphasized the need for the professional services

expertise. Strong cloud MSPs will demonstrate cloud capabilities aligned with hyperscale cloud infrastructure and platform services (CIPS) providers and will embrace new technology innovations such as artificial intelligence, automation, data services, and edge computing.

User Advice: Organizations considering cloud managed service offerings must carefully assess providers to ensure the provider has up-to-date expertise and a track record of success. Providers typically offer cloud-related IT service offerings across the adoption spectrum from initial and ongoing advisory services (design), implementation services (build) and managed services (run). Look for providers with capabilities across this continuum and evidence of 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 services 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: Good cloud MSPs help cloud-adopting organizations scale their cloud skills and capabilities quickly and effectively. The primary benefit is to augment the organization's expertise with certified, experienced personnel to provide advice and convey best practices. Even so, some customers choose to fully outsource large portions of their cloud estate to an MSP. The secondary benefit is to provide the tooling and day-to-day management of a highly dynamic operating environment, which many organizations are often unable to source themselves. In these ways, cloud managed services help an organization to fully exploit the full capabilities of the cloud for near- and long-term benefits. Addressing the immediate challenges of workload migration and establishing an operational environment result in only modest benefits. However, when organizations work with providers to unlock the disruptive potential possibilities of cloud computing, engaging in more innovative, digital processes, they are more likely to achieve profound transformative outcomes over time.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Accenture; Bespin Global; Capgemini; Cognizant; Deloitte; Logicworks; Rackspace; Smartronix; Tata Consultancy Services; Wipro

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

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

Hybrid Cloud Computing

Analysis by: David Mitchell Smith, Milind Govekar

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 theoretically 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. Hybrid cloud 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 can also be enabled by service providers focused on delivering 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 and TCS) and other service providers and system integrators.

Microsoft's Azure Stack Hub, Google's Anthos, VMware's hybrid cloud portfolio, and AWS's Direct Connect and Amazon Virtual Private Cloud (VPC) are all attempts to support hybrid cloud implementations. Red Hat's OpenShift and Pivotal Web Services are attempts to support hybrid PaaS implementations.

As more providers deliver hybrid cloud offerings, they are increasingly delivering a packaging of the concept. "Packaged hybrid" means you have a vendor-provided private cloud offering that is packaged and connected to a public cloud in a tethered way. Azure Stack from Microsoft is a good example of this packaging, but there is another approach as well. We call these two main approaches "like-for-like" hybrid and "layered technology" hybrid (spanning different technology bases). Packaged hybrid cloud is a key component of the distributed cloud concept.

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 approach improves the economic model and agility. It also sets the stage for new ways for enterprises to work with suppliers and partners (B2B) as well as customers (B2C), as these constituencies are also moving 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”

“Top 10 Strategic Technology Trends for 2020: Distributed Cloud”

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

“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 services as a way to augment service capacity and respond to increases in IT system requirements. Cloudbursting can occur between on-premises IT environments and public or private cloud environments, across cloud providers or across resource pools of a single provider.

Position and Adoption Speed Justification: Cloudbursting is based on the concept of utilizing cloud services as a way to rapidly add resource capacity when applications or services experience spikes in demand. Cloudbursting is seeing a resurgence as applications are implemented using container-based models and microservices architectures. The growing preference for hybrid and multicloud strategies increases the value of cloudbursting across systems. Cloudbursting is implemented as a type of autoscaling where applications scale across system boundaries. Although cloudbursting includes any scenario where cloud services are allocated in an on-demand fashion when additional capacity is required, cloudbursting also includes scenarios where less critical resources are moved to a cloud service in order to free up 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 can 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 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 workloads in parallel across distributed resource pools. If a microservices architecture is established on the target system, runtime expansion is much easier. Most legacy applications have storage and database architectures that cannot be easily adapted to

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

Barriers to cloudbursting usage include the lack of cross-platform cloud API standards, inadequacy of application instrumentation and management tools, networking latency between data centers, identity and security limitations, configuration management, technology license restrictions, and incompatible application architectures. Standardization of application models and the use of technologies that facilitate application migration, such as containers, can mitigate some of the cloudbursting challenges. While some organizations (mostly large organizations) report the use of cloudbursting, the actual number of applications and services that make use of cloudbursting is small.

The rising use of multicloud and distributed cloud architectures has renewed interest in cloudbursting as a means to leverage cloud capacity and capabilities across cloud environments. Distributed cloud offerings such as AWS Outposts, IBM Satellite, Microsoft Azure Stack and Oracle Cloud at Customer will drive cloudbursting scenarios. Additionally, platform abstraction technologies such as IBM/Red Hat OpenShift, Google Anthos, VMware Tanzu and others help establish a common set of capabilities across cloud and non-cloud environments and theoretically simplify cloudbursting across these systems.

User Advice: Cloudbursting is often cited as a key use case for hybrid cloud or multicloud environments. In practice, cloudbursting remains an aspirational notion for most organizations because of the difficulties in implementing cloudbursting. Use cloudbursting in situations where there is notable benefit to offset implementation cost and complexity:

- Select workloads and applications that are conducive to scale out execution using parallel and distributed processing models and which experience periodic spikes in resource requirements.
- 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.
- Leverage cross-platform abstractions to increase compatibility between systems.
- Implement cloudbursting as an automated, operational process that can dynamically identify cloudbursting opportunities and automatically initiate cloudbursting.
- Implement robust network connectivity between cloud environments where cloudbursting is expected to occur.
- Carefully evaluate the financial implications of cloudbursting; there may be significant costs associated cloud resource consumption as well as increased networking costs.

Business Impact: Cloudbursting has the potential to reduce the overall cost of supporting applications by dynamically provisioning computing resources on-demand using cloud resources. This is particularly true for workloads with variable resource demands. Cloudbursting makes use of cloud services to satisfy capacity overflow for on-premises and cloud-based workloads.

Benefit Rating: Moderate

Market Penetration: 5% to 20% of target audience

Maturity: Early mainstream

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

Recommended Reading: "Revisiting the Top 10 Cloud Myths for 2020"

"Define and Understand New Cloud Terms to Succeed in the New Cloud Era"

"'Distributed Cloud' Fixes What 'Hybrid Cloud' Breaks"

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

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 multicloud), 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: Enterprises are looking for ways to use a variety of cloud services efficiently and effectively. 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.

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 and problem management
- Protecting the enterprise — In terms of security, compliance and resilience from provider failures

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 (HPE); 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"

Cloud Center of Excellence

Analysis by: Lydia Leong; Ed Anderson

Definition: A cloud center of excellence (CCOE) is a centralized enterprise architecture function that leads and governs cloud computing adoption within an organization.

Position and Adoption Speed Justification: A CCOE is usually the most effective way for most organizations to achieve organizationwide cloud governance. The CCOE has three core functions — cloud brokerage, cloud governance and leadership of a cloud community of practice. It serves as an internal cloud consulting practice that delivers cloud architectures and recommended solutions. It also partners with the sourcing team to provide cloud vendor management, including cloud service expense management. It gathers knowledge and best practices from the from the cloud community of practice, to raise the organization's level of cloud expertise. The CCOE achieves success by ensuring that the "path of least resistance" for cloud use is also the path that is well-governed and meets the organization's security and regulatory compliance requirements. Although it is responsible for developing cloud computing policies, it primarily influences, rather than controls, and depends on other teams to implement and enforce policies.

Many organizations that have adopted cloud services have created a CCOE, but most such CCOEs are not yet mature. Furthermore, some organizations make mistakes in setting the structure and mission of the CCOE, resulting in a failure of the CCOE to make the desired business impact. Most cloud migration service providers strongly recommend that customers create a CCOE, and will assist customers in doing so. The CCOE is typically small, and its effectiveness depends on educating and influencing others throughout the organization who are actually implementing the use of cloud services. The CCOE also helps the business to cloud-enable digital transformation, and may ideate new cloud-enabled business innovations. The CCOE helps guide an organization's cloud journey, as cloud use grows within an organization, and the organization discovers the best practices for cloud usage that are specific to its business needs. In most cases, the CCOE, governance guidelines and guardrails, and solutions must evolve with the business and its cloud use.

User Advice: A CCOE should be led by a chief cloud architect and staffed by cloud architects. The chief cloud architect typically also leads a cross-functional cloud computing advisory committee that contains representatives from the business; technical end-user teams (such as the application development teams); infrastructure and operations; and sourcing, security, compliance, risk management, and legal teams. Some organizations hire an individual contractor with very strong knowledge of their primary cloud services to lead their CCOE, but such an individual needs an enterprise architect partner who has very strong knowledge of the business and the necessary cross-functional relationships. Do not understaff the CCOE, since this can be a major threat to its influence and success. If the organization has a rapidly growing number of cloud projects, it may be wise to open head count for CCOE architects well in advance of demand, since there is significant competition for this skill set.

A CCOE frequently chooses governance tools and sets policies, but is often not responsible for operating those tools, and may not be responsible for implementing the policies. In organizations that utilize significant self-service — especially decentralized organizations — the CCOE must maintain strong developer relations in order to both evangelize existing best practices, as well as to continuously collect best practices from these teams. The CCOE frequently facilitates knowledge sharing between these technical end-user teams.

Business Impact: The CCOE is the hub of the cloud community within an organization, and it must build and foster that community. It is a critical part of helping the organization mature its use of cloud computing. The CCOE holds together the disparate ways that an organization might adopt cloud computing, through its centralization of cloud knowledge, best practices and common tools, as well as its active outreach throughout the organization. The CCOE function may also be closely aligned to the internal cloud service brokerage (CSB) function.

Nearly all organizations that use cloud services can benefit from a CCOE until their cloud adoption is fully mature and cloud expertise is dispersed across all related functions. In smaller organizations, the CCOE function may be performed by a single cloud architect. A single CCOE can serve both modes of bimodal IT, but will likely have different best practices for each mode; and the most successful CCOEs are typically more focused on business agility than cost reduction.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Recommended Reading: “Innovation Insight for the Cloud Center of Excellence”

“How to Build a Cloud Center of Excellence, Part 1: Designing for Cloud Adoption Success”

“How to Build a Cloud Center of Excellence, Part 2: Implementing the Foundations for Cloud Adoption Success”

“The Cloud Architect: Skills Guidance for Modern Technical Professionals”

Climbing the Slope

Cloud Networking

Analysis by: Sid Nag

Definition: Cloud networking is a cloud provider service to connect hybrid IT, hybrid cloud and multicloud environments and IaaS networking. Such services provide robust interconnectivity within a cloud provider’s network and between external cloud data centers; a customer’s on-premises, hosted data centers; and colocation facilities. It includes capabilities such as virtual private cloud, QoS and latency, content distribution; network availability for applications, hosted or colocated environments, private clouds and external public cloud services.

Position and Adoption Speed Justification: Cloud networking which includes cloud interconnect, VPC networking, zero trust networking and network services, is a major decision criterion for selection of cloud providers by 75% of enterprises. Organizations must select providers that include cloud networking as a cornerstone of their cloud provider's capabilities, as issues with network connectivity across the hybrid IT environment and multiple cloud providers' data centers increase in complexity. Cloud networking is therefore a critical component of an organization's multicloud adoption model. Over 80% of organizations have adopted or plan to adopt multicloud environments by the end of 2020, making cloud networking an important technology. Cloud networking is also the technology that provides for building and managing secure private networks over the public internet by utilizing global cloud computing infrastructure. In cloud networking, the traditional network functions and services, including connectivity, security, management and control, are delivered as a service in the cloud.

User Advice: As users move applications into the cloud, new cloud networking requirements may emerge:

- There will often be a requirement for the application and (users of such applications) running in a cloud provider's data center to interact and interoperate with other applications that still reside in the customer's data centers.
- Cloud applications may need to interact with other applications running in a different cloud provider's cloud data center.
- As multicloud adoption increases, organizations need to be familiar with multiple CSP stacks, and may look at third-party solutions for help.
- Due to governance and compliance reasons, the data associated with an application running in the cloud may still have to reside in the customer's data centers.

All these scenarios create a need for a robust connectivity model to achieve optimal application performance. Organizations must:

- Select cloud networking offerings that include capabilities to select the right connectivity provider whether it is a cloud provider, a cloud networking exchange provider (such as a data center hosting or colocation provider) or a traditional ISP. Furthermore, cloud networking offerings should provide cost comparisons of selecting one connectivity provider over the other.
- Institute a requirement that critical quality of service (QoS) and latency and availability issues are addressed by their cloud provider, especially for mission-critical applications that are running in the cloud. Provider offerings should address requirements for dual homing, peering point selection, route advertising, elastic load balancing, content distribution, virtual private cloud, and other networking issues.
- Mandate other capabilities which include rapid provisioning of MPLS, VPN and SD-WAN support for complex overlays for connecting their on-premises locations into the cloud provider's data center.

Business Impact: Cloud networking challenges, which continue to be a top challenge to the adoption of cloud, have gained attention in the industry as a critical element that many organizations are using as selection criteria for cloud services. It is clear that cloud interconnect architectures (see "Market Insight: How to Seize the Cloud Networking Service Opportunity") are important for all applications across the disaggregated multiclouds, hybrid cloud and hybrid IT environments. Moving forward, as organizations increasingly adopt multiclouds and move their vertical-specific mission-critical applications to the cloud, cloud interconnect architectures will become even more critical.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Amazon Web Services (AWS); AT&T; Aviatrix; Cisco; Digital Realty; Equinix; Google Cloud Platform; Microsoft Azure; Verizon; VMware

Recommended Reading: "Market Insight: How to Seize the Cloud Networking Service Opportunity"

"A Tour of Gartner's Cloud Networking Research"

"Utilizing Network Service Provider Direct WAN Connectivity for the Cloud"

"Five Key Factors to Prepare Your WAN for Multicloud Connectivity"

"How to Interconnect With Azure, AWS and Google Backbones"

"How to Architect Your WAN for Hybrid Cloud and Multicloud"

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. Recent offerings from the major cloud providers for on-premises cloud footprints (tethered cloud) have created another, newer form of private cloud computing — and these immature alternatives are keeping private cloud from the Hype Cycle plateau.

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, and 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, tethered cloud 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 accomplish 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 (HPE); IBM; Microsoft; Red Hat; VMware

Recommended Reading: "Rethink Your Internal Private Cloud"

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

CIPS

Analysis by: Sid Nag; Yefim Natis

Definition: Cloud infrastructure and platform services is the business and technology arrangement where IaaS and/or PaaS capabilities are offered as cloud services. Integrated CIPS implies integration of IaaS and PaaS. The degree of integration may vary but it includes the use of a single self-service portal and catalog, shared identity and access management, a single integrated low-latency network context, unified security, unified monitoring and unified billing.

Position and Adoption Speed Justification: IaaS and PaaS are naturally complementary, causing IaaS providers to expand into PaaS. The more ambitious providers rooted in PaaS are expanding into IaaS, typically through partnerships. Hyperscale cloud providers such as AWS, Azure, GCP offer these integrated capabilities themselves. Integrated approaches allow users to combine different cloud delivery models of system and application infrastructure within a unified environment.

Cloud infrastructure and platform services (CIPS) represents a continuum, and some offerings in the market have characteristics of both. For example container management IaaS, like Google Kubernetes Engine (GKE), is often compared to an application PaaS, however GKE offers no tooling and abstractions to support developer workflows. GKE does however offer greater control and flexibility for configuring the compute resources. A traditional application PaaS, like Salesforce (Heroku), enables customers to build and deploy applications through developer-centric abstractions and configures and automates the IaaS resources on behalf of the user.

The appeal for CIPS is not in best-of-breed offerings, but in the unification and integration of platform capabilities across these services enabling a scalable user experience for enterprise governance and operations.

Most customers that use a hyperscale CIPS provider, such as Amazon Web Services or Microsoft Azure, have adopted a blend of the provider's IaaS and PaaS capabilities. IaaS resources are typically supplemented with cloud software infrastructure services, such as dbPaaS, aPaaS and iPaaS. Indeed, the availability of this broad portfolio of services is a key aspect of choosing a strategic cloud platform provider. Hyperscalers deliver PaaS services with a direct dependency on their IaaS services. As a customer, whether you are using PaaS services or IaaS services, they are built on a common substrate. The combination of these services means you are making a strategic bet on the cloud provider.

The complexity and level of investment required to offer a full, integrated portfolio of multifunctional PaaS and IaaS services will likely limit the vendor options in this market to a handful of hyperscalers. Some of the hyperscalers will form ecosystems, enabling smaller PaaS specialists to be included in this market. However, the maturity of this technology will be primarily dependent on the capabilities of the hyperscalers.

User Advice: CIOs, CTOs, IT leaders and planners must:

- Use CIPS in both cloud-native and legacy migration projects to expand your design and deployment options. In some cases, this may involve using capabilities from multiple cloud providers.
- Prioritize consolidating systems on a hyperscaler CIPS offering when you are operating and governing fleets of applications at enterprise scale. This improves your economies of scale, skills and resources through standardization and consistency across your company and industry.
- Consider integrated CIPS providers to be long-term application platforms. They should be managed as such, with appropriate attention to potential application portability issues.
- Do not assume that all services of the provider are of the same maturity, functional completeness or quality of service.
- When considering a smaller specialist PaaS provider, give extra credit to those that are multicloud and, therefore, can be colocated with multiple larger suites of CIPS capabilities.

Business Impact: Consider the following impact areas:

- A well-functioning CIPS will offer enterprises a more natural, flexible and comprehensive ramp-up path to cloud computing and, consequently, will increase the rate and scope of adoption of cloud by mainstream IT.
- CIPS allows customers greater flexibility to come into a cloud environment, with the balance of control and ease of use that suits their needs at the time, and to shift that balance in either direction as their needs evolve.

- Vendors also benefit from CIPS — those coming from IaaS and those specialized in PaaS increase their customer value proposition and ability to compete when covering the broader set of capabilities. Because only the largest vendors are able to offer their own implementations of IaaS and PaaS, the increasing popularity of CIPS will contribute to the trend of PaaS market consolidation.

Benefit Rating: High

Market Penetration: 20% to 50% of target audience

Maturity: Early mainstream

Sample Vendors: Alibaba Cloud; Amazon Web Services; Google Cloud Platform; IBM; Microsoft Azure; Oracle; Tencent

Recommended Reading: "Why Product Managers Must Enable a CIPS Adoption Model"

"Technology Insight for Integrated IaaS and PaaS"

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

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

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 and IaaS. CASBs consolidate multiple types of security policy enforcement into one place. Examples include authentication, single sign-on, authorization, device profiling, data security, logging, alerting, and malware removal. 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 and apply consistent policy across multiple providers. Execution across all vendors is variable: while some have incrementally improved and added new capabilities, the leading vendors continue to make significant investments that have contributed to the rapid maturation of the market. The acquisition phase of the market has ceased. Major incumbent security vendors now offer a CASB, either stand-alone or as part of a product portfolio; integration with other products in portfolios is inconsistent but improving. 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, cloud security posture management (CSPM) capabilities, and user and entity behavior analysis (UEBA) features. The most relevant independent vendors continue to receive venture capital funding, while funding for the less well-known private vendors remains uncertain. The pace of client inquiry indicates that CASB is a popular choice for cloud-using organizations. Gartner's 4Q19 security spend forecast predicts a significant but slowing growth rate for CASB: 45.3% in 2020, 40.7% in 2021, 36.7% in

2022, and 33.2% in 2023. While the forecast predicts slowing spend for all security markets, CASB's growth remains higher than any other information security market (see, "Forecast: Information Security and Risk Management, Worldwide, 2017-2023, 4Q19 Update").

User Advice: Examine vendor capabilities in four functionality areas: visibility, data protection, threat detection and compliance. All relevant CASB vendors interact with SaaS applications via APIs and can be positioned in-line for real-time traffic visibility. CASB proxies may or may not require endpoint agents for traffic steering outside proxied networks; factor this into your evaluation. Increasingly, CASB vendors offer remote browser isolation as an adjunct to in-line deployments.

Common deployment scenarios that deserve special scrutiny include:

- **Cloud 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 (ask vendors for information about how often this is updated), 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.
- **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 classification tools.
- **Adaptive access control (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.
- **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 vendor is already deployed.
- **Third-party app discovery and control.** Ensure that the CASB can detect all third-party apps that have been granted access to SaaS applications (almost always via OAuth). Look for more than single yes/no controls for each app and instead favor the ability to group third-party apps into categories based on OAuth scopes.
- **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; Censornet; CipherCloud; Forcepoint; McAfee; Microsoft; Netskope; Proofpoint; Symantec; Zscaler

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

"Critical Capabilities for Cloud Access Security Brokers"

"Peer Lessons Learned: Implementing Cloud Access Security Brokers"

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

"Best Practices for Planning, Selecting, Deploying and Operating a CASB"

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 some strategies 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 cloud focus is on agility, speed and other benefits beyond cost savings.

"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 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 profile 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, each at various stages of industry hype.

New and advanced use cases for cloud introduce even more terms such as distributed cloud, multicloud and cloud-native. These add to the overall cloud hype as well as the applicability of cloud to more and more scenarios, including enabling next generation disruptions.

User Advice: User organizations must demand clarity from their vendors around cloud. Gartner's definitions and descriptions (which align with other useful ones such as NIST) 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 "Revisiting the Top 10 Cloud Myths for 2020" 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 their service portfolios grow.

Potential benefits of cloud include cost savings and capabilities related to the flexible and dynamic usage models of cloud (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 for organizations embracing cloud 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 2020"

“The Cloud Strategy Cookbook, 2019”

“Revisiting the Top 10 Cloud Myths for 2020”

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

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 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 services (apiPaaS), 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 even accelerating, brought about by the blurring boundaries between PaaS on one hand and IaaS or 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 hyperscale vendors that offer integrated collections of IaaS and xPaaS capabilities often in the form of cloud integrated platform service (CIPS).

The increasing maturity of the overall PaaS offerings is due to:

- Fast-improving execution by IT megavendors (including Microsoft, Amazon Web Services [AWS], Google, SAP, Salesforce, IBM and Oracle)
- Growing market acceptance of the smaller xPaaS innovators.
- Momentum of SaaS and IaaS offerings that are introducing PaaS to more organizations.
- Emerging born-on-the-cloud xPaaS capabilities (such as serverless fPaaS) that are inherently cloud-only.

All these trends are increasing customers’ confidence. And are also advancing adoption of PaaS overall toward the Plateau of Productivity. Some widely used 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. Also, 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.

- Utilize PaaS offerings for a full scale of their capabilities, well beyond the most popular application PaaS, including integration, event processing and stream analytics, IoT, business process management, database management and business analytics.
- When public cloud is not an acceptable option, consider the provider-managed (remote or local) virtual private PaaS ahead of the self-managed private option. Self-managed private PaaS is often too hard to carry out, for organizational and cultural reasons.
- Choose the hyperscale IaaS+PaaS or SaaS+PaaS 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.

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 (AWS); Dell Technologies (Boomi); Google Cloud Platform; IBM Cloud; Microsoft Azure; Oracle Cloud Platform; OutSystems; Salesforce Platform; SAP Cloud Platform

Recommended Reading: "Top 10 Trends in PaaS and Platform Innovation, 2020"

"Market Opportunity Map: PaaS, Worldwide"

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

"How to Manage and Optimize Costs of Public Cloud IaaS and PaaS"

"Application Architecture and Platforms for Technical Professionals Primer for 2020"

"Solution Criteria for Cloud Integrated IaaS and PaaS"

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, cost transparency with workload optimization to remediate cost overruns and handling newer functions like containers and serverless deployments). At the same time, major market consolidation will continue. For example, many vendors, that initially targeted cost management, have been acquired as this functionality is becoming a part of the basic CMP. Additionally many vendors in adjacent markets are acquiring CMP vendors and combining this functionality with asset management (software and hardware) and SaaS operational management. 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. Finally vendors in different markets (e.g., monitoring) are also entering the market. 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.
- First consider native cloud services as an alternative or option versus CMPs, particularly if you favor depth with an individual cloud provider versus breadth 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 financial management and capacity management areas.

Business Impact: Enterprises will deploy CMPs (increasingly as a part of a larger product suite) 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. This can be in support of DevOps initiatives.

Benefit Rating: Low

Market Penetration: 5% to 20% of target audience

Maturity: Mature mainstream

Sample Vendors: CloudBolt; Flexera; CloudSphere; Morpheus Data; Scalr; Snow Software; VMware

Recommended Reading: “Magic Quadrant for Cloud Management Platforms”

“Critical Capabilities for Cloud Management Platforms”

IaaS

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 while the nonhyperscale providers have largely been relegated to specialized 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. 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, greenfield 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 results 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: Transformational

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

Sample Vendors: Alibaba Cloud; Amazon Web Services (AWS); Google; IBM; Microsoft; Oracle; Tencent Cloud; Virtustream

Recommended Reading: “The Cloud Strategy Cookbook, 2019”

“Cloud and Edge Infrastructure Primer for 2019”

Entering the Plateau

Software as a Service

Analysis by: Christian Hestermann

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: SaaS has existed in some markets for more than 20 years, and has established itself as the normal delivery model for various application types. It is the primary delivery model for productivity tools, communication tools and line-of-business solutions including CRM, HCM, financials and procurement. 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 multitenant 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 broad operational ERP suites or 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 lack of critical functionality, concern for data residency requirements, complex integration requirements or when the regular updates are too disruptive. If you want to help your organization make the most effective use of SaaS:

- Give up on the idea that the IT department will own application choice and usage. IT can and should 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 most application capabilities, but prepare your organization for ongoing changes in business processes as a result.
- Strengthen IT's ability to build and maintain integrations between SaaS applications, including cloud-to-cloud integrations. Build data management and analysis as well as security skills across multiple clouds.
- Embrace standard SaaS offerings, if you can afford to give up some capabilities seen as less critical.
- Account for the fact that frequent updates of SaaS applications will occur, and you will not have control over them. To reduce business risk, frequent regression testing needs to be highly automated.
- Build a culture of continuous improvement to take advantage of upgrades while minimizing negative impact.
- 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, customization and decommissioning.
- Strengthen your organization's SaaS cloud contract management to reduce risk and minimize unexpected costs.

Business Impact: The one-size-fits-all model of SaaS represents a form of discipline and adherence to standard processes 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 or grows over time. The majority of SaaS vendors does not offer full pay-per-use models. 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. However, business innovation does not come for free and needs the ability to frequently review, revise and change business processes. 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. Also, the cost for continuous regression testing in more complex, multicloud environments can reduce the cost benefit.

Benefit Rating: Transformational

Market Penetration: More than 50% of target audience

Maturity: Early mainstream

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

Recommended Reading: "How to Cut Software and SaaS Costs and Quickly Improve Cash Flow in Times of Crisis"

"SaaS Cloud Contract Management Must Be Strengthened to Reduce Risk and Minimize Unexpected Costs"

"How to Plan for Resiliency in the Cloud"

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

"4 Preparation Steps to Optimize SaaS Negotiations"

"Toolkit: Prudently Accelerate Cloud Acquisitions for SaaS Using Gartner's Triage Methodology"

"A Public Cloud Risk Model: Accepting Cloud Risk Is OK, Ignoring Cloud Risk Is Tragic"

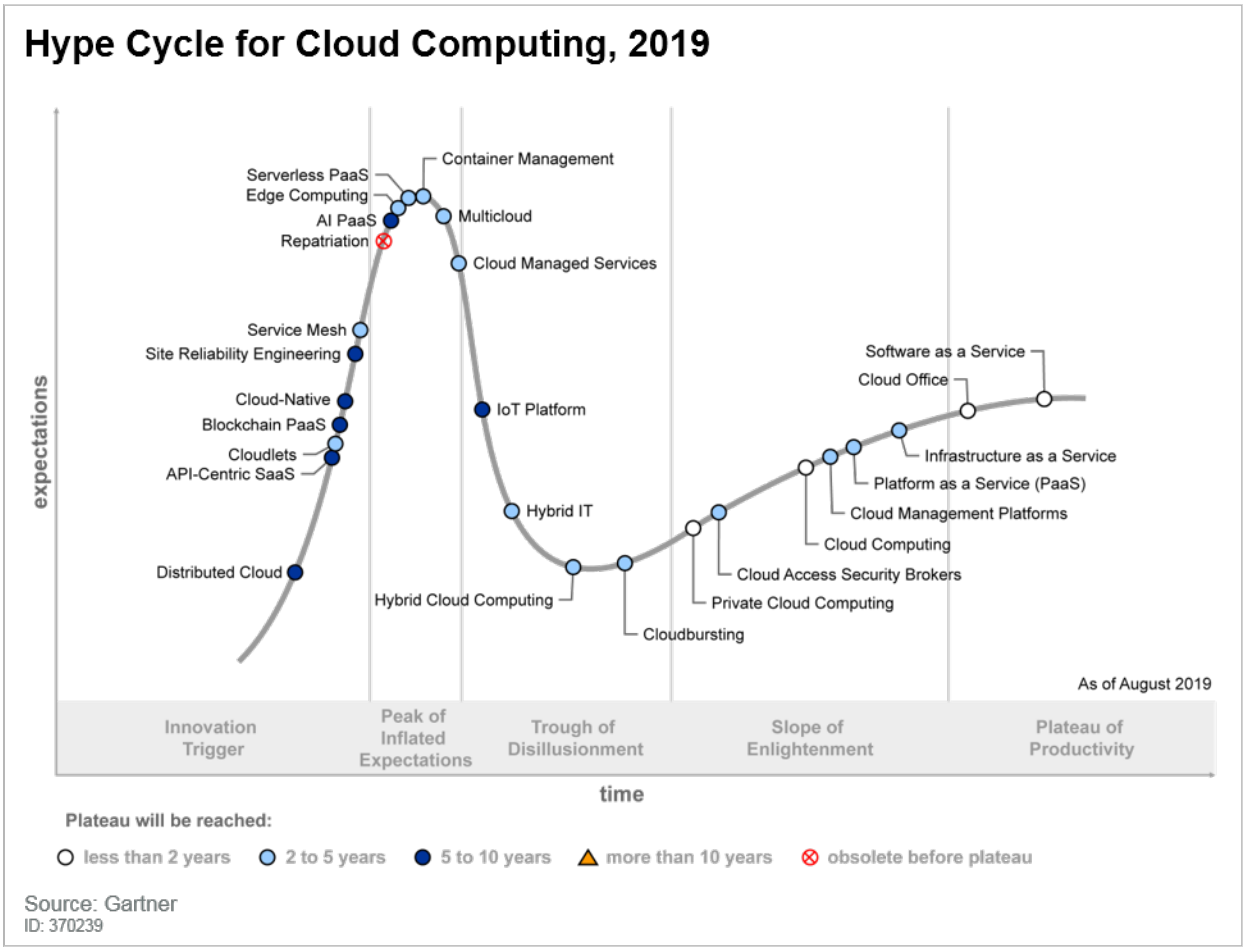
"Magic Quadrant for Cloud Access Security Brokers"

"Midsize Enterprise CIOs: Take These 4 Key Actions When Deploying SaaS"

"Toolkit: Comparison of Total Cost of Ownership Between On-Premises and SaaS Business Applications for Midsize Enterprises"

Appendixes

Figure 3. Hype Cycle for Cloud Computing, 2019



Source: Gartner
ID: 370239

Hype Cycle Phases, Benefit Ratings and Maturity Levels

Table 1. Hype Cycle Phases

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 2020)

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

Source: Gartner (August 2020)

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
Obsolete	■ Rarely used	■ Used/resale market only

Source: Gartner (August 2020)

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

Understanding Gartner's Hype Cycles

Cloud Computing Primer for 2020

The Cloud Strategy Cookbook, 2019

Define and Understand New Cloud Terms to Succeed in the New Cloud Era

Revisiting the Top 10 Cloud Myths for 2020

'Distributed Cloud' Fixes What 'Hybrid Cloud' Breaks

Hype Cycle for Cloud Security, 2020

Hype Cycle for Platform as a Service, 2020

Hype Cycle for Software as a Service, 2020

More on This Topic

This is part of an in-depth collection of research. See the collection:

- 2020 Hype Cycle Special Report: Innovation as Strategy

GARTNER HEADQUARTERS

Corporate Headquarters
56 Top Gallant Road
Stamford, CT 06902-7700
USA
+1 203 964 0096

Regional Headquarters
AUSTRALIA
BRAZIL
JAPAN
UNITED KINGDOM

For a complete list of worldwide locations,
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