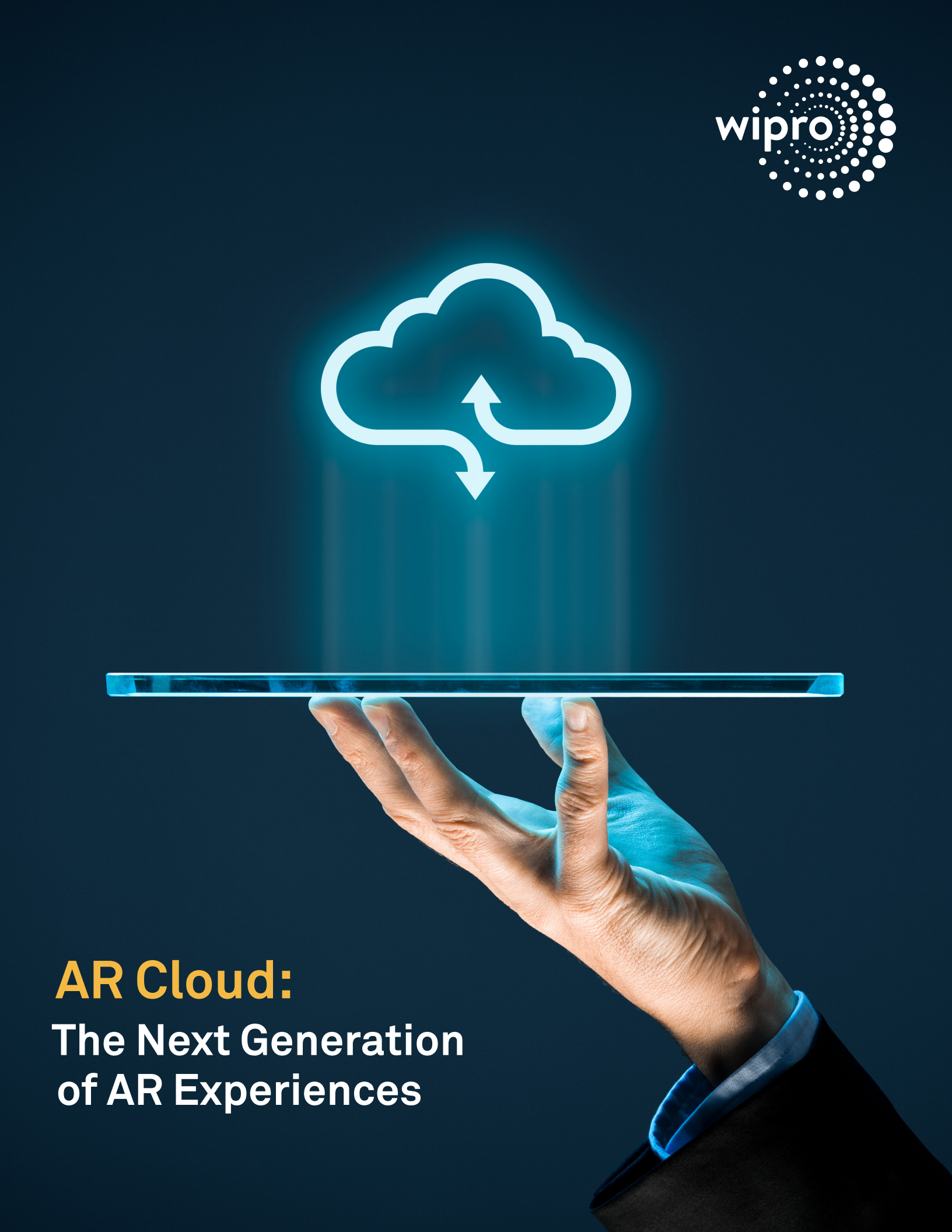


AR Cloud:

The Next Generation of AR Experiences

There is a lot of buzz around AR Cloud. What is AR Cloud, and how can it impact the AR value chain?

Virtual Reality (VR) and Augmented Reality (AR) have been around for some time. Augmented reality (AR) enables interactive, immersive environments where real-world objects are overlaid by digital content based on the multimodal sensory events including visual, auditory, haptic and external Internet of Things (IoT) sensor data. The virtual content is interactive in real-time and registered in 3D space. The term Extended Reality (XR) refers to all real and virtual combined environments with real-time interaction. We could soon see many more use cases for XR technology across different industry segments, such as field service advisement, step-by-step visual guidance and training simulations.

This whitepaper explains AR Cloud, its core technological components, and how it will disturb business and addresses some important questions:

- What is the market potential?
- Who are the key players in AR Cloud?
- Who will benefit from the AR Cloud explosion?
- Will there be a single owner or multiple players in the AR Cloud market?
- What challenges and opportunities are present in AR Cloud?
- What security and privacy issues do we foresee?
- What are some use cases for AR Cloud?

What is AR Cloud?

AR Cloud is a persistent digital copy of an environment based on the real world's spatial properties. Also described as a digital twin of the real-world, AR Cloud enables sharing AR experiences with multiple users in real-time. This virtual world can be seen as a shared screen that allows AR experiences.

AR Cloud technology will change the way users engage and search for information and disrupt how businesses operate and communicate with customers and employees. In the next generation of the internet, information will be "explored," using visual contexts.

Ori Inbar, Partner of Super Ventures, stated, "The principle of AR Cloud is that all the experiences should be persistent in the real world across Space, Time and Devices." When you create the AR experience in a physical environment, this experience must remain in space and time so that the user experiences what exists at the location.

According to ABI Research, AR Cloud will disrupt the complete AR value chain, predicting growth of US $102 billion by 2024.

What are the challenges and opportunities in using AR Cloud?

The main challenges in AR adoption are meeting user expectations of an immersive experience, justifying device and implementation costs, overcoming difficulties in content creation, sharing content to multiple users in real-time, technical maturity and features within AR devices.

With the current global pandemic impacting the way we live, communicate and conduct business, digital applications and services are seeing significant adoption.

Enterprises are using XR to implement remote assistance and step-by-step visual guidance using AR integrated with Artificial Intelligence (AI) technology. The ability of AR Cloud to share experiences in the virtual world will lead to collaborative engagement opportunities across healthcare, construction and design, manufacturing, gaming and many others.

Components of AR Cloud

Figure 1: Ori Inbar has laid out three main components of AR Cloud.

1. **A scalable and shareable machine-readable representation of the world aligned with the real-world coordinates**
2. **Ability to instantly localize from anywhere on multiple devices**
3. **Ability to place virtual content in the world's digital devices and interact in real-time, on-device and remotely supporting multiple users**

The creation of digital 3D virtual maps (representations of the world aligned with the real-world reference coordinate system) is one of the technology components. Spatial mapping technology is used for enabling 3D mapping.

The other AR Cloud components are instantly localizing the device from anywhere and the persistence of the AR experiences across applications and devices with the ability to interact with it in real-time. Here, localizing means positioning the device's camera with the reference point.

The combination of mapping the digital 3D content and localization enables realistic interactions with AR experiences overlaid as digital content. Multi-user engagements with persistent information on the cloud will enhance customer experiences by transforming how customers interact and collaborate to do their business.

Component Architecture of AR Cloud

Most AR experiences overlays either 2D or 3D content on the physical object with no context to real physical realities. For the user to have realistic experiences, the context-aware AR content needs to be overlaid on the physical world.

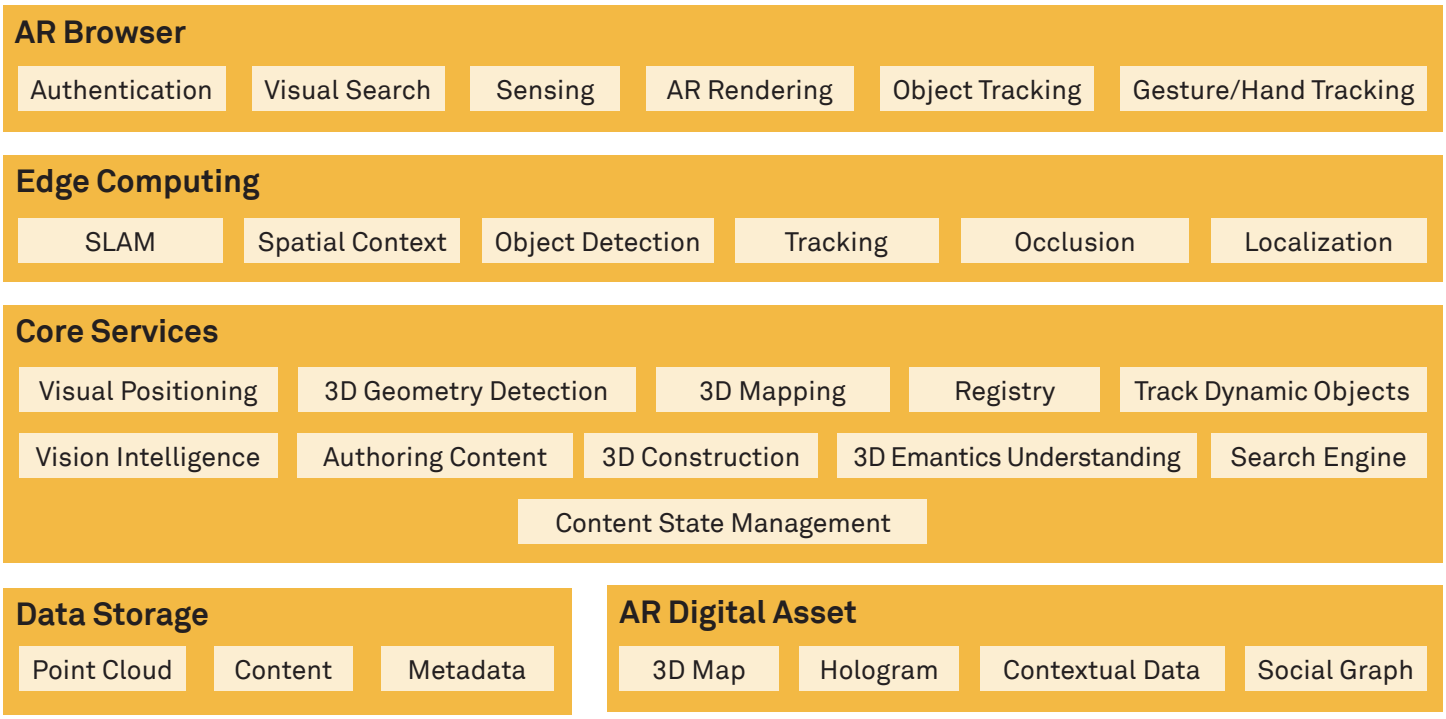
A scalable and sharable point cloud representing the object or space in 3D needs to align with the real-world coordinates. For AR Cloud, where everyone can share AR experiences, the point cloud must be persistent with references to the real-world coordinate system. That's why we need to have a point cloud of our world.

AR Cloud content needs to be updated continuously and should localize from anywhere on any device. The device camera needs to understand the precise location of its environment. Understanding the scene semantically (segmenting objects/ identifying the physical properties of surfaces) and positioning the digital content in the physical space considering the occlusions and collisions (colliding virtual objects with physical objects) are some of the building blocks of AR Cloud.

The ability to position and visualize virtual content registered in 3D space will enable multiple users to interact remotely with virtual objects in real-time. The visual positioning component will help the AR application to rely on precise localization instead of using a GPS-based solution. The GPS based solution cannot provide less than 10cm level of accuracy; hence, visual positioning systems are most important in AR Cloud. The 3D Geometry detection component detects 3D ground, building and surrounding objects to provide occlusion and interaction experiences.

Think of the client component as an AR browser, where the user can do a visual search, interact with the virtual object, share experiences, track the object and perform AR annotation. With 5G and edge computing technology, components, such a spatial context awareness, object detection, localization and tracking will be pushed at the edge layer for better response and latency, resulting in immersive experiences.

Figure 2: Building blocks of an AR Cloud platform



The spatial context of an AR Cloud platform enables an augmented view of the real world with an understanding of the environment. It allows interfaces/services to push the AR content associated with the geographical location with an understanding of the context, such as time and environment. Content Authoring Service providers ensure the authenticity and ownership of the content.

For example, businesses can leverage AR Cloud for marketing their products. Instead of putting advertisements physically in a real-world location, they can use the virtual world location to share the persistent and spatially aware digital content.

To have an interactive AR experience in real-time, it must have an intersection of Internet of Things (IoT), 5G and Artificial Intelligence (AI). Based on the events generated via IoT sensors, the rendering of the content can be dynamic and provide a more realistic experience.

AR Cloud–The Next Generation of Browser

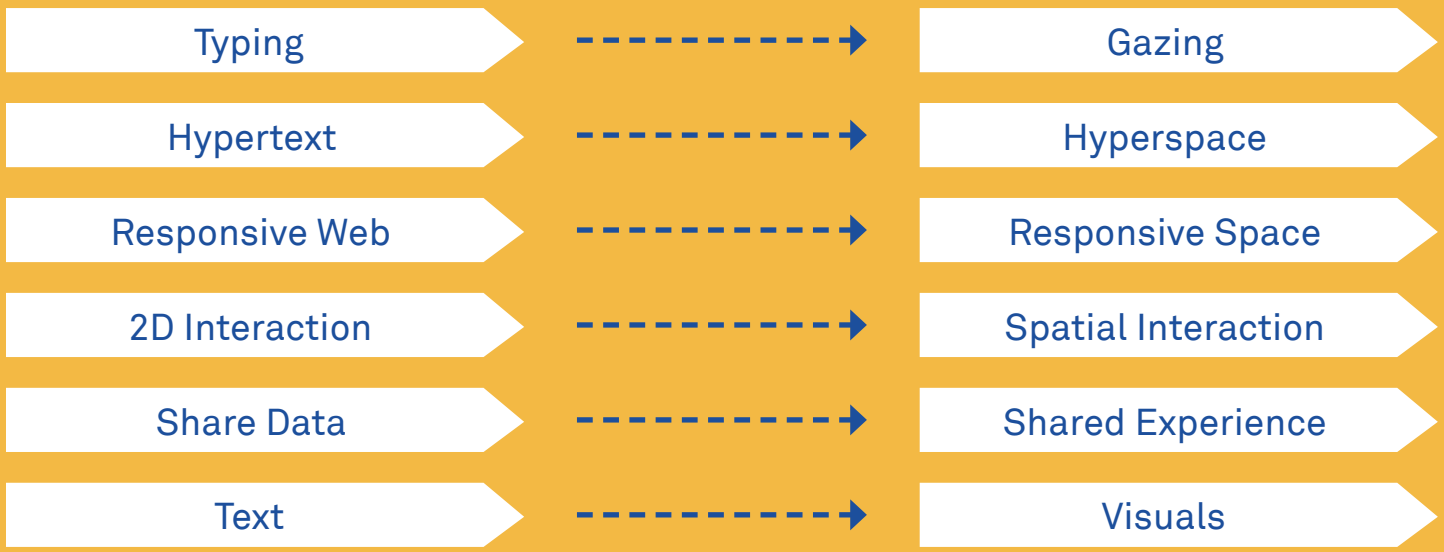
The AR cloud will transition people away from using an internet browser to search for information to using an AR browser to search for information visually. It's like googling the world by just looking at it. The information to be searched will be in the current context.

For example, a Field Advisor technician gets a ticket for a service repair and maintenance task. Instead of searching for the possible solution or procedure by entering an error code or a description of the problem.

The technician can use an AR-enabled camera pointed at the object or error screen and visually it will detect/understand the problem/issue and then fetch the relevant procedure. The technician can also see past experiences of other technicians who have fixed similar concerns.

In the travel industry, AR Cloud-enabled apps, or WebAR, can provide multi-user engagement experiences during the exploration of historical places or new sites and locations.

Figure 3: Analogy between an internet browser and an AR browser



What will drive the adoption of AR Cloud?

AR Cloud adoption will not explode until 5G networks mature. For the massive adoption of AR Cloud to occur, substantial changes need to happen in the overall infrastructure.

- The mobile device camera needs to have depth perception. 3D mapping needs to be an embedded capability through SDK. Apple has launched iPad Pro with a LiDAR sensor. Other mobile device manufacturers are also planning to add these capabilities to their products.
- Advancement in HMD device capability and standardization will help to accelerate AR Cloud adoption.
- High-bandwidth and low-latency networks with edge server computing will help push processing to the edge, leading to improved experiences.
- As AR Cloud providers multiply as the technology matures, having an open standard and decentralizing the AR Cloud model will drive more adoption.
- Data privacy and ownership protections need to improve.

Who is investing in AR Cloud?

Most tech giants are investing in AR Cloud technology. Apple has partnered with DentReality in developing indoor navigation technology. The latest version of ARKit uses the iPad Pro LiDAR sensor to support 3D scene understanding, occlusion and precise localization.

- Apple has also acquired NextVR, a virtual reality content streaming company, to provide a content engine for its AR/VR devices. Apple is also planning to launch AR Glass by 2022.
- Facebook has announced “Live Map,” a project that will create a 3D map of the world using crowdsourced data, which would require bringing AR wearables to the mainstream.
- Google has acquired North, a Canadian startup that produces smart glasses for the consumer market.
- Amazon is investing in AR Cloud technology to boost their product sales and improve margin.
- Scape Technologies, Visualix and Fantasmo are 3D mapping startups building 3D maps of the real world.

Apart from these tech giants, Niantic, Magic Leap and Ubiquity 6 are focusing on developing AR Cloud platforms and capabilities. Niantic acquired spatial mapping startup 6D.ai, which will help them create planet-scale AR experiences with their Niantic Real World platform. Sturfee is focusing on creating AR Cities using its powerful visual positioning system (VPS). Their approach is to capture the images from satellite and convert them into a 3D mesh. 6D.ai is mainly focusing on indoor navigation leveraging the AR Cloud. Ubiquity 6 is building interactive and persistent AR gameplay to drive significant consumer adoption. YouAR is building an AR Cloud platform for B2E that focuses on productivity improvements.

AR Cloud is the Key for the Future of AR

Enterprises are seeing the value and ROI by using AR technology. They are using AR technology for Do It Yourself (DIY) remote collaborations, training the user via immersive, realistic experiences. Real-world mapping will enable enterprises to expand their use cases and provide multi-user AR experiences.

The existing AR approach, which uses marker-based AR, or object detection, will be transformed to leverage the real-world mapping information. This will lead to many more use cases in the enterprise world, driving more demand.

Business and Trade Opportunities in the AR Cloud Ecosystem

Multiple startup players in the AR Cloud race are building "mini" AR Clouds that provide 3D maps of the real-world or a city. These AR Cloud providers will offer users subscriptions to their virtual worlds.

Registry services providers will emerge and enable users to register digital objects providing public access to the API endpoints. For example, owning land or a location or store in the virtual world.

3D digital content and mapping services will advance through crowdsourcing. Some players will offer AR Cloud API/SDK for 3D mapping and localization at centimeter-level accuracy. These API/SDKs will enable developers to leverage the capabilities in localization, 3D scanning and visual positioning.

Other business opportunities could be marketplaces for digital assets, avatars, trading between users and ownership of real-world locations. Advertising in the virtual space and virtual travel offerings will evolve.

Security, compliance and regulation in AR Cloud

As there are many players in the AR Cloud race, we see significant challenges and risks to ensuring data security and privacy. An independent organization needs to put in place regulations to mitigate this risk.

Data collected via sensors, 3D mapping of real-world locations (private or public), and various digital assets of the owner, need to be protected according to individual rights of privacy, security and personal freedom. The integrity of the content is also very important for authenticity of the data.

Regulations should restrict anyone from tampering with content or identity, preserve the individual's secrecy in that location, and protect the privacy of homes, property and commercial spaces. Consent to data collection must also be limited by context.

Whenever the context changes, new permission must be acquired. Users should have the right to know what data is being collected and used. While using AR Cloud solutions, data should not be captured that is not already public. Without regulations, ensure cloud solution developers and providers are following security and compliances will be challenging.

To ensure the openness and interoperability for the data and services offered by different AR Cloud platforms while ensuring data security, privacy and freedom, an open AR Cloud organization whose mission is to address these challenges must be created.

AR Cloud pricing models

As multiple cloud service providers offer their digital twin of the real-world, pricing models will vary depending on the service offerings. AR Cloud providers might offer fixed pricing, usage-based dynamic pricing, subscription-based pricing, or a combination of fixed and usage-based pricing.

There will be virtual land sellers who may sell or rent virtual land as raw space. It will be interesting to see how pricing models and services evolve in the future.

Conclusion

The AR Cloud will be a vast cloud infrastructure with multiple providers offering several AR Cloud platform solutions.

The infrastructure's success will depend on how the other technologies, such as 5G, IoT, edge computing and spatial computing integrate to collect data, and update the point cloud in real-time to a multi-user AR experience in near real-time on different devices.

Standardization, security and privacy frameworks will also play an important role in driving major adoption.

Many business opportunities and use cases will evolve once the AR Cloud infrastructure is in place, similar to how the internet grew and matured.

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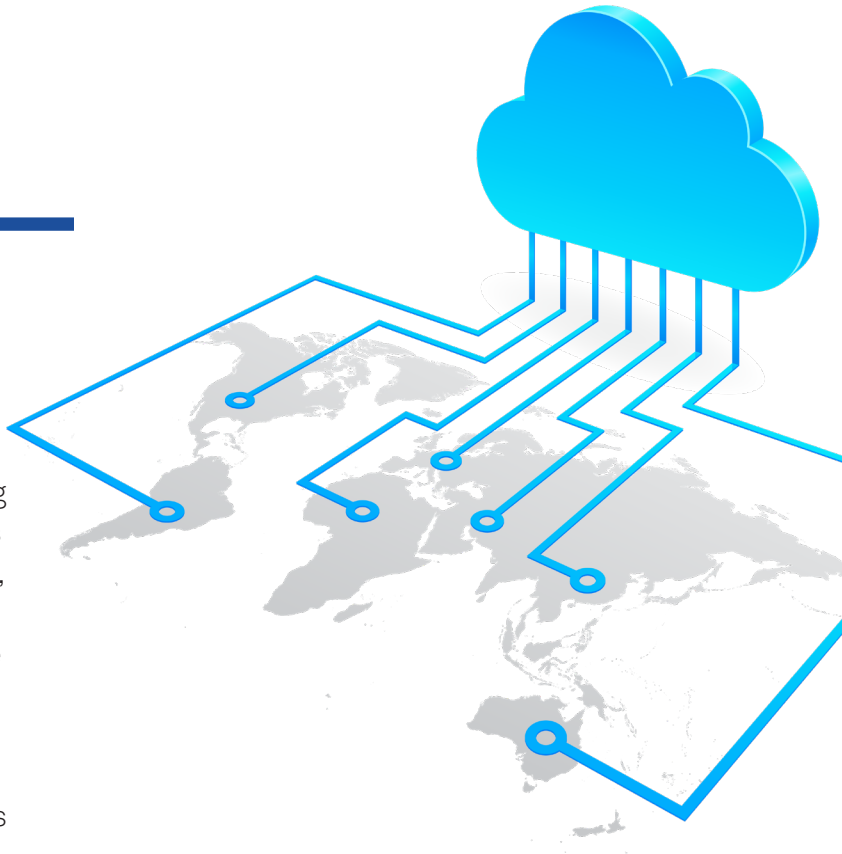

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