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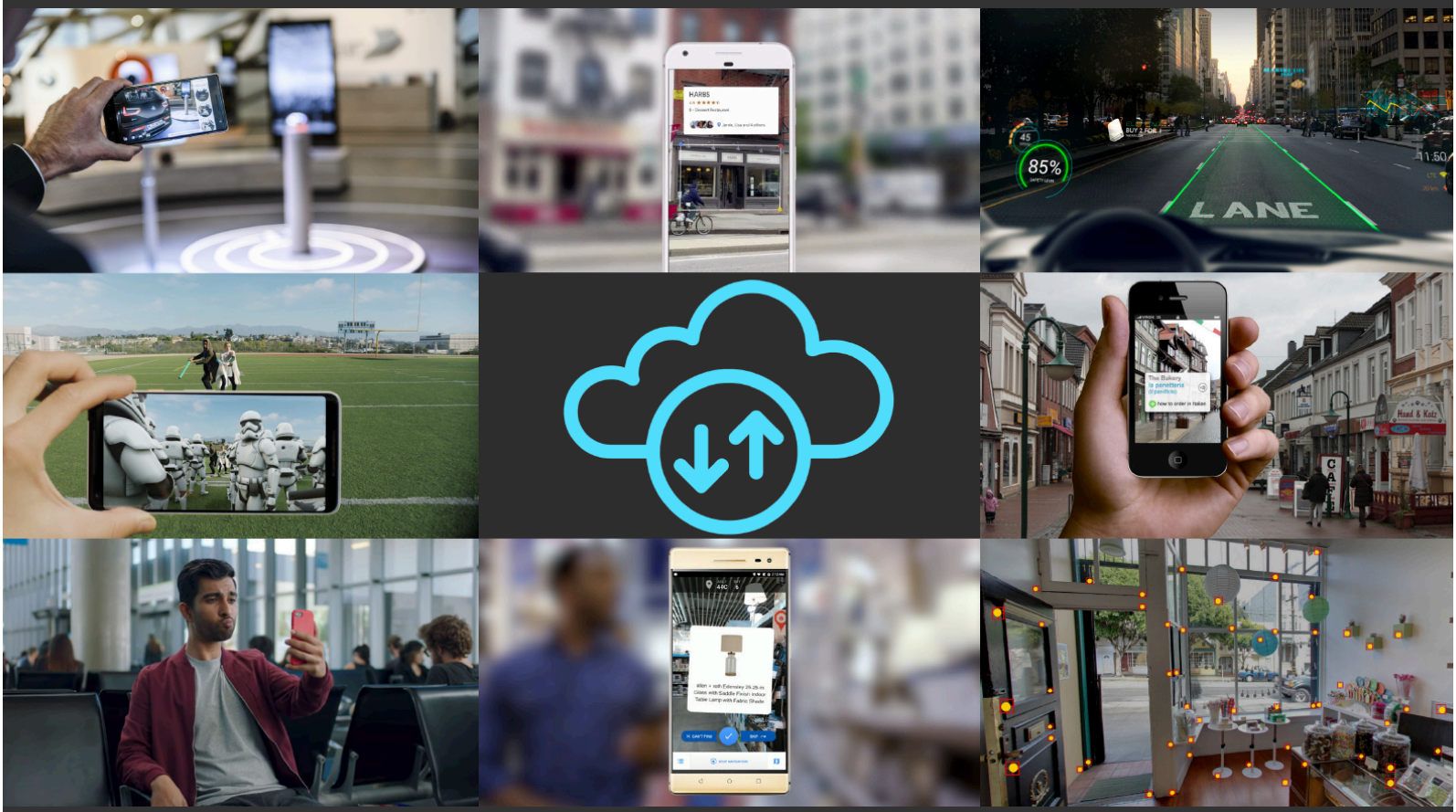

ARTILLRY INTELLIGENCE BRIEFING

AR CLOUD AND THE 'INTERNET OF PLACES'

APRIL 2018

ARtillry

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Executive Summary

Among several areas where AR will apply, one of the most exciting and potentially lucrative is local commerce. This includes consumer spending that's consummated offline, and usually in proximity to one's home. AR will join the tools that help us discover products and qualify buying decisions.

As background, it's often overlooked that most consumer spending happens offline in the physical world. Despite the attention to e-commerce over the past decade, it only accounts for eight percent of consumer spending. The remainder – about $3.7 trillion in U.S. spending – is brick & mortar.

But that's not to downplay digital technologies. Online media – including desktop and mobile – have a big *influence* on that offline spending, to the tune of about $1.7 trillion in U.S. consumer spending. This is known in the search and advertising worlds as "online-to-offline (O2O) commerce."

This is where AR could have an impact. Just think: is there any better technology to accelerate O2O commerce than one that literally melds physical and digital worlds? Indeed, AR can shorten gaps in time and space that currently separate digital interactions (e.g. search) from physical-world outcomes.

This will play out in several ways, including informational overlays that add context and commerce to items you point your phone at. It's everything from restaurants, to shoes you see worn on the street. Not only does it offer consumer utility but it taps into high buying intent, which leads to monetization.

But before we get too utopian and carried away in blue-sky visions – as is often done in XR industry rhetoric, trade shows and YouTube clips – it's important to acknowledge realistic challenges. There are several interlocking pieces required, including hardware, software and the AR Cloud[1].

Coined by Super Ventures' Ori Inbar, the AR cloud underpins the AR future many of us discuss. In short, it's a cloud repository of geo-relevant data and object blueprints that will empower far-flung AR devices with contextual and situational awareness. It's the active ingredient in an "internet of places."

But how will the AR cloud be built? Who will own it? How will information be indexed and accessed? And how will AR devices translate that data into AR magic on the front end? These are key questions that will define the next era of mobile AR. And they're the questions we begin to tackle in this report.

Key Takeaways

Key takeaways are also highlighted throughout the main body of this report.

- Local brick & mortar commerce is an opportune and underrated market for AR.
  - $3.7 trillion is spent in consumer retail purchases in the U.S..
  - Of that total, only $300 billion (8 percent) is e-commerce.
  - The remaining 3.4 trillion is offline, half of which is influenced by digital media.

- This "online-to-offline" (O2O) segment is where AR will take the biggest bite
  - It will involve AR overlays that contextualize items you point your phone at.
  - This consumer utility taps into "high buying intent," akin to mobile search today.
  - ARtillry survey data indicate demand for AR city guides, retail assistance and commerce.

- Google's angle is "visual search," its the next generation of monetizable search
  - The search input is your phone's camera and the search "terms" are physical objects.
  - Google's will index and contextualize this "Internet of Places" just like it did the web.
  - Google has visual databases and AI assets to pull this off. The rest of us don't…

- A robust AR ecosystem with visual search and AR capability requires an AR cloud.
  - It's a theoretical cloud data repository that enables AR devices to perform anywhere.
  - It will deliver scene mapping and object recognition blueprints to AR devices.
  - This lets AR devices "recognize" scenes versus exhausting computational muscle mapping them.
  - With this burden offloaded to the AR Cloud, developers can focus instead on the front end.

  - The AR cloud will enable the consumer AR industry to reach ARtillry's projected $14 billion by 2021.
  - This will mostly be mobile AR, and include in-app purchases, commerce, and other revenue sources.
  - The AR cloud will enable a key function: image persistence across sessions and users.
  - Image persistence is key for multiplayer support, which will unlock social AR killer apps.

- There are mini-AR clouds developing and several supporting technologies.
  - Google, Niantic and others have built proprietary AR Cloud-like technologies.
  - A more open and federated AR cloud will be necessary for startups to tap into its capability.
  - A rich ecosystem will develop around the AR cloud, including infrastructure, front-end software and data.
  - Like the early (and current) web, this will create several gaps for business opportunity.

- No one company is big enough to build the AR cloud so it will likely be crowd-sourced.
  - Companies like 6D.AI build tools to crowd source and unify the AR cloud's construction.
  - Devices using such APIs will collect AR cloud data while they benefit from it.
  - This will work like Waze: an incentivized system of give and take for area-mapping data.
  - Autonomous vehicles could also be tapped for AR cloud-building mapping data

- Ownership of the AR Cloud will be determined in the coming years
  - Like the Internet, there will be no owner but protocols and standards for interoperability
  - Centralized authorities or systems (possibly blockchain) will govern IP ownership within the cloud.
  - Scarcity – due to finite physical space -- will drive IP asset value in the AR cloud (unlike the web).

- There will be considerable challenges, uncertainties and factors to iron out.
  - Device location tracking (to communicate with the cloud) requires app-level permissions.
  - AR's nascence means that case law will determine impactful regulations and viability.
  - The vessel is uncertain: Apps (powerful but cumbersome) vs. web (weaker but frictionless)?

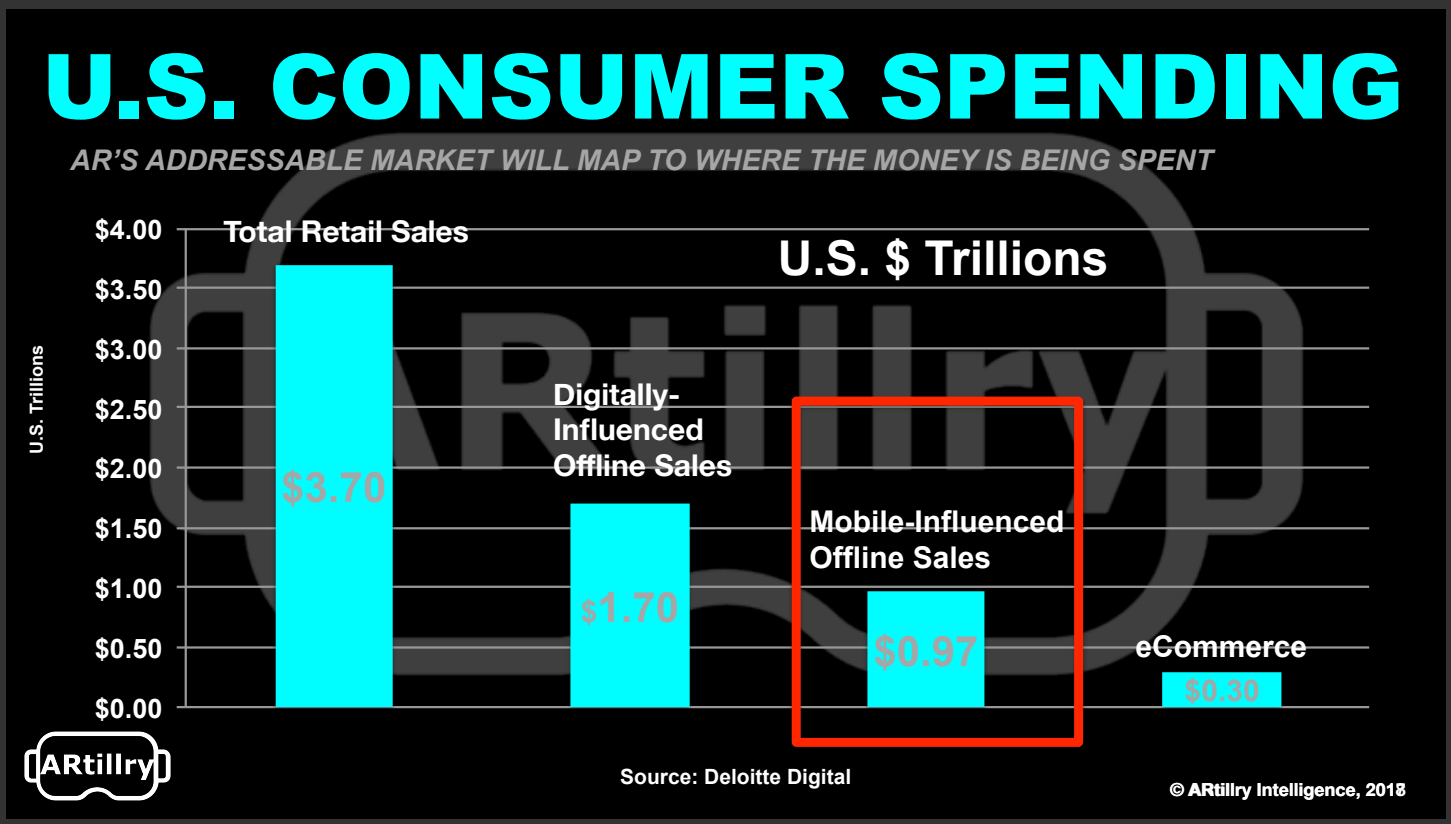
Introduction: Buy Local

It's often forgotten that about $3.7 trillion is spent in consumer retail purchases in the U.S..[ii] Of that total, $300 billion (8 percent) is spent in e-commerce. This means that offline brick & mortar spending – though often overshadowed by its sexier online counterpart – is where the true scale occurs.

But digital media like mobile search is still impactful. Though spending happens predominantly offline, it's increasingly *influenced* online. Specifically $1.7 trillion (46 percent of that $3.7 billion) is driven through online and mobile consumer interactions. This is known as online-to-offline (O2O) commerce.

O2O is one key area where AR will find a home. Just think: is there any better technology to unlock O2O commerce than one that literally melds physical and digital worlds? AR can shorten gaps in time and space that currently separate those interactions (e.g. search) from their offline outcomes.

We're talking contextual information on items you point your phone at. AR overlays could help you decide where to eat, which television to buy, and where to buy the shoes you see worn on the street (offline-to-online). This is what ARtillry Intelligence calls "Local AR," and it will take many forms.

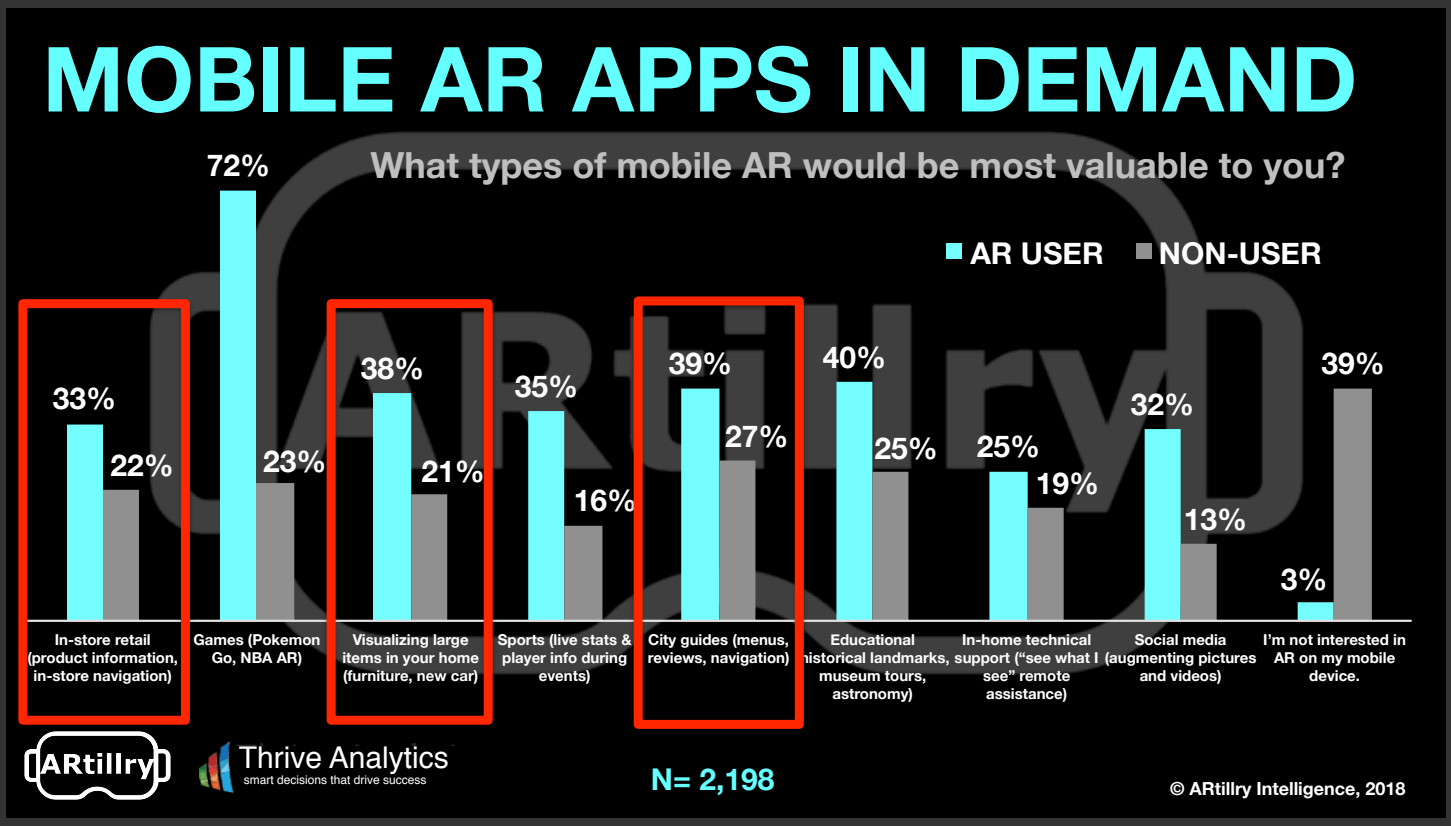


Visual Search

One of the first and predominant formats where Local AR will manifest is visual search. If you think about it, AR in some ways is a form of search. But instead of typing or tapping search queries in the traditional way, the search input is your phone's camera and the search "terms" are physical objects.

This analogy applies to many forms of search, but is particularly fitting to local. Traditional (typed) local search performs best when consumers are out of home, using their smartphones.[iii] This is when "buying intent" is highest, and therefore when click-through-rates and other metrics are highest.

Furthermore, proximity-based visual searches through an AR interface could gain traction if our recent consumer survey research is any indication.[iv] Among the categories and types of AR apps that consumers want, city guides, in-store retail and commerce apps showed strong demand.



These proximity-based searches are conducive to AR because the phone is near the subject (think: a restaurant you're walking by), and can therefore derive information and context after mapping it visually. This really just makes it an evolution of a search query… but done with the camera.

"A lot of the future of search is going to be about pictures instead of keywords," Pinterest CEO Ben Silberman said recently. His claim triangulates several trends such as millennials' heavy camera use, mobile hardware evolution, and AR software (such as ARkit) that further empowers that hardware.

The Internet of Places

These are some reasons why Google is keen on AR. As is common to all its XR initiatives, Google's AR efforts are driven to advance its core business.[v] In other words, to continue dominating and deriving revenue from search, it must establish its place in this next visual iteration of the medium.

"Think of the things that are core to Google, like search and maps," said Google XR Partnership Lead Aaron Luber at ARiA. "These are core things we are monetizing today and see added ways that we can use [AR]. All the ways we monetize today will be ways that we think about monetizing with AR."

For example, a key search metric is query volume (along with cost-per-click, click-through-rate and fill rates). Visual search lets Google capture more "queries" when consumers want information. And these out-of-home moments, again, are "high intent" when monetization potential is greatest.

These aspirations will manifest initially in Google Lens. Using Google's vast image database and knowledge graph, Lens will identify and provide information about objects you point your phone at. For example, point your phone at a store or restaurant to get business details overlaid graphically.

This can all be thought of as an extension to Google's mission statement to "organize the world's information." But instead of a search index and typed queries, local AR delivers information "in situ" (where an item is). And instead of a web index, this works towards a sort of "internet of places" (IOP).

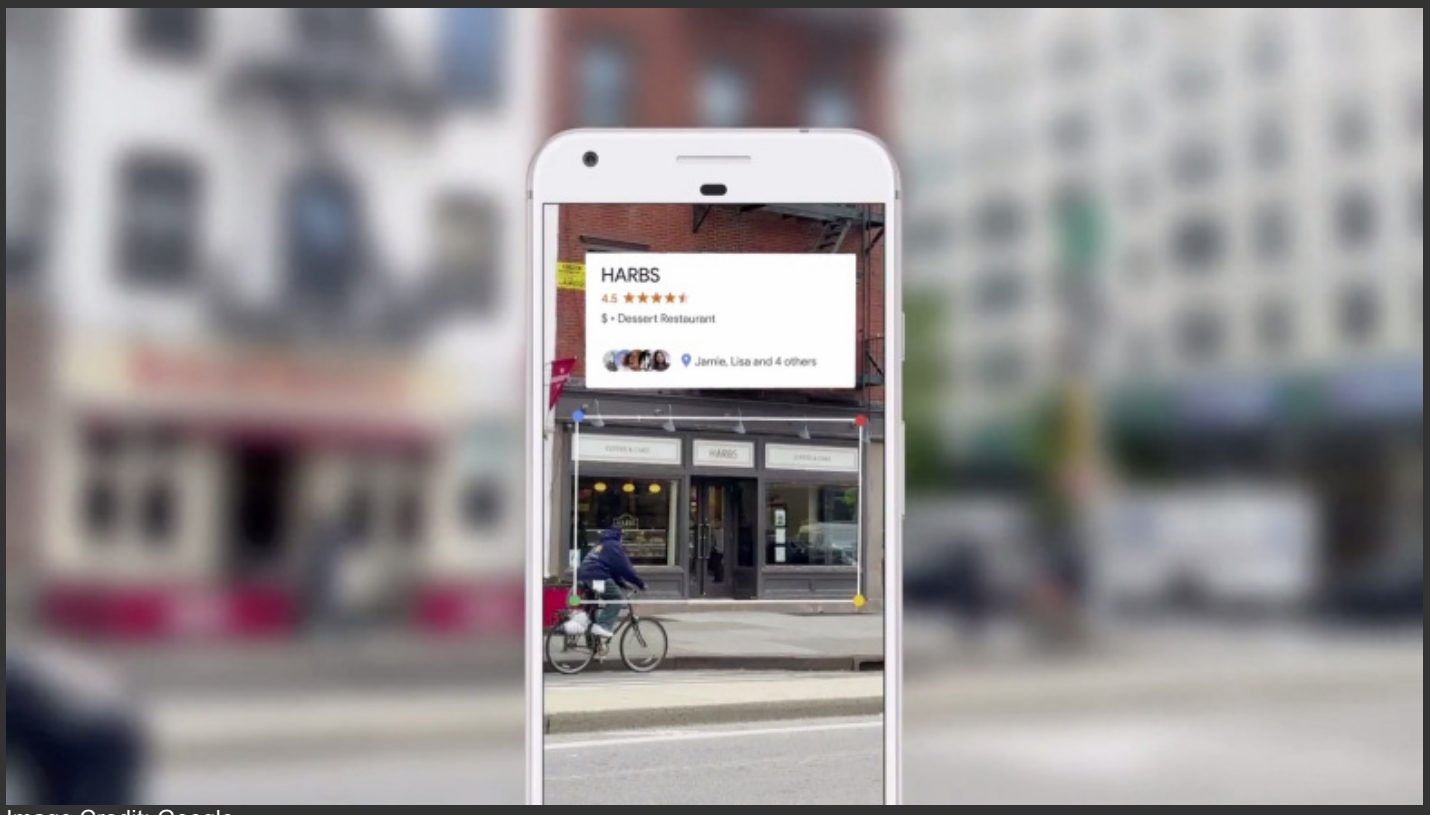


Image Credit: Google

It Works Indoors

Google's visual positioning service (VPS) is another manifestation of IOP. It helps shoppers navigate and obtain product information in retail stores like Lowes. Using point-cloud based 3D mapping data within retail partners' locations, it will help consumers find the aisles and products they're looking for.

"GPS can get you to the door, and then VPS can get you to the exact item that you're looking for," said Google's VR/AR lead Clay Bavor at last year's VPS unveiling at Google I/O. "Imagine in the future your phone could just take you to that exact screwdriver and point it out to you on the shelf."

Like visual search, this will help Google serve monetizable information to consumers. But it also ties nicely into Google's ad business with "last-mile" attribution data to report ROI to its advertisers. And it knows the best way to do that is to track dollars where they're mostly spent – again, offline.

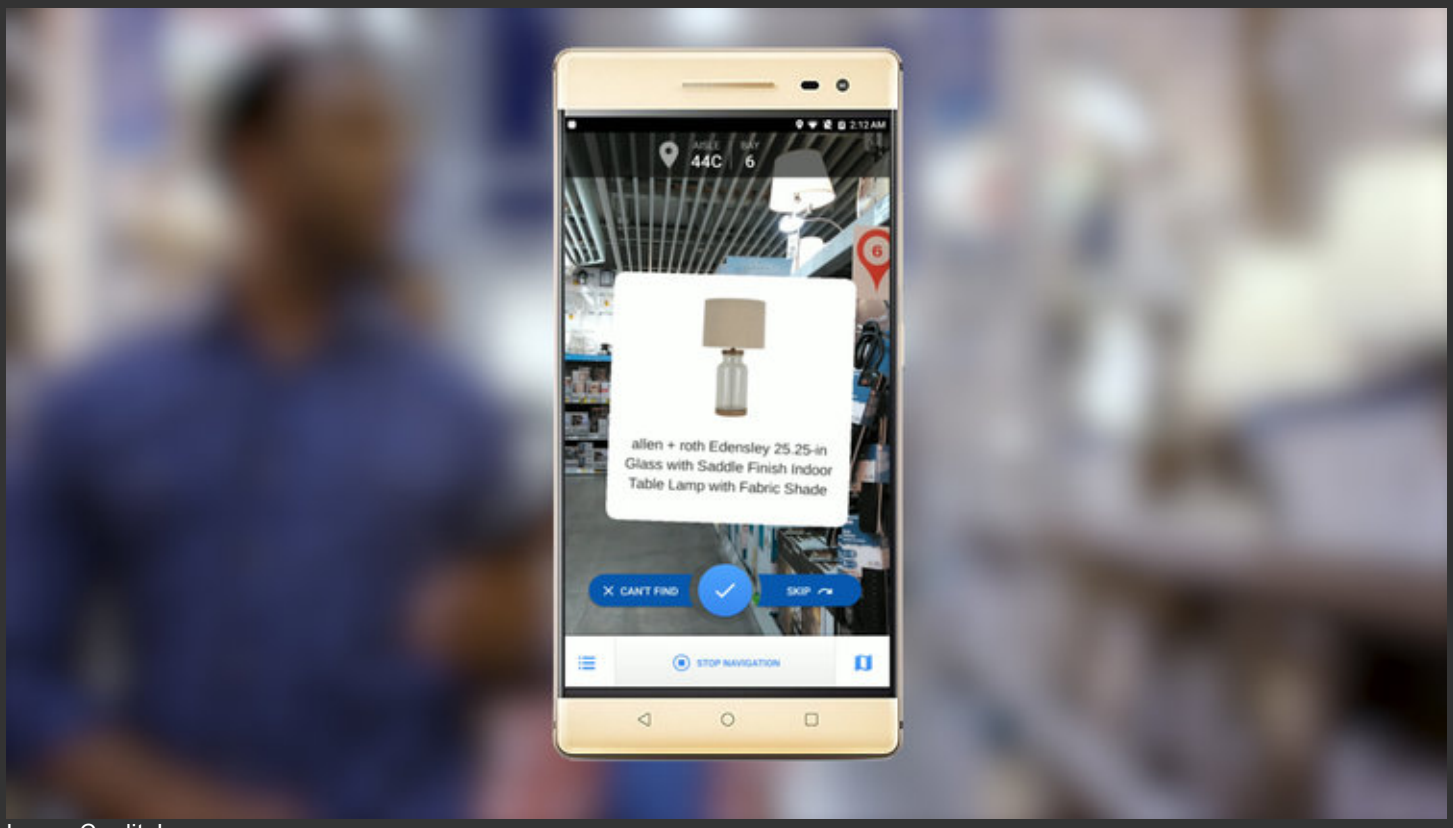


Image Credit: Lowes

What About Everybody Else?

Google can pull off many of these Local AR and visual search initiatives because… it's Google. It not only takes heft and deep pockets to do things like 3D scan hundreds of Lowes Hardware stores, but Google sits on a massive image database that will enable visual search through image matching.

For example, Google's aspirations for location-based visual search queries like the storefront example above will tap into its Street View database. Because it has street-level imagery of most of the storefronts in the U.S., it can use that as an object recognition database to power Google Lens.

And its work with autonomous vehicles in its Waymo division will further spin out computer vision and geographically relevant object recognition for an Internet of places. Beyond Local AR, Google can also power "general interest" visual search using its Google Images database and other work in AI.

But that begs the question "what about everybody else?" Other tech giants are similarly positioned to apply assets to their AR products,[vi] but what about the startups of the world? Google's positioning in its many AR initiatives unfortunately isn't representative of the tools available to smaller players.

To obtain some of those Google-like capabilities, more shared resources are needed for visual search, AR object recognition and other components of local AR. And the theoretical entity that's missing to unlock such capabilities for a robust AR ecosystem? It's the fabled *AR Cloud*.[vii]

Video Companion: AR in Local Commerce

(Click URL to Open)

https://youtu.be/GSidwTWiiUM

Enter the AR Cloud

The AR Cloud is like dark matter. Still theoretical, it's a missing puzzle piece whose adjacent pieces provide evidence of its existence and possible shape. Replace the puzzle metaphor with theoretical physics equations and that's dark matter. We know it has to be there if the equation is to balance.

The AR cloud is similarly something we know needs to happen for AR's fully intended vision to materialize. It's the critical, yet still non-existent, piece of nearly every glowing and futuristic AR vision that you may have heard in conference presentations, generalist op-eds or YouTube clips.

The “What?”

So what is it exactly? Though its still-theoretical status dictates that it will take shape in unknown ways, it’s generally a cloud data repository that enables AR devices to perform some of the actions outlined in previous sections. That includes geo-relevant data and object-recognition blueprints.

Stepping back for a minute, AR works by mapping its environment before overlaying graphics. True AR works as less of an overlay, and infuses graphics in dimensionally accurate ways such as occluding physical objects. ARkit and ARcore have democratized some of that, with lots to go.

In the local AR examples explored earlier, scene mapping happens when the smartphone scans its surroundings. This applies a combination of computer vision, object recognition (a la Google Street View) and GPS data. But the issue is that all that data can’t be stored locally on your phone.

In other words, ARCore and ARkit perform well in individual AR sessions including mapping a given space using surface detection, localization and inertial odometry. But to map large (outdoor) areas, or come back to previously mapped areas requires more computational muscle than smartphones offer.

That’s where the AR cloud comes in. It will help AR devices to “recognize” scenes, rather than exhaust computational muscle (and battery life) mapping already-chartered territory. It will register devices’ location dynamically, then serve mapping and object recognition data tagged to that location.

Image Credit: Google

The "Why?"

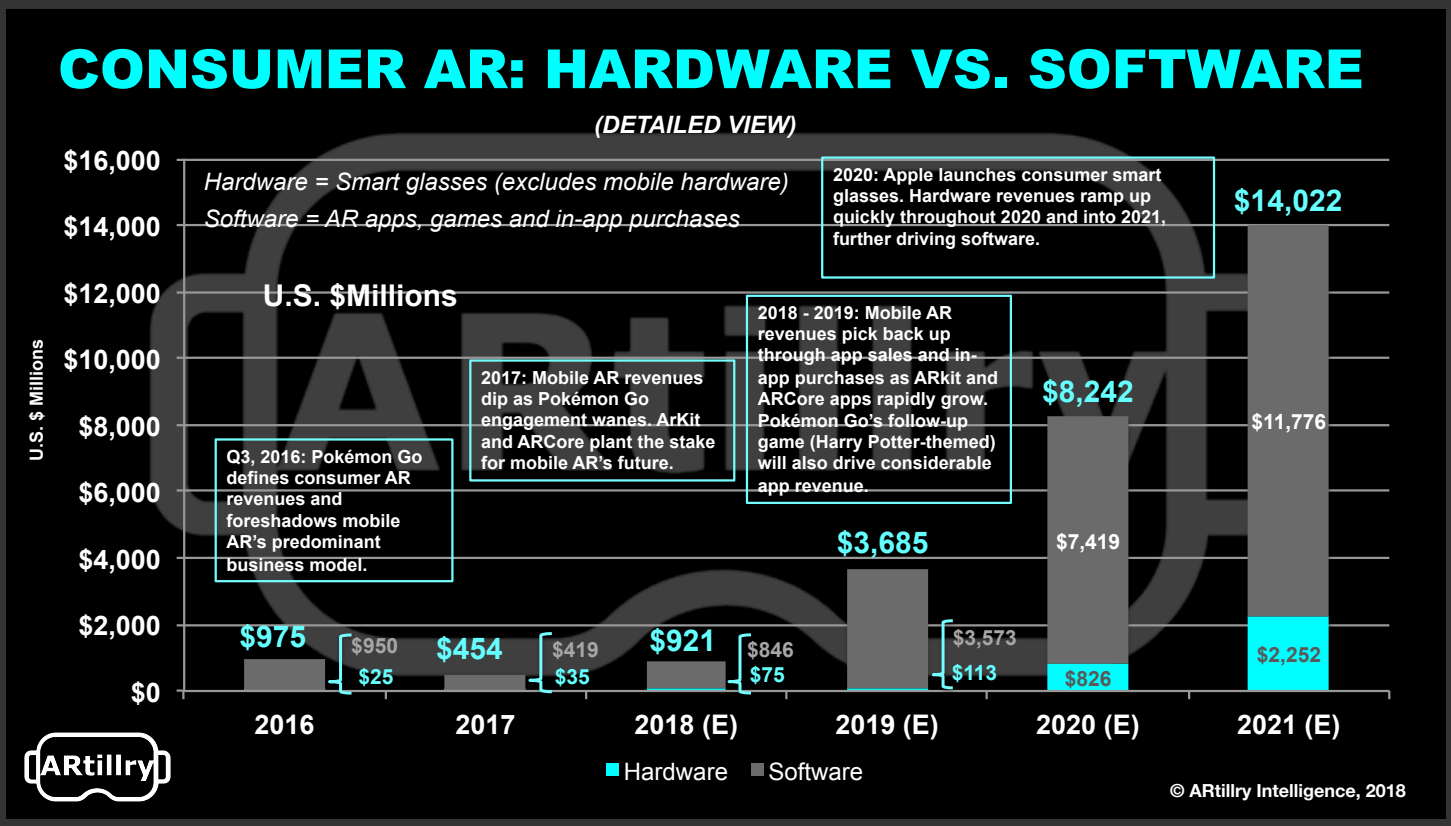
Why is this important? It gives AR apps more functionality, and advances the industry by giving app developers the capability of a Google – a la Google Lens and VPS. Instead of having to build or worry about those extensive and enabling data sets, developers can focus on UX and business models.

In fact, the AR cloud will enable the consumer AR industry to reach ARtillry Intelligence's revenue projections. Specifically, the sector will grow from $454 million last year to $14 billion in 2021. As we detailed in February's report,[viii] this will mostly involve mobile app-related revenue in the near term.

Another AR cloud benefit, like cloud computing generally, is offloading computational burden. Because, mapping and object-recognition data for the entire world is too extensive to store on-device, smartphones can tap the AR cloud to conserve computational muscle – a precious resource in AR.

The AR cloud will also enable a key function: image persistence. This refers to AR graphics that remain in place across separate AR sessions, and between users. The latter is key for social AR experiences and multiplayer support — both projected to drive AR's killer apps (see Charlie Fink[ix]).

Social AR is a big topic, and one to which we'll devote an entire Intelligence Briefing in Q3. In short, social connectivity will accelerate AR's growth through network effect that fuels adoption and active engagement. Image persistence and multiplayer support, care of the AR cloud, will be a key enabler.



The “How?”

At this point, you may be thinking, don’t we already have an AR cloud? For example, Pokémon Go works by having geo-tagged assets that are more or less persistent and viewable across sessions and players. Similarly, the above Google examples rely on cloud data to support AR sessions.

The answer is that these are sort of mini-AR clouds. Google utilizes Street View and other data sets as mentioned, while Pokémon Go works through a GPS database built over years from its forebear, Ingress. Other startups are building enabling technologies for image persistence, such as YouAR.

But these are smaller and proprietary AR clouds. And they often involve giants that can afford, or have spent years building those clouds. To unlock the AR app economy and revenue projections above requires a universal and open AR cloud that can be tapped and fed by billions of phones.

“Fed” is the operative and deliberately used verb in the previous sentence. The AR cloud’s outer bounds are as vast as the physical world itself, at least the inhabited parts. The point is, it’s huge and therefore so is the task of populating it with useful data like positional mapping and object blueprints.

The prevailing wisdom is that a job so big can’t be accomplished by one entity – no matter how deep their pockets. Google for example built a web index using crawlers, and the analog-world equivalent is essentially cameras. It’s covered some ground through street view cameras, but it will need more.

That logically leads to a crowd-sourced approach. The thought is that all of these outward facing cameras can capture data and feed the AR cloud, so it perpetually builds over time -- like Google’s web index. Indeed, Google Lens and VPS will likely *collect* mapping data as people are using them.

Image Credit: Google

The “Who?”

The crowd-sourced approach is what 6D.ai is pioneering. Think of it like Waze for the AR Cloud: Devices tap into the data, while feeding back the 3D mapping data they capture. And through that, the physical world gets mapped. 6D.ai’s technology will be packaged as an API for AR developers.

This will work best with apps that have massive usage and long outdoor sessions. Pokémon Go for example would be well-suited to collect mapping data as users roam the physical world. There will likely be a Waze-like value exchange for opt ins, such as in-game incentives or better performance.

Autonomous vehicles will also play a key role in populating the AR cloud. The computer vision that let’s AVs “see” the world is similar to AR’s area mapping, as mentioned. So as growing fleets of cars are mapping roads in order to drive on them safely, a byproduct could be valuable AR cloud data.

There are also smaller companies working on pieces of the puzzle. This will create an important value chain or ecosystem of supporting parts, such as image persistence technologies. In addition to those mentioned, startups feeding into this ecosystem include Membit, Esher Reality and Ubiquity6.

Image Credit: BMW

Who ‘Owns’ the AR Cloud?

With all these entities contributing to an AR cloud, the question that emerges is, who will own it? The answer is likely no one. Just as the Internet doesn’t have an owner, the Internet of places likewise won’t. It’s more of a network of owned assets that follow standards and protocols to coexist.

But asset ownership and operational protocols still have to be established. Indeed, the protocols that govern the world wide web, though mostly open and decentralized, have provided important standards that have enabled the consumer internet to be so interlinked and interoperable.

That is likely a model that the Internet of places – fed and fueled by the AR cloud – will follow. For example, Google and other self-interested tech giants building AR cloud assets (e.g. image databases) will likely have their ownership established and protected through a centralized authority.

This could take form in entities similar to ICANN and DNS. But more likely these governing entities won’t be traditional organizations, but will rather formulate under today’s native capabilities. In other words, it could be governed by something more automated or tokenized, such as blockchain.

Though we don’t want to get too deep into matters of the blockchain (an entirely separate report!), its capability aligns with the construction, maintenance and authentication needs of the AR Cloud. There will also be blockchain-centric issues like intellectual property and ownership of digital assets.

Image Credit: WayRay

Scarce Resource

Questions of ownership and regulated assets lead to another aspect of local AR that could create value: scarcity. As examined by 6D.ai's Matt Miesnieks,[x] the geography that defines AR graphics' location relevance renders them relatively finite. Could that scarcity define the value of AR assets?

Geographic positioning for AR graphical assets will be established mostly to add value in the form of location-based relevance and all the reasons we examined earlier (e.g. nearby commerce). But an important byproduct of that localization will be to create limitations through geographic scarcity.

For example, grounding digital assets in physical-world relevance could create value that's analogous to the location-based and temporal relevance of a live event. It's boosted by collective interest in a specific time and place, bound by finite atoms rather than infinite bits. The outcome: ticket prices.

This contrasts the digital real estate that's flooded and devalued digital content in the consumer Internet and smartphone eras. Banner ads for example are commoditized by expanding ad networks and fill rates – thus driving down CPM value. Could physical bounds conversely preserve value?

Image Credit: Wikitude

An Ecosystem is Born

Speaking of value, several other sub-sectors will feed the AR Cloud. Like the internet, there will be many moving parts and gaps that need to be filled (read: business opportunity). Also, like the Internet, the value chain will span enabling technologies, infrastructure, front-end software and data providers.

As one small and representative example of the areas that will emerge – or adapt/evolve from other areas – the local search and listings industry could play a key part in the "maintenance," of the AR Cloud. This hinges on the fact that a visual-search world will place lots of value on reliable place data.

As background, there's a subsector of search that maintains and optimizes local business data. Including everything from structured info (name, address) to unstructured info (reviews, specials, holiday hours), it's a lynchpin in SEO and marketing, especially for multi-location brands.

This local search and "listings optimization" area could take on new life in an AR and visual-search dominant world. It's what we're calling "VSEO" for visual search. This means that companies like Yext, Foursquare and Aisle411 could play a valued and lucrative part of the Internet of places.

We're already seeing signals for this: location data analytics provider Placed was bought by Snapchat last year to infuse location relevance in its brand advertising. Snapchat has also begun to localize its successful AR products, such as a new AR feature for its location-based "geo-filters" product.

Local data providers could similarly be well positioned for a visually-oriented search future. We're talking data sets like business details, menu items, store layouts, real-time product availability, and foot traffic-based popularity scores. These will all be key parts of the AR cloud value chain.

Meanwhile, there will be a need for 3D graphical assets, such as accurate product renderings like cars and furniture, such as what AR real estate company rooOomy is doing. The point is that there will be a broad ecosystem of supporting players in the tech stack that brings us the AR cloud.

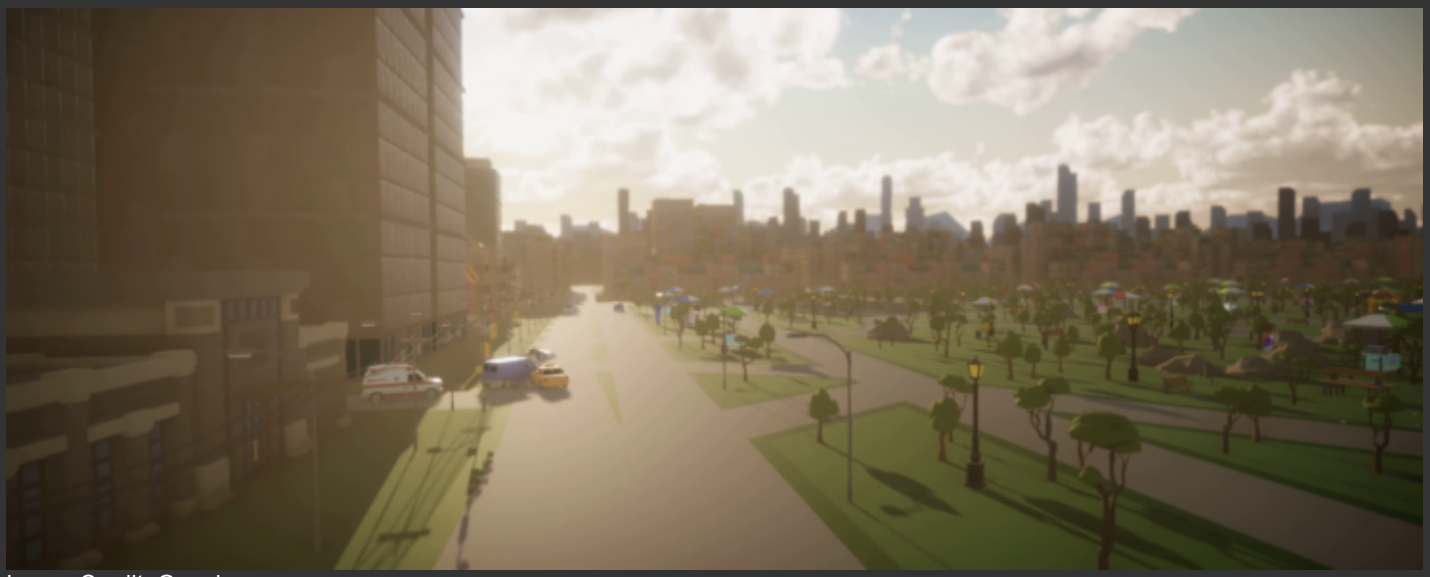


Image Credit: Google

Storm Clouds

Though the AR cloud will be a great enabler, as characterized throughout this report, there will be ample challenges that arise and questions that surround it. Some challenges will be technical and some will be practical and cultural. Here is a non-exhaustive drill-down on a few of those challenges.

Opt-in Friction

As explored above, a lot of relevance in AR will be tied to physical places. Graphical overlays will add context to everything from historical sites (education) to storefronts (commerce) to hiding spots (gaming) to people (social). That spatial relevance will be a source of value, a la scarcity.

But the downside is that AR's linkage to geographically-defined relevance could subject it to the same challenges that face other location-targeted content on smartphones. And the biggest place these challenges have become evident over the past decade is with geo-targeted mobile ads.

One issue is that mobile devices can't always report their location due to app-level permissions. As background, location-targeted ads are served by ad networks that partner with apps. So when you've opted in to GPS tracking within a given app, you can be pinpointed within a meter for ad targeting.

But when an ad network doesn't get that opted-in GPS signal (often), it will fall back to other methods, such as reverse IP lookup or cell tower triangulation. In those cases, they'll report successful delivery of geo-precise ad placements to advertisers… but what they actually delivered can be off by miles.

Of course, consumers aren't complaining about not getting the most geo-relevant ads. But with AR graphical overlays, the spatial imprecision could be more apparent and damaging. You don't want to point your phone at one restaurant and get bad reviews for another, to use an earlier example.

There are a few takeaways for AR. One is that scene awareness and context gathering will happen through a combination of geo-data, localization and object recognition. So the above drawbacks of geo-data may boost the value of, and reliance on, cloud-delivered object recognition, a la 6d.ai.

The second lesson is the importance of getting the GPS-tracking opt in. We've all seen it: "This app would like to use your location." That could be a key moment for AR apps. Because permission happens at the app-level, the strategies (and spoils) of getting it are in the hands of app developers.

So AR app developers should think about how they're going to entice that opt-in. Look to best practices in opt-ins from the last decade. In short, provide a clear value exchange for what you're asking for. That will be easier with some apps (think: weather) than others (think: social).

For example, one of the most under-rated things Pokemon Go did was get tens of millions of people to opt-in to GPS tracking. It was an unprecedented level of GPS tracking opt-ins, due mostly to the value exchange. Because GPS is necessary for player performance, the opt-ins flowed in easily.

That won't always be the case. But some form of value exchange will often be a key component to mobile AR app strategies — for location tracking and in general. But especially with location tracking, the AR cloud will be empowered to support devices that can report where they are.

Image Source: Google Poly

Legal Precedent

Last year, a class-action lawsuit was filed by property-owners across several states, seeking damages from trespassing. The trespassers had one thing in common: They were playing Pokemon Go. But the interesting part: the defendant in the suit was the game maker… Niantic.

“The plaintiffs are actually alleging that the Niantic committed a form of ‘virtual trespassing,’ said Foley & Lardner Attorney Lucas Silva at January’s ARIA Conference. “The theory being that Niantic can control where these elements are placed and [they] have GPS coordinates.”

This may seem silly, but it’s important. At AR’s early stages of adoption and cultural assimilation, case law will be impactful in setting precedents. For a sector that’s already a bit fragile in its infancy, legal impediments could stunt its growth. And this will impact the way the AR cloud operates.

“The court had a chance to dismiss the case early on and did not, suggesting that maybe this claim does have a little more legs than some people would have thought,” said Silva. “I think this is a case that has potentially far-reaching implications for augmented reality.”

Some of these issues also drive towards important questions like who “owns” AR and digital real estate, as examined briefly above. This could build up to something more impactful. And it will be particularly contentious wherever money is being made, such as AR in retail shopping.

“If you are in a Lowe’s store and you’re using a wayfinding app, what if the owner of that store and presumably Lowe’s rents space from the owner of a strip mall?” Silva posed. “Does that strip mall owner potentially have to sign off on the placement of these virtual elements?”

Another area of AR where money — and thus legal attention — will accumulate is advertising. Given location-targeted ad scenarios explored earlier, questions will face courts such as ownership of digital ad inventory. This could involve ad overlays on private property, or even on *other ads*, says Silva.

There are also issues of privacy and data collection. Klaris Law media and entertainment lawyer Alexia Bedat advises AR developers to follow existing guidelines for collecting data. Only collect what you ask and get explicit permission for… good timing given Facebook’s current data privacy issues.

That gets more sensitive for anything to do with location data, which will be a key component of AR products and business models, per the examples throughout this report. And it gets even more controversial with biometric data, like fitness tracking, which will likewise be central to lots of AR apps.

Whether its biometrics, ads or private property, legal governance of the AR cloud will be a moving target as case law sets precedent in coming years. Meanwhile, decisions could defer to legal precedents that rule physical property ownership. It is after all nine tenths of the law, they say.

Delivering AR: Apps vs. Web?

Another important question surrounding the AR cloud, and AR in general, is the delivery mechanism. Because we live in such an app-centric world — partially driven by Apple’s influence and vested interest in apps — they’re are the heir-apparent modality for mobile AR. But is it the optimal format?

Many AR thought leaders are asking that very question and doubting if the app-heavy paradigm that ruled the smartphone era is best for AR. The thought is that AR’s existing adoption challenges are exacerbated by the friction and latency of finding and downloading disparate apps.

“You effectively have all the same problems that a mobile app has,” Presence Capital partner Amitt Mahajan told ARtillry. “You have to convince someone to download it, and convince them to come back every day. All of the friction to get to that experience is still pretty high.”

We’re already seeing this play out in high-value consumer verticals like retail. One historical parallel is retail beacons. Everyone thought they were a good idea, but they fell flat due to requirements for users to download specific apps and adjust system settings like Bluetooth.

“We’ve seen some interest in AR for brick & mortar shopping,” StepsAway CEO Allan Haims told ARtillry. “But ultimately there’s not enough user adoption yet, and the friction is too high to download apps to use AR. Similar friction has been the challenge with retail beacons.”

Why is this important to the AR Cloud? Apps' download friction makes them incongruent with the AR cloud's (proposed) highly-dynamic ways of delivering data to devices. Beyond friction for users, apps are disadvantaged by their lack of interoperability compared to the link-structured web.

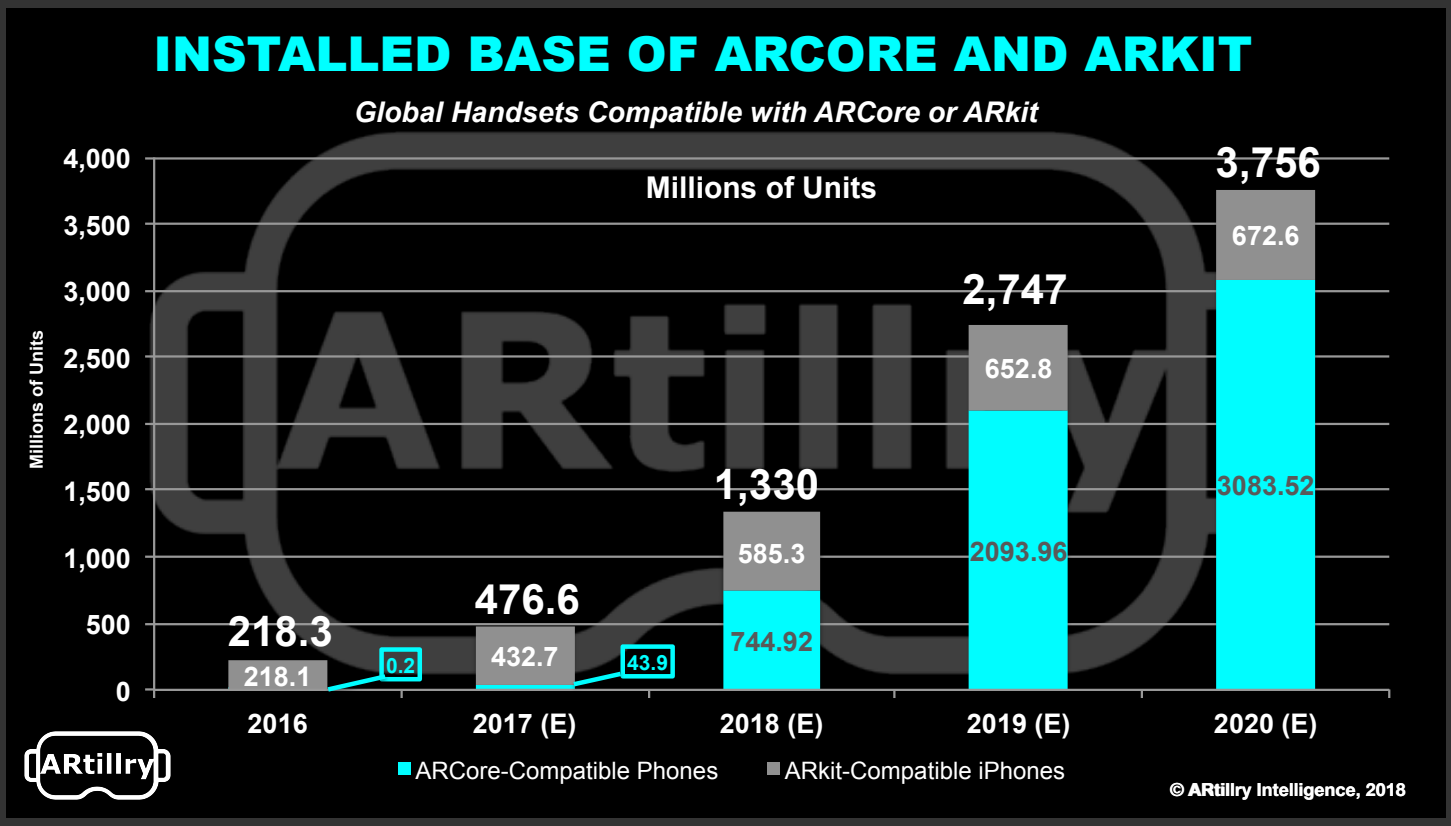
For example, social AR experiences require dynamic multi-player "pick-up" functionality. Would that be saddled by the need for participants to stop and download the right app? More dynamic and networked AR will be a key tenet of the AR cloud, which app-like silos don't align with.

The apps vs. web outcome could also be influenced by Google. Just as Apple has a vested interest in apps, Google's DNA leads it to web-based AR. It's already expressed support for web AR, as part of an overall web XR strategy. Given Google's strength, this could influence how mobile AR is delivered.

But influence could ultimately be greatest from whoever attracts the most users and developers. Apple has the nearer-term scale in device compatibility, while Google has a longer-term edge with Android's installed base. And let's not forget the scale Facebook will reach with Camera Effects.

Beyond influence from tech giants, it could be the best consumer experience that wins out. Apps have more robust functionality today but could web AR catch up? It won't be winner take all: they'll coexist as iOS and Android have for years. And the right answer could be somewhere in the middle.

These dynamics should be watched closely by anyone deciding where to apply development resources, and which platforms and distribution channels are optimal. Though web AR is currently inferior to apps in functionality, it could gain ground as the AR cloud's longer-term vessel of choice.



Video Companion: AR Cloud and the ‘Internet of Places’

(click URL to open)

https://youtu.be/_UTq8K_wbSM

Key Takeaways (redux)

Key takeaways are also highlighted throughout the main body of this report.

- Local brick & mortar commerce is an opportune and underrated market for AR.
  - $3.7 trillion is spent in consumer retail purchases in the U.S..
  - Of that total, only $300 billion (8 percent) is e-commerce.
  - The remaining 3.4 trillion is offline, half of which is influenced by digital media.

- This "online-to-offline" (O2O) segment is where AR will take the biggest bite
  - It will involve AR overlays that contextualize items you point your phone at.
  - This consumer utility taps into "high buying intent," akin to mobile search today.
  - ARtillry survey data indicate demand for AR city guides, retail assistance and commerce.

- Google's angle is "visual search," its the next generation of monetizable search
  - The search input is your phone's camera and the search "terms" are physical objects.
  - Google's will index and contextualize this "Internet of Places" just like it did the web.
  - Google has visual databases and AI assets to pull this off. The rest of us don't…

- A robust AR ecosystem with visual search and AR capability requires an AR cloud.
  - It's a theoretical cloud data repository that enables AR devices to perform anywhere.
  - It will deliver scene mapping and object recognition blueprints to AR devices.
  - This lets AR devices "recognize" scenes versus exhausting computational muscle mapping them.
  - With this burden offloaded to the AR Cloud, developers can focus instead on the front end.

  - The AR cloud will enable the consumer AR industry to reach ARtillry's projected $14 billion by 2021.
  - This will mostly be mobile AR, and include in-app purchases, commerce, and other revenue sources.
  - The AR cloud will enable a key function: image persistence across sessions and users.
  - Image persistence is key for multiplayer support, which will unlock social AR killer apps.

- There are mini-AR clouds developing and several supporting technologies.
  - Google, Niantic and others have built proprietary AR Cloud-like technologies.
  - A more open and federated AR cloud will be necessary for startups to tap into its capability.
  - A rich ecosystem will develop around the AR cloud, including infrastructure, front-end software and data.
  - Like the early (and current) web, this will create several gaps for business opportunity.

- No one company is big enough to build the AR cloud so it will likely be crowd-sourced.
  - Companies like 6D.AI build tools to crowd source and unify the AR cloud's construction.
  - Devices using such APIs will collect AR cloud data while they benefit from it.
  - This will work like Waze: an incentivized system of give and take for area-mapping data.
  - Autonomous vehicles could also be tapped for AR cloud-building mapping data

- Ownership of the AR Cloud will be determined in the coming years
  - Like the Internet, there will be no owner but protocols and standards for interoperability
  - Centralized authorities or systems (possibly blockchain) will govern IP ownership within the cloud.
  - Scarcity – due to finite physical space -- will drive IP asset value in the AR cloud (unlike the web).

- There will be considerable challenges, uncertainties and factors to iron out.
  - Device location tracking (to communicate with the cloud) requires app-level permissions.
  - AR's nascence means that case law will determine impactful regulations and viability.
  - The vessel is uncertain: Apps (powerful but cumbersome) vs. web (weaker but frictionless)?

About ARtillry Intelligence

ARtillry is a publication and intelligence firm that examines augmented reality and virtual reality, collectively known as XR. Through writings, data and multimedia, it provides deep and analytical views into the industry's biggest players and opportunities. It's about insights, not cheerleading.

Run by career analyst and journalist Mike Boland, coverage is grounded in a disciplined and journalistic approach. It also maintains a business angle: Though fun and games permeate VR and AR (especially the former) long-term cultural, technological and financial implications are primary.

Learn more at **https://artillry.co/about**

About Intelligence Briefings

ARtillry Intelligence Briefings are monthly installments of VR/AR data and analysis. They synthesize original and third-party data to reveal opportunities and dynamics of VR and AR sectors. In addition to data, a layer of insights is applied to translate market events and raw figures into prescriptive advice.

More information, past reports and editorial calendar can be seen at:

https://artillry.co/artillry-intelligence/

About the Author

Mike Boland was one of Silicon Valley's first tech reporters of the Internet age, as a staff reporter for *Forbes* (print) starting in 2000. He has been an industry analyst covering mobile and social media since 2005, and is now Chief Analyst of *ARtillry Intelligence*, covering emerging tech.

Mike is a frequent speaker at industry conferences such as VRLA, ad:tech and LeadsCon. He has authored in-depth reports and market-sizing forecasts on the changing tech & media landscape. He contributes regularly to highly read online news sources such as *TechCrunch*, *Business Insider* and the *Huffington Post*.

A trusted source for tech journalists, his comments have appeared in A-list publications, including *The New Yorker*, *The Wall Street Journal* and *The New York Times*.

Further background, history and credentials can be found at:

http://www.mikebo.land/

Methodology

This report highlights *ARtillry Intelligence* viewpoints, gathered from its daily in-depth coverage of the XR sector. To support the narrative, data are cited throughout the report. These include *ARtillry Intelligence* original data, as well as that of third parties. Data sources are attributed in each case.

For market sizing and forecasting, *ARtillry Intelligence* follows disciplined best practices, developed and reinforced through its principles' 15 years in tech sector research and intelligence. This includes the past 2.5 years covering AR & VR exclusively, as seen in research reports and daily reporting.

More about ARtillry's market-sizing credentials can be found here:
https://artillry.co/artillry-intelligence/forecasts/methodology/

Disclosure and Ethics Policy

ARtillry has no financial stake in the companies mentioned in this report, nor was it commissioned to produce it. With respect to market sizing, ARtillry remains independent of players and practitioners in the sectors it covers. It doesn't perform paid services or consulting for such companies, thus mitigating bias — real or perceived — in market sizing and industry revenue projections.

ARtillry's disclosure and ethics policy can be seen in full at:
https://artillry.co/about/disclosure-and-ethics-policy/

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Questions and requests for deeper analysis can be submitted at:
https://artillry.co/contact/

Resources

Friends of ARtillry Intelligence, and sources of AR thought leadership and business opportunity.

Augmented Reality.org: **http://www.augmentedreality.org/**
Charlie Fink: **http://www.charliefink.com/**
Tom Emrich: **http://www.tomemrich.com/**
Super Ventures: **http://www.superventures.com/**
6d.AI: **https://www.6d.ai/**
Augmented World Expo: **https://augmentedworldexpo.com/**
VR/AR Association: **http://www.thevrara.com/**
AR in Action (ARIA): **http://arinaction.org/**

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