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Ovum Market Radar: AR Cloud's Promise of Persistent Virtual Data and Interactions

How the AR cloud will transform the way enterprises engage and interact with customers

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Summary

Catalyst

The augmented reality (AR) cloud has been called the single most important software infrastructure in computing. The complex architecture of technologies enables a 3D virtual map that is overlaid onto the real world, where information and experiences are augmented, shared, and tied to specific physical locations to occur and persist across apps and devices. This geospatial, geo-database environment will appear as a 3D spatial web of the future and will eventually serve as the data framework that will enable hundreds of millions of digital devices to use shared spatial screens. These shared experiences (not just videos and messages) are augmented with information to visualize a dimensional universe of virtual data, objects, and logic.

Such capabilities will inevitably transform the way enterprises serve and interact with customers, the way they work and collaborate with employees, and, ultimately, the whole way they conduct business. Put simply, instead of clicking on something, real-world participants will be able to visualize the item, person, or place and see all the information present about it.

This Market Radar explores the origins of the AR cloud and the business value, market dynamics, vendor landscape, and future developments necessary to build momentum toward universal adoption of the AR cloud and grow a foundation of standards to safeguard the platform for enterprises and participants to leverage on a global scale.

Ovum view

With the AR cloud, the entire world will become a shared spatial screen that enables multiuser engagement and collaboration. The AR cloud and its resulting enabled landscape will facilitate real-world multiuser engagement and collaboration via augmented information.

Ovum believes the enablement of multiuser engagement combined with the AR cloud's persistence of information will greatly enhance the overall customer experience by transforming the way enterprises serve and interact with customers and the way they work and collaborate with employees. The scenarios for how the AR cloud will improve customer support and engagement are endless and include reinforcing service organizations by providing complete customer information and making product information available for commerce and product guides.

Consumers can search for information, for example, just by visualizing an object or concept rather than by clicking through pages online. When reporting issues or a product malfunction, customers can simply present the object, such as a cable box that is not working, via an AR-enabled camera to a technician who can not only see the issue on their end through an AR-ready device or visual browser, but also the complete history of the relationship with the cable company and the customer.

On the business side, rather than click through customer histories, contact center associates can simply visualize the information. Together, the components of the AR cloud will give in-store associates a real window into inventory to search for products on the floor for customers as well as historical and unified data. And marketers can use AR tokens or objects as a means of gamification or to engender customer loyalty.

Most notably, businesses in retail and commerce, healthcare, tech industries, and travel and leisure will experience immediate transformative results from the AR cloud. For example, physicians could conduct remote examinations, and customers could book hotels and make travel reservations after viewing properties virtually.

Despite its lofty ambitions and initial proofs of concept, core elements of the AR cloud must transform for it to work effectively and take hold globally. Notable points include changes to the internet's infrastructure, establishment of ownership – through either a centralized or a decentralized model – an increase of computational power, the availability of mobile devices must with AR-ready cameras, and the expansion of survey-grade local positioning to enable more large-scale testing. The changes and investments made now will dramatically change the destination of the AR Cloud. An inflection point is at hand. But it will take time and iteration after iteration, with a multitude of challenges – spanning hardware, software, content, and user experience – to overcome.

Momentum toward creating the AR cloud is already building quickly. The vendor and AR investor communities are engaging in palpable, substantive work to advance the AR cloud, address the challenges that prevent widespread adoption, raise awareness, and create privacy standards. The Open AR Cloud initiative, for example, a consortium of vendors collaborating on methodologies that promote discreet data through data decentralization, is steadfastly pursuing strategies that are respectful of consumers' privacy.

Some experts predict that the AR cloud will represent a bigger shift in technology than the introduction of smartphones. As augmented reality continues to advance, a question emerges: How can we create a global AR infrastructure that is equipped with the adequate tools to realize the AR cloud's full potential? That future involves the enablement of persistent data and real-time dimensional visualization of communication between endless objects and humans on a global scale.

Key messages

- The AR cloud will eventually serve as the data framework that will enable augmented experiences to occur across apps and locations, changing the future of information.
- The AR cloud involves a complex architecture with numerous technology layers to function.
- There are numerous business benefits to be gleaned from engaging with customers and employees via the AR cloud.
- Advancement of the AR cloud relies on several key initiatives.
- Tech giants, as well as startups, are putting the components in place to build the AR cloud.

Recommendations

Recommendations for enterprises

The AR cloud will offer tremendous potential for enterprises, promising to increase productivity, lower costs, improve workplace collaboration, and engage with customers in more personalized and interactive ways.

As enterprises start exploring the benefits of engaging in the AR cloud and investing in solutions to build an infrastructure, they must build a strategic case that determines a range of needs across the enterprise. A cross-enterprise AR evaluation team could help answer questions such as "Does HR

want to use AR in its onboarding program to help show employees around the organization, or does marketing want to gamify virtual objects with the intention of creating a new path to customer loyalty?" Determine the overall business goal (e.g., increase productivity, enhance performance support, drive customer engagement). Finally, pilot an AR learning initiative to help remove snags before expanding to a larger audience.

As more enterprises realize the AR cloud will serve as another communications platform, content should not supplant other channels but augment them. Enterprises must understand which value-based relationships to focus on by determining which objects to build for each demographic.

Enterprises of all sizes across industries are tapping into the potential of the AR cloud to visualize data and instructions and overlay digital assets in the real world in real time, but success depends on the ecosystem built around it. Such ecosystems are composed of many industry players that need to work together to deliver on the promise of the AR cloud and compose the principles that guide and govern it. The enterprises that use AR technology, the solutions providers, and academic institutions must work together to ensure the AR cloud is being developed in a way that delivers value to the broadest range of users.

Recommendations for vendors

The AR cloud infrastructure remains in early stages, but the technology is evolving quickly. That has opened the door for ample opportunities. As vendors build out their software, they must be careful not to force fit traditional customer engagement technologies onto the AR cloud.

They must think about how the content will be surfaced and how it will change, from a PDF to html to a rich video experience and eventually an AR hologram. Careful consideration must be given to the tools needed to deliver, curate, and manage that content. Vendors must also work with enterprises to determine the specific environment to stream to end users, as well as the process flows, screens, reports, analytics, digital assistants, and the role of machine learning, artificial intelligence (AI), and video chat.

They must build out AR experiences across several customer bases to maximize their learnings, co-innovate, and outline flow for future customers to determine potential value and provide a proof of concept so future customers can visualize the future state of their business.

Finally, the AR cloud will only become mainstream with the broadscale adoption of 5G and its convergence with the cloud to deliver low-latency bandwidth connection. The arrival of 5G means vendors can push their capabilities away from servers and into the edge cloud to provide low-latency service. For 5G to take hold requires industry-wide collaboration across mobile operators, technology vendors, and other players in the AR cloud ecosystem. A collaborative approach to adoption will accelerate the delivery of 5G cloud-based AR services.

Defining and exploring AR cloud

Definition and characteristics

The AR cloud will link all services and tools into a shared platform to create a singular augmented view of the world. Within this single shared cloud, all items that exist in any AR application and are

associated with a geographical location can be experienced and accessed among multiple users. It creates what has been described as a kind of "spatial Wikipedia" of all virtual objects.

This spatial memory will enable users to share experiences, not just videos or messages, and it will allow people to collaborate in gaming, design, marketing, and commerce. In this "enabled landscape" people can choose tailored and personalized streams of digital data when present at any location and can interact with this virtual content in real time via AR-enabled devices.

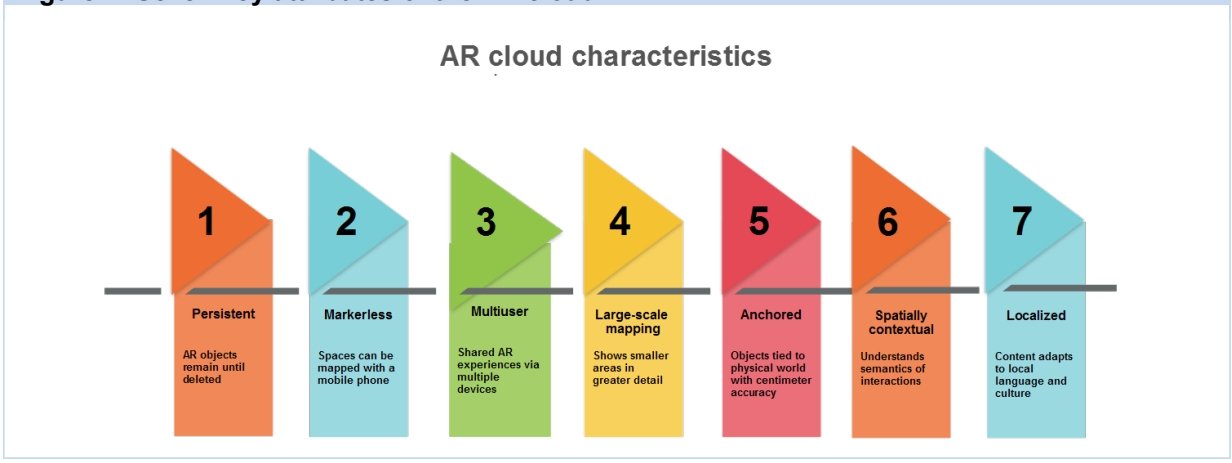
It is the core technology that will enable data rich, contextual, and interactive AR experiences, whether providing workplace information or helping to navigate an airport. The AR cloud is not just visual; it is also contextual and predictive. Essentially, it is the much-needed interface where AI and the Internet of Things (IoT) intersect and create real value.

Ovum believes the AR cloud will eventually serve as the data framework that will enable augmented experiences to occur across apps and locations. This data framework is realized through a combination of computer vision, localization, mapping, and analytics; interactions are enabled via AR-camera equipped devices and a visualization browser, akin to how the World Wide Web is browsed.

In the same way that Google indexes the web and makes textual information available via a browser, the AR cloud will serve as an index of the real world. With the AR cloud, product instructions, the history of any place, and the background of any person will be found on the virtual object. An analogy is Google searching the world around users just by looking at it. This means eventually we'll be able to search physical spaces by hyperlinking objects into them just as the web hyperlinks words. For example, users can access the visual browser to find all the cafés along Main Street in Stamford, CT that offer alfresco dining.

Ovum believes the AR cloud contains seven critical attributes that serve as its foundational elements. These characteristics enable interactive, visual experiences at scale (see Figure 1). Objects should persist in the cloud until deleted; sources should be able to be mapped with a mobile device; experiences should be shared among multiple participants; users should be able to search for and locate smaller objects within large spaces; objects should appear not floating in space but rather anchored with precise or near precise accuracy to their actual location in the physical space; the objects should understand the user's interactions and respond in real time; and objects and content should adapt to local languages and cultures to enable AR on a global scale.

Figure 1: Seven key attributes of the AR cloud



Source: Ovum

Key capabilities

The AR cloud inevitably needs a complex architecture including numerous technological layers to function as intended. Ovum defines three layers that constitute the core mechanics (see Figure 2). The aesthetic layer includes the technologies that scan faces and can localize devices. When someone gazes at a scene through a device, particularly wearable glasses, tiny embedded cameras looking out will map what they see.

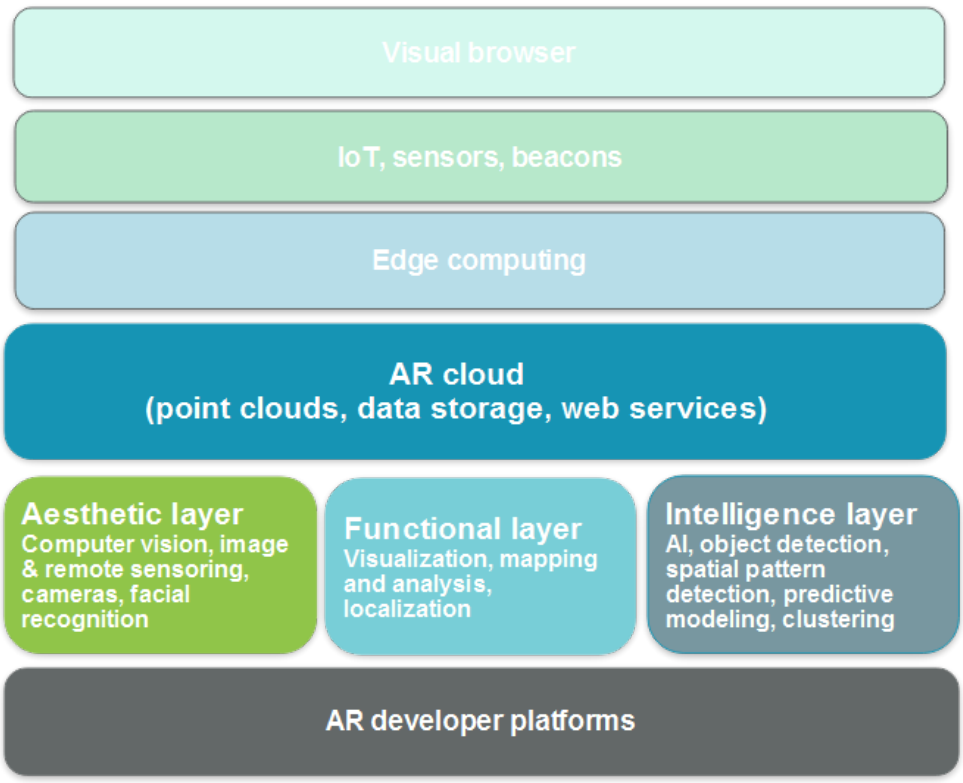
It is the AI embedded within the device, in the cloud, or in both that makes sense of those pixels; it will pinpoint the location of a participant and at the very same time assess the micro-locations or objects at that place. The technical term for this is simultaneous localization and mapping (SLAM). This is included in the functional layer, or location layer, which pinpoints objects' locations through a combination of computer vision, indoor navigation, spatial analytics, imagery and remote sensing, and mapping and visualization. Together they anchor discreet objects and enable users to automatically detect them in large collections of geospatial imagery, identify all characteristics about them, and recommend next best steps or products.

The bigger promise lies in the persistence of information in the real world, as humans equate persistence with value. When something disappears, the value diminishes. To achieve persistence, the AR architecture must fully leverage web services, elastic computing, and data storage capabilities provided by the cloud to enable extensive sharing and integration of distributed geo-referenced data. The sets of data points, or point clouds, produced by such inputs must be persistent and accessible and must enable multiuser engagement in real time.

Finally, in the dynamic – or intelligence – layer, a combination of AI-driven contextual and predictive capabilities help determine what users are looking for by understanding the space beyond the geometrical shape and what will happen next. These include clustering, spatial pattern detection, classification, and predictive modeling to construct and visualize complex patterns, relationships, and situations.

Predictive capabilities help determine what will happen next and ensure the information is accessible. This depends on machine-learning algorithms that run against data stores to automate processing from geospatial data generated from inputs such as user-generated IoT sensor feeds, social media, vehicle sensors, cameras, imaging sensors, and 3D cameras to reveal predictive insights. Because the AR cloud's intention is to understand images and videos beyond the labeling of objects, simply identifying a person in a car is not enough. The vehicle could be carrying other passengers, so what are their relationships, and where are they traveling to?

Figure 2: Anatomy of the AR cloud: visualizing the architecture



Source: Ovum

Each layer of the AR cloud's composition serves as a critical asset for the collaborative set of capabilities realizing its ultimate objectives, yet Ovum believes the contextual and predictive capabilities within the intelligence layer are most crucial to the AR cloud's realizing optimal functionality. While AR is the underlying technology of the AR cloud, AI serves as its driving force.

Retrieving such granular visual information will entail users aiming a camera or AR glasses at a building or object to learn all information, past and present, about the object or destination. This will require a visual browser that can detect the world around it with hyper-precision and filter contextually relevant data to be displayed to the user based on location, activity, or time of day. The visual browser interfaces with individuals' belongings and relationships and the places they go. Computing requirements for this real-time situational awareness must be engineered to scale, workable across the entire viewable world and all devices, and built on open standards as the internet is.

Finally, the arrival of 5G means these capabilities can be pushed away from the PC and into the edge cloud, which provides more reliable experience and low-latency service. AR cloud adoption will not become truly mainstream without the broadscale adoption of 5G networks and its convergence in the cloud.

Business value and applications

In his 1950 book *The Human Use of Human Beings*, cybernetics theorist Norbert Wiener argued that machines are meant to interact harmoniously with humanity and provide respite from the industrial

trap we have made for ourselves. Wiener describes the automaton as inherently necessary to humanity's societal evolution. People could be free to expand their minds and pursue artistic careers, while automata take over assembly-line production to create necessary commodities.

The AR cloud could fulfill Wiener's prophecy. Whether guiding people through crowded environments or uniting remote workforces, the promise of the AR cloud is vast.

Here are six examples of the potential business benefits gleaned from engaging with customers and employees via the AR cloud.

Enhancing customer engagement and loyalty

Many businesses, particularly in retail, are finding that AR is providing a crucial boost to their customer engagement efforts. The interconnectivity and transparency of personal data enabled by the AR cloud will allow enterprises, especially retailers, to deliver hyper-personalized interactions because of the ability to analyze IoT data and then enable it to persist. This allows enterprises to deliver guided interactions and customized offerings with ease.

The capability to visualize products or get quick information on products right on the mobile screen enables retailers to personalize offers and drive engagement by using strategic techniques that allow customers and brands to connect in hyper-personalized ways. Having the ability to place virtual objects in AR builds a value-based relationship when they are persistent and gamified.

American Apparel, for example, is equipping customers with mobile app-driven experiences. Essentially, a shopper opens the app and scans a picture of signage. The app pulls up product details, including customer reviews, color variants, and pricing. And the latest version of the Warby Parker app for iOS includes a new Virtual Try-On feature that shows users how they will look in any pair of glasses.

Creating shared experiences at scale

Like all interactions in the AR cloud, this virtual realm will be layered over the view of the physical world, so the technology can detect the real-time movements of people. The ability to enable shared experiences will yield engagement opportunities across commerce, gaming, and medicine and will create new ways for employees to collaborate.

Those in automotive are already seeing the value of creating shared experiences. Lyft, the ride-hailing startup, for example, acquired Blue Vision Labs, the London-based AR localization and mapping startup, last October. Blue Vision connects ride-sharing passengers with their drivers by overlaying the car's position onto the rider's smartphone screen in AR. The company said the application of the AR cloud is allowing developers to create shared AR experiences that were not possible before at unprecedented scale.

Connecting the global workforce

Companies are increasingly investigating augmented and virtual reality to deliver new workplace experiences such as improving collaboration or making hands-free data access easier. Typical examples of these workplace experiences include training, design, and field service. The potential of AR headsets such as Oculus Rift and the HoloLens connected to the AR cloud could create virtual meeting places and communications platforms where documents and information persist, enabling users to conduct business collaboratively, work in teams, and transact.

Ford, for example, is using the Oculus Rift to create virtual models of cars and collaborate on design changes with different team members. Virtual reality (VR) minimizes Ford's need for physical prototypes and allows the engineers to explore creative design. And Microsoft is equipping the global workforce of deskless employees in warehouses and factories with HoloLenses to conduct activities such as building 3D models and to receive training.

Reducing support costs

Many companies are turning to AR to improve maintenance, repair, and support processes as well as to reduce on-site and travel costs for technicians. The advantage is that important information is provided quickly and at the right place, resulting in faster repairs and prevention of mistakes during specific tasks.

ThyssenKrupp, an elevator manufacturer, is using Microsoft's HoloLens to visualize an elevator repair before the technician reaches the site. Once on site, the technician can use AR to view digital overlays of manuals and repair guides while they are fixing the elevator. Another example is Re'flekt, which provides a combination of real-time video support and AR to provide visual guidance on mobile devices. Such remote assistance reduces downtime on machines and eliminates expensive travel and labor costs for technicians.

Shon Wedde, senior director of Oracle Product Management, said Oracle's customers are engaging with AR to identify the gaps in their training and to deliver improved content by visualizing and annotating the world in real time. Oracle has completed an AR toolkit for ARKit and is rolling it out to internal teams as well as customers and partners this year.

Development for a toolkit for ARCore is planned for the second half of 2019. A proof of concept developed by Yamaha Motors and Oracle shows how Oracle Knowledge Advanced, supplemented by AR glasses and bike sensors plugged into Oracle Internet of Things Cloud Service, could transform the way field-service technicians and owners maintain and repair a power sports product such as a motorcycle. A digital overlay displays the component's metrics after an individual aims the AR glasses at the vehicle's VIN.

Receiving real-time employee visibility and productivity metrics

Ovum expects the greatest momentum around the AR cloud will come from the adoption of AR tools to create greater visibility and transparency throughout organizations internally. A specific hotbed for growth lies in the contact center. Consequently, in the coming months, Ovum expects to see several cloud contact center and platform providers offering AR tools geared toward supervisors to monitor performance levels and identify coaching opportunities.

Simon Wright, head of Virtual and Augmented Reality at Genesys, told Ovum that the ability to overlay virtual objects onto the real world can create a new kind of immersive customer experience, especially in the contact center. For example, Genesys has experimented with an AR solution that lets customer service agents interact virtually with the real world around a customer by, for example, pointing to objects or using virtual gestures to help explain something as if they were standing next to them. Last year, Genesys demonstrated AR software loaded onto a tablet that the supervisor can use to scan the contact center. Three-dimensional icons of contact center agents at their desks pop up on the screen, depending on where it is aimed. The device simultaneously displays real-time data, so supervisors and agents can simply visualize the clusters of data around them presented in bubbles and nodes through a 3D user interface. Using AR to visualize large amounts of complex contact center data like this helps supervisors decide where to go and who needs help in real time.

Increasing redemption and conversion rates

The AR cloud presents a unique opportunity to move off-screen and into the physical world. This is especially valuable in retail, where companies can overlay products with targeted offers and upsells. In the AR world, retailers can guide and inform users along their shopping journeys, providing a concierge-like marketing and guided service that is rarely achieved in physical stores.

Many retailers such as Walmart and Ikea will begin adopting immersive AR experiences that allow shoppers to use their phones to view how products will look and feel in their homes. The home goods retailer Wayfair, for example, has released an AR app that uses a phone's camera to create a digital version of an interior. The app can then place a 3D object such as a virtual sofa in a room to see how it would fit in certain spots and to try different fabric colors and patterns. Such strategies lead to higher conversions. Houzz, another home goods retailer, reports that shoppers who use the company's AR app for this purpose are 11 times more likely to make a purchase.

Market landscape and participants

Market origin and dynamics

Ori Inbar, co-founder of AugmentedReality.org and founder and general manager at Super Ventures, has spent the past decade fostering the AR ecosystem. As president of the Augmented Reality Consortium and executive producer of Augmented World Expo, he has established himself as a thought leader in the sector. He is also the one who coined the term "AR cloud," describing it as the single most important software infrastructure in computing. "The AR cloud is really about enabling a persistent and shareable AI experience anywhere you go in the world," Inbar said.

As previously noted, the AR cloud comprises several technology layers, and Inbar is leading efforts to create this global infrastructure. He helped forge the formation of Open AR Cloud, a grassroots initiative led by a consortium of vendors tasked to connect and coordinate the efforts to build out the interconnected ecosystem necessary to enable the collaboration and persistence from the AR cloud.

Jan-Erik Vinje, managing director of Open AR Cloud, said the goal is to build an open ecosystem of providers to allow multiple players to participate and collaborate. The group, which launched last October, plans to develop an open AR cloud to link all the services and tools into a shared platform that creates a singular augmented view of the entire world.

Key trends in the AR cloud market

A battle for AR dominance

Apple's ARKit and Google's ARCore will stir growth, create awareness, and build momentum around the AR cloud. Google is truly equipped more than any other vendor to launch the AR cloud. Its Google Street View cars combined with remote-sensing data provide a high-precision digital view of the whole world. If Google acquires some AR startups focused on creating algorithms, it will better position itself to lead further development of the AR cloud. Both ARKit and ARCore must enable shared experiences that persist in the real world across space, time, and devices if mass adoption is to occur.

The new capabilities of the AR cloud world bring a host of technologies for existing infrastructure solutions. The ability to map, reconstruct, and simulate could grant superpowers to the otherwise regular nodes in the global network.

Established vendors in this category are investing in AR development and will also likely acquire some startups in the coming months. They include Google, Apple, Samsung, Microsoft, Facebook, Amazon, Niantic, 6D.ai, Ubiquity 6, Tencent, and Magic Leap. It is Lyft's acquisition of UK-based Blue Vision that signals a festering battle for AR cloud dominance among enterprises as well. As more realize this will be a critical infrastructure, the market will see substantial partnerships and acquisitions as the leaders race to be the first to launch an ecosystem to enable the AR cloud and thus control how the world's information is organized and accessed.

Future market development

The rise of the AR cloud will rely on several fundamental shifts in infrastructure development as well as a renewed mindset around enacting data governance standards. Ovum highlights the need for key eight initiatives to enable the advancement of the AR cloud.

Mobile devices must change

Adoption of the AR cloud will fuel a shift from the phone to the camera as the primary communications tool, enabling mixed reality experiences to occur through mobile devices. The next version of Apple's iPhone is even rumored to feature such capabilities embedded in the camera. That means AR on iPhones and Android phones will enable apps such as indoor navigation and AR product manuals.

The issue with mobile devices is that they are not equipped with room-mapping or depth-sensing technology. This depends on smartphones being equipped with dedicated 3D cameras, which give AR the ability to sense depth. The problem is that nearly all of today's smartphone cameras can only map environments in two dimensions.

The development of in-depth cameras in smartphones will increase the availability of scans. AR-enabled cameras on mobile devices will be able to identify shapes at higher quality and resolution and create a higher-quality AR cloud. Three-dimensional sensors and camera capabilities will enable AR developers to build apps with better depth perception and motion tracking, resulting in more precise alignment and object positioning within a physical space.

Smartphones and tablets are an affordable and reliable AR option and work particularly well for several use cases, including plant maintenance, field service, B2B sales tools, and education. As the AR market ramps up, Ovum expects AR to become an increasingly embedded mobile capability through SDKs, giving mobile cameras the ability to scan any physical space and turn it into a persistent, shared canvas for AR content. In fact, Ovum's sister company Tractica estimates that the monthly active users (MAUs) for smartphone/tablet enterprise AR will be 49 million by the end of 2022. In contrast, the installed base of enterprise smart glasses users at the end of 2022 will be approximately 19–21 million.

Improved smart glasses and headsets will help accelerate AR adoption

The headset is the natural form factor for AR where information can be easily presented to users. Therefore, Ovum believes headsets will be a critical device for the advancement of AR. Smart glasses can be clunky in design or painful to wear. But AR glasses are finally approaching prime time, as both established players and startups such as Vuzix, Linus, WaveOptics, DigiLens, Snap Specticals, Vue, and North Focals are launching newly designed glasses fit for applications from fitness tracking to mixed reality. Even key engineers at Apple attended CES 2019 to meet with AR glasses parts suppliers, which stirred rumors that Apple will also launch a pair of branded AR glasses.

Location data must expand breadth and depth

There's a need for large-scale AR – a solution that provides outdoor location recognition at a city scale – as well as room location. AR apps also rely on precise localization, but current GPS-enabled solutions are not accurate enough to ensure that a menu shows up in the restaurant window rather than 10 feet down the road. As the AR cloud creates a "map of the real world," there will be a need for more precise mapping visualization and location data, likely enabled by SLAM, which provides more location data accuracy than GPS and can cover entire cities (city scale). SLAM enables precise pose estimation to overlay complex virtual content onto physical locations: roads, retailers, restaurants, and points of interest.

The cloud infrastructure needs to change

For the AR cloud to proliferate, it needs an infrastructure that allows the AR ecosystem to expand into a system of interconnected experiences, objects, places, and content. The current cloud infrastructure, comprising networks of data centers that distribute content from a centralized location to endpoints, does not make sense for latency-sensitive localized AR applications. In the 3D virtual world created by the AR cloud, information needs to be accessible in real time.

AR is both created and consumed locally, so it follows that AR content should be stored close to its physical location to minimize latency, rather than an AR headset or mobile device having to reach all the way to some server far away to retrieve the data it needs to render the information. For the AR cloud to function properly, data must be able to flow unrestricted through systems to ensure that the most relevant and up-to-date information is always available, and proprietary systems stand in the way of this free flow of data.

Such real-time localization capabilities will be supported by 5G, a high-bandwidth, low-latency network that will push the compute power to the network edge. Therefore, if AR is to deliver on its promises, the infrastructure of the internet must change.

A new visual browser will replace web browsers

Oracle's Wedde said the company looks at AR as a new browser war. That is because enabling spatial computing via the AR cloud requires a visual browser that can detect the world around it with hyper-precision and filter contextually relevant data to be displayed to the user based on location, activity, or time of day. It will interface with everything consumers own and know, and everywhere they go. This spatial iteration of the web browser will allow users to develop and load both VR and AR experiences with just their web browser and share all the qualities and values of the AR cloud, such as interoperability across all platforms and maximum accessibility.

The flexibility of web experiences will grow the access to the AR cloud while at the same time unifying platform fragmentation caused by different hardware and form factors. This, combined with upcoming reduction in latency and 5G's promise of higher bandwidth, positions the visual browser as a scalable and key fundamental layer for AR cloud experiences in the very near future.

The user experience around the AR cloud must be refined and reinvented

Widespread adoption of the AR cloud will likely bring a radical change in human-computer interaction. The consequence is that the user experience around it must also be reinvented. The biggest user experience (UX) challenge is the ability to transition to a world where all knowledge is captured visually and is accessible by a glance rather than captured in text. To create a meaningful experience

in the AR cloud, developers must use natural ways of interacting with this new technology. The challenge is for the early builders of the AR cloud to make users feel familiar in a new environment.

In the Genesys example, the vendor offers graphical and intuitive visualization of the AR data. With a swipe of the screen, a supervisor can pull from the menu any number of metrics about the employee, such as their customer satisfaction scores. And the devices display the real-time data as information bubbles appearing over each agent's head. The supervisor sees such data as the agent's name, whether they are using email, and whether they are on a customer call and for how long. That data can also be displayed in any number of three-dimensional formats, as well as 3D fever charts or butterfly graphics that give supervisors an even more vivid graphical summary of agent metrics. Using a handheld device, the supervisor can overlay the information with individual customer satisfaction scores and performance data to help guide the agents.

Open standards for a decentralized AR cloud model must occur

There's a general sense among AR developers and experts in the space that if the AR cloud becomes fragmented, it will become too difficult to adopt. Several global organizations and industry consortiums are pushing for the adoption of open standards around the AR cloud and around identity management. Many even believe that the open standards for persistent shared spaces will change humanity.

Groups such as the Open AR Cloud initiative and the Global Systems Mobile Association (GSMA), and even technology leaders such as Samsung and Google, are promoting awareness around a decentralized model for indexing, mapping, and storing data to create more robust experiences. But a common approach will not happen without industry-wide collaboration that focuses on avoiding market fragmentation from the outset. To this end, the GSMA has been working to create a forum with multiple global mobile operators, vendors, and other players in the ecosystem with the aim of encouraging all parties to collaborate on accelerating the delivery and deployment of 5G cloud-based VR/AR services.

An interesting concept by WorldCloud is intended to incentivize crowdsourcing through rewards to collect the massive amounts of data required to construct this 3D replica and build a complete ecosystem for the global AR industry. Profits from the use of this data would go to the participants if they gave permission. This would create a decentralized infrastructure and give ownership of the AR cloud to citizens.

Leaders at the forefront of its development must be cautious of the abuse of personalized data and introduce open standards around the AR cloud and around identity. As identity in the AR cloud proliferates, having standards around persistent and shared spaces that are open will change humanity.

Privacy laws must be enacted

Once society moves into the spatial computing realm of the AR cloud, privacy issues will become magnified. The scale of big data that would be created from the AR cloud is currently unimaginable. For 3D persistence to work, it will require the synchronization of the virtual twins of all objects and people. This will require tracking people and things to a degree that can only be called a total surveillance state. When scanners see faces through cameras, and algorithms can detect emotional state and publicly score job or school performance, it is a privacy infringement of epic proportions.

With facial recognition poised to spread to vehicles and webcams, it will be more readily used to track people's emotions and identity. The technology is a truly formidable way to invade people's privacy. Data therefore should be encrypted and sent to the edge rather than be aggregated to a central location. There must also be mandatory transparency and accountability for any party that touches the data.

Vendor landscape

Replicating what the human eye and brain does naturally is very complex, and this list of startups and organizations just begins to scratch the surface on the technological solutions needed to recognize text, people, objects, and buildings.

Realizing AR cloud's full potential depends on three things working seamlessly together: computer vision, AI, and edge computing. Not surprisingly, tech giants Amazon, Google, Microsoft, Apple, and Facebook are the top contenders to build the AR cloud, but these behemoths also have their share of hurdles to overcome. Experts in the industry say Google's ARCore is not persistent, and Apple's ARKit is unable to detect full shapes and does not enable multiuser device access.

The bottom line is a mature AR service may be in the distant future. Acceleration will come from startups such as Vertical, Scape, Dotty AR, Occipital, Placenote, 6D.ai, and Augmented Pixel that can offer cross-platform support. Perhaps it will take a consortium like Open AR Cloud to bring the massive project together. It is not here yet, but for the first time in history, the elements are in place. Finally, it is important to note that all these companies have something in common: their success depends on the success of developers who incorporate their APIs into their technology stacks.

Vendors on the Ovum Market Radar in AR cloud

On the Radar: Blockv

Ovum view

Blockv provides a development platform with a set of APIs, tools, and training that enable developers to create and emit digital objects on blockchain. These objects, called Vatoms, can be obtained and viewed across any mobile device. Vatoms store digital goods securely and allow them to move seamlessly between users. Vatoms can be dropped onto a map, captured in AR, moved into virtual reality, and shared between users across any smart device in the AR cloud.

Key messages

- Blockv's platform is intended to enable developers to create smart Vatoms – or digital objects on blockchains – that are transacted via the AR cloud.
- Blockv's goal is to become the next generation of computing.

Why put Blockv on your radar?

Blockv provides a development platform with a set of APIs and training tools that enable developers to create and emit digital objects on blockchain. These objects, called Vatoms, can be obtained and viewed across any mobile device. Vatoms are programmable, store digital goods securely along the blockchain, and move seamlessly between users. These objects retain value and rules, resulting in less fraud, low intermediaries, and a controlled orchestration of the distributed value. When combined

with the Blockv developer and partner community, Vatoms become the experience layer to the blockchain and present a new level of human engagement.

Highlights

Blockv's mission is to create the next-generation digital goods economy by bridging the physical and virtual worlds through Vatoms, which are intelligent, interoperable digital objects. The company offers enterprises the ability to interact with customers along the discovery and buying journey.

CMO Michael Dobak said Blockv offers an open development platform that provides education, support, and a toolkit to create and emit Vatoms. The platform comes with a selection of tools, templates, and built-in actions that allow developers to quickly deploy interactive experiences on or off the blockchain. Ready-made APIs and SDKs are designed to be compatible with existing system infrastructure.

In more basic terms, the Blockv's platform is intended to enable developers to create smart digital objects on blockchains then transact those objects to the AR cloud. Users can interact with the objects, or "experiential currency," in meaningful ways, turning them into dynamic virtual goods.

Blockv demonstrated how this works at the National Retail Federation's Big Show 2019 in New York. There, it partnered with Intel and CataBoom to launch Project NGAGE, a blockchain-based retail initiative that released hundreds of virtual butterflies in the Javits Center. Attendees were able to catch butterflies using their mobile devices as well as grab objects in AR. They could swap the butterflies for hidden prizes such as gift cards or drones.

Background

Blockv is led by CEO Reeve Collins, a pioneer in the bitcoin and blockchain space and co-founder and CEO of Tether. Other key members of the team include CTO Gunther Thiel, COO Lukas Fluri, and Craig Sellars, the company's blockchain architect.

The team began developing the Blockv platform in 1Q16. By 3Q16, the first Vatom smart object demos were launched on the bitcoin blockchain, along with an iOS app for demonstration purposes.

The public launch of Blockv v1 occurred in 1Q18, and it has received millions of dollars in funding since its launch.

Current position

Blockv is headquartered in Zug, Switzerland, with offices in Wroclaw, London, Cape Town, and Santa Monica.

Its customers are primarily across retail, sports, technology, and gaming. Many are reporting 3× to 5× improvements in customer-focused metrics such as customer satisfaction.

Dobak said that, in the future, Blockv wants to become an IoT platform that enables smarter objects embedded with code and will serve as the primary interfaces of the IoT. "We are making these objects more scalable and reliable, which represents the next generation of computing," he said.

Data sheet

Table 1: Data sheet: Blockv

Product name	Blockv platform	**Product classification**	PaaS for developers of small digital objects
Version number	4	**Release date**	2018
Industries covered	Retail	**Geographies covered**	Global
Relevant company sizes	n/a	**Licensing options**	n/a
URL	www.blockv.io	**Routes to market**	Direct and through digital agencies
Company headquarters	Zug, Switzerland	**Number of employees**	26

Source: Ovum

On the Radar: ContextGrid

Ovum view

ContextGrid is a global data registry and lookup service that enables data to be placed anywhere across the globe and be made accessible by any business or person. This process enables persistent AR and the ability for people to find objects located in AR.

Key messages

- The technology supports multiple channels for registering data, including computer vision, Bluetooth beacons, and point clouds.
- ContextGrid's AR SDKs and APIs enable out-of-the-box AR experiences in the form of information, deals, and warnings.
- ContextGrid is involved in the Open AR Cloud initiative, working to create awareness of benefits of building an open AR cloud.

Why put ContextGrid on your radar?

ContextGrid positions itself as an integration layer in the central registry of AR objects by providing public access to its API endpoints, which retrieve information from computer vision, beacons, and point clouds. It goes beyond providing camera-based AR that scans images and applies ways to use data in a more personalized way through IoT and sensor data. Its ability to integrate other AR cloud technologies into the platform makes ContextGrid a unique offering.

Highlights

ContextGrid refers to itself as the DNS for augmented reality. The company provides an open environment for developers to create holograms using its precise location data. The result is participating brands' customers can look up 3D objects and their associated actions anywhere in the world.

The technology supports multiple channels for registering data, including computer vision, Bluetooth beacons, and point clouds. Together, they help to enhance the user experience with microdata.

Companies can make their data public, allowing any app to look up and deliver data. Therefore, more apps mean more traffic to the data.

It works like this: a company registers places (e.g., a store), micro-locations (objects within the store), and data (product information, offers, or guidance that appear as holograms above the micro-locations). ContextGrid SDKs and APIs enable out-of-the-box AR experiences in the form of information, deals, and warnings to help companies deliver AR experiences with little effort. Users, in turn, see the holograms via the WorldBrowser, an app to browse stores, parks, and malls using AR.

Background

The startup was founded in 2016 by Arka Bala, a data scientist, and Charles Walsh, an interaction designer. The two founders first met in 2014, where they co-founded TravAlarm Inc, a journey planner. They are joined by founding investor Keith Teare, who has more than 25 years as a serial entrepreneur in the domain registration service. Today, Bala serves as the CEO, Walsh serves as head of design and research, and Teare is a product advisor.

Bala told Ovum that ContextGrid started as a provider of Bluetooth beacons. "Everything in the world should have some contextual data about it," Bala said. "Initially we were using beacons but then realized that augmented reality is a better way to browse data."

Current position

ContextGrid is involved in the Open AR Cloud initiative, working to create awareness around the benefits of building an open AR cloud and collaborating with other members to develop standards. The company is also leading a work group to build a universal visual browser (UVB) as well as a central registry of all AR objects and anchor points. Bala said the company has succeeded in producing a version of the UVB and is set to release it in mid-2019.

Additional 2019 roadmap announcements will include the introduction of navigation capabilities in April and the continued integration of SDKs throughout the year. Bala said the company is also aggressively pursuing partnerships with Google, Magic Leap, and 6D.ai.

Investors in ContextGrid include Candela Partners, General Catalyst, and Archimedes Labs. So far, the company has five corporate clients, including Visa and other household name brands in financial services and travel and hospitality. Bala said several hotels are interested in obtaining the ability to place holograms throughout their hotels to help guests navigate and get information about services. There is even interest from a solar farm that wants to replace technicians' tablets with data sets aggregated from data sensors and connected to AR objects to determine when panels break.

Data sheet

Table 2: Data sheet: ContextGrid

Product name	ContextGrid	**Product classification**	Global data registry for the AR cloud
Version number	3	**Release date**	June 2016
Industries covered	Financial services, travel and hospitality	**Geographies covered**	Global
Relevant company sizes	Enterprise	**Licensing options**	n/a
URL	www.contextgrid.com	**Routes to market**	Direct
Company headquarters	New York, NY	**Number of employees**	10

Source: Ovum

On the radar: Immersal

Ovum view

Immersal is an AR SDK for 3D scanning and visual positioning that enables augmented reality apps for environments such as games, retail, movie theaters, and conference spaces.

Key messages

- Immersal is one of the first vendors to conduct large-space AR.
- The company became a pure AR cloud SDK company in Jan 2018.
- The long-term goal of Immersal is to become one of the primary visual positioning systems for the global AR cloud.

Why put Immersal on your radar?

The AR SDK utilizes ARKit, ARCore, and works now with Unity (other platforms such as native iOS, Android, and Unreal Engine will follow). It is anchored, persistent, and enables multiple users. Immersal is one of the first vendors to conduct large-space AR that is anchored to real-life coordinates such as GPS. Immersal plans to make the necessary investments that will position the company as a leading provider of visual positioning.

Highlights

Jufo Peltomaa, CEO and founder of Immersal, said he founded the company in 2015 on the premise of visualizing and curating the hundreds of millions of data layers floating around us. In January 2016, with its first customer and a fresh injection of €100,000 in capital from Silicon Valley-based Presence Capital, Immersal took the first step in launching a permanent large-space AR experience by enabling 200×130m of space in Helsinki Exhibition Center. Peltomaa likens the importance of the large-space offering to the need for a mobile phone network to increase its limited range. "If you're on a network that covers 10% of your city, it has only limited number of use cases. If it covers the whole continent, then you can use it for anything," he explained.

In 2017, Peltomaa said, the company decided to abandon the visual markers and AR app making and instead focus on developing a markerless AR SDK that other developers want to use to create their apps. Today, its Immersal AR Cloud SDK gathers information while people use the app. Immersal then creates the AR infrastructure and cloud with that data, thus enabling the physical space in question.

Background

Peltomaa, who imported the first virtual reality headsets to Finland in 1995 and co-founded technology companies Hybrid Graphics (exit to Nvidia in 2006 for $37m) and ZenRobotics, went on to launch Immersal in 2015. "I founded Immersal three years ago because I wanted to be at the vanguard of the AR revolution," he said. "Everyone else seems to be thinking either small or long term. I want the first wave of the AR revolution to happen today."

He most recently served as Immersal's vice president of business development. In August 2018 Immersal's board of directors unanimously appointed Peltomaa as CEO.

Immersal went live with its first permanent, shared large-space customer case in January 2017 at an exhibition center in Helsinki.

Current position

There are now 152 companies in the waiting list and the Early Access version of the AR Cloud SDK has been delivered to 51 companies.

The Early Access program marked Immersal's entrée as a pure SDK company. The SDK is developed initially for Unity, and Immersal will add direct support for native iOS, Android, and, for example, Unreal Engine later.

Through the SDK, Finnkino (part of Odeon Group, which is owned by AMC, the largest movie theater chain in the world) recently launched an AR app. AR platform provider Umbra and AR content creator FlyAR are currently testing Immersal's SDK in Early Access.

Investors in Immersal include Reaktor Ventures, Nordic XR Startups, Polkuni, and Presence Capital. In the long term, Immersal plans to put a greater focus on making the investments that will position the company as a primary provider of visual positioning.

In August 2018, Immersal joined the global VR/AR Association. It will participate in the association's AR cloud committee with the likes of 6D.ai, Ubiquity6, and Umbra to actively define the future and standards for the global AR cloud.

Data sheet

Table 3: Data sheet: Immersal

Product name	Immersal AR Cloud SDK	**Product classification**	AR cloud SDK company
Version number	1	**Release date**	January 2016
Industries covered	Gaming, entertainment, exhibitions, retail	**Geographies covered**	n/a
Relevant company sizes	Enterprise	**Licensing options**	n/a
URL	www.immersal.com	**Routes to market**	Direct and partners
Company headquarters	Helsinki, Finland	**Number of employees**	10

Source: Ovum

On the Radar: Visualix

Ovum view

Visualix is a Berlin-based computer vision company, enabling centimeter-precise mapping and localization at scale with commonly used smartphones. The Visualix Platform allows businesses to scan a space and subsequently attach AR content persistently to any position in the world through its persistent AR-ready digital twin of space. The patent-pending technology can also be used for visual asset tracking without beacons or markers, as well as cost-efficient AR-ready mapping and simulation of indoor spaces or cm-accurate low-latency persistent multiplayer AR experiences.

Key messages

- ▪▪The Visualix Platform conducts large-scale mapping of small and large areas.
- ▪▪Users can map venues with a mobile phone.
- ▪▪The platform enables localization and mapping at scale.
- ▪▪The platform combines ARKit or ARCore with a hybrid spatial computing platform in the cloud.
- ▪▪The technology understands the semantics of spatial context.

Why put Visualix on your radar?

Visualix Platform uses the patent-pending spatial computing platform in the back end(utilizing its computational resources for real-time map creation and re-localization), which allows robust AR on an area of at least 100,000 sq. feet – around 9,300 sq. meters (m2). Also, to enable interactions within the AR cloud at scale, mapping and positioning must be precise. Visualix's ability to conduct large-scale navigation without beacons or markers therefore gives the vendor an advantage over others that rely on GPS or can only enable an area of less than 200m2.

For the AR cloud to work effectively, it must enable shared experiences. With Visualix, separate devices with different perspectives can share an AR session, allowing the users to see the same 3D object in the same physical location on an area of 100,000 sq. feet. Updates to objects can be made across devices in real time.

Finally, additional computation takes place on the Visualix server (runnning the Visualix Service), which helps avoid negative effects on the user experience such as batteries draining and the limitations of reflective surfaces.

Highlights

Visualix provides a range of technologies through its Visualix API and Visualix Localization SDK. Using the Visualix Platform allows users to achieve precise, persistent, and personalized AR interactions at a large scale in dynamic environments. The Visualix Platform includes a mapping app, a content placement system, and the localization SDK. The company's patent-pending technologies in computer vision, localization, large-scale navigation, and mapping allow the tracking of physical objects and anchoring them through smartphones. Its persistent AR cloud enables content and 3D maps to be storedand applications to be augmented with 3D content and positioning information.

It works like this: businesses map their spaces using a phone, and that generates an actionable 3D model as a base for AR deployment. A browser-based placement app renders a 3D model of the venue. Companies can attach AR content to any position or object on earth with centimeter precision (indoors and outdoors), which makes the content available to passersby for interaction. Viewers can then interact with the AR content through a specialized app.

The technology allows businesses to map spaces and attach content to the maps they have created. Through Visualix's SDK, companies can build their own applications for the AR cloud. Visualix has a patent-pending combination of what is possible on the mobile side with what can be achieved in the cloud for the most reliable mapping and positioning. This allows software engineers to build their own large-scale AR applications.

Visualix enables many separate devices to share an AR session with centimeter-range accuracy, and then users can see the same 3D objects placed in the same physical location. If one device sees a change in the physical environment or makes an adjustment to the AR layer on top, the AR cloud can update the 3D map in real time across devices.

Background

CEO Darius Pajouh and CTO Michael Bucko started the company September 2017. They intended to help businesses to create efficiencies through augmented information, navigation, simulation, and shared AR experiences.

They started out using regular cameras and created an intelligent multicamera system that gained understanding about the spatial attributes of the world and objects moving within it by reconstructing interactions in the world with camera input.

Bucko said they soon realized the potential of mobile phones and eventually combined the best of the learnings from the regular camera world and the mobile world to develop a device-agnostic solution. Also, the need for robust re-localization and mapping at scale prompted them to focus on algorithms, optimization, and scalability.

Current position

Visualix launched its technology in June 2018 and introduced the second version in September. The company launched the third version in March 2019. Visualix has several patent-pending technologies to improve mapping and positioning. In January in Las Vegas, the vendor introduced the largest-scale navigation at CES 2019 with 100,000 sq. feet (9,300m2). The company already works on 1-million-sq.

feet (93,000m2) installations. "We want to focus on our core. We want to make mapping and positioning better and give it to more enterprises to allow them to build killer applications," Bucko said.

Visualix works with several partners and large OEMs, including Deutsche Telekom and other telecom providers that use 5G and edge computing. The company also partners with several AR companies. The company also works with large international industrial corporations that build products using the Visualix Platform.

Visualix is funded by innogy Ventures, which conducted a seed round of funding on February 15, 2018.

Data sheet

Table 4: Data sheet: Visualix

Product name	Visualix Platform	**Product classification**	Computer vision
Version number	3	**Release date**	June 2018
Industries covered	Gaming, retail, museums, automotive, manufacturing, real estate	**Geographies covered**	Europe, US, South America
Relevant company sizes		**Licensing options**	Yearly license
URL	www.visualix.com	**Routes to market**	Direct or through agencies
Company headquarters	Berlin, Germany	**Number of employees**	12

Source: Ovum

Appendix

On the Radar

On the Radar is a series of research notes about vendors bringing innovative ideas, products, or business models to their markets. On the Radar vendors bear watching for their potential impact on markets and could be suitable for certain enterprise and public sector IT organizations.

Methodology

This research was prepared from numerous interviews with vendors and industry experts.

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