

Western Digital.

VALUE OF DATA BILLIONS OF FRONT ROW SEATS

How Edge Processing Brings the Heart of the Action to You

With brands and sports becoming increasingly global, the demand for new technologies that enhance the experience of connecting with live events presents a big opportunity:

While an average of only 53,592 people were able to watch the 2014 FIFA World Cup in person in Rio de Janeiro, the global in-home audience reach amounted to more than 2.1 billion fans worldwide across 207 countries.

With advancements in edge computing, a suite of three new technologies will enable the next generation of remote viewership, helping to generate \$63.5 billion in new revenue by 2030.



Plenty of research in social psychology details the human need for connection. In the era of instant communication, this need can be met instantly. That's one of the reasons why live video has grown exponentially in the past few years and is expected to grow 15-fold from 3% of internet video to 13% by 2021.¹ It reflects people's need to connect with far-reaching events as they happen.

This need to connect also is seen in the huge popularity of big live music, sports, and entertainment events. For example, global phenomenon Adele sold 750,000 tickets to her most recent tour in 2016-17—but she could have sold far more: An estimated 10 million fans actually tried to buy tickets in the United States alone, the vast majority of whom were ultimately disappointed.²

Then there's the **FIFA World Cup** soccer tournament, the every-four-year spectacle that captivates the world like no other sporting event. On average, <u>only 53,592 lucky souls were able to watch a 2014 World Cup game in Brazil in person</u> at one of the 12 stadia across the country.³ But an additional 2.1 billion fans around the world tuned in to watch the matches on television. Surely most if not all of those fans would have preferred cheering on their favorite teams from the stands.

The fact is, for an overwhelming number of fans, the two-dimensional and dull computer, television, and phone screen are the only alternatives to seeing Adele or the World Cup final live. And these viewing experiences haven't changed in the past few decades, leaving fans feeling dissatisfied and disappointed they can't be a part of the action.

But the next time Adele heads out on the road and the latest World Cup comes around, things could be dramatically different. There may be several new alternatives to experience her concert and all the World Cup matches that could come close to rivaling actually being there. And it all will be made possible by innovative virtual or augmented reality events driven by edge processing.

GETTING AN "EDGE" OVER LACK OF TICKETS

As the preceding examples show, the demand for attending in-person live entertainment and sporting events far outstrips the supply of tickets fans can purchase. And that gap is growing exponentially as fans of artists and sports become increasingly global.

The reality is, an increasing number of people can't attend the events they want. This means not only more dissatisfied fans, but also billions of dollars of potential revenue left on the table by event promoters, performers, and sports teams.

But what if there are alternatives to attending events live that aren't subject to the practical issues of having only so many physical seats to go around or being able to present events in only so many cities? And what if these alternatives are so compelling—and that they still provide the social interaction that people crave—that fans would find them close enough to the "real thing" to be worthy of their time and money? Such alternatives are now possible because of the massive strides made recently in edge processing technology.

Broadly speaking, edge processing or computing refers to the processing of data outside of the traditional central data center. Gartner defines edge computing as "solutions that facilitate data processing at or near the source of data generation."⁴ When used in the context of live entertainment, edge processing creates powerful new ways to monitor and manage sensor-based devices—such as virtual reality (VR), augmented reality (AR), and holographic solutions that promise a fundamental change in the remote viewing experience.

Edge Processing: The Great Enabler in Live Entertainment



Many of the technologies that will enable the future of remote viewing of live entertainment and sports events are driven by edge processing. By definition, edge processing creates powerful new ways to monitor and manage sensory-based devices—such as virtual reality (VR), augmented reality (AR), and holographic technology—take local actions based on incoming events and data, and provide visualization capabilities locally and remotely.⁵ Think about what fans have access to today. Despite all the advancements in technology in the past decade, the experience of watching live events remotely has hardly changed. The millions of fans who can't attend live concerts, sports games, or shows are limited to Pay-Per-View or streaming online at home (or, maybe, watching at a local bar). But these options pale in comparison to "being there." That's because, from a viewer's point of view, the streaming or broadcasting experience involves simply receiving information that's captured at and sent from the source (i.e., the event)— which vastly differs from the ability to interact with the performers or athletes, and with each another, at a live event.

Edge computing offers the potential to transcend streaming's flat, one-way transmission of information by enabling a suite of technologies to boost the level and quality of access to live entertainment—offering fans an immersive, social experience comparable to attending in person. Two scenarios illustrate this enticing potential.

TWO SCENARIOS ILLUSTRATE THIS ENTICING POTENTIAL:

O1 At-home VR/AR: Redefining the couch-watching experience

02 Location-based Solutions: Bringing the Social Aspect to Remote Fans

SCENARIO 1 AT-HOME VR/AR: FROM COUCH TO COURT SIDE

One possible application is using consumer-grade, low-cost VR/AR head-mounted displays (HMDs) in the home, which is a nascent but growing market.

According to a Gartner survey, **12% of American households now have a VR headset**,⁶ and nearly \$2.5 billion was invested in VR/AR in 2017.⁷

Here's how it would work: Fans at home don a VR headset and stream the concert, game, or show live, allowing them to have a fully immersive experience, interacting with others watching, as if they were there. Behind the scenes, edge computing technology helps produce a low-latency, real-time immersive experience for users by capturing their movement and interactions. Highly tailored advertisements are presented during the downtime moments of the live streaming, enabling fans to buy a band's t-shirt or a replica team jersey directly in the VR stream. Unlike traditional forms of TV advertising in which generic ads are displayed, in-app VR ads will be relevant to each fan to create a highly-personalized experience.

At-home VR/AR would be a huge plus for many fans, but particularly those who are disabled or ill and unable to attend events in person. The technology would, for example, allow a bedridden person to "attend" the upcoming Adele concert she eagerly wants to see without having to leave her house.

VR Adoption Requirements



VR streams must be duplicated twice to stream individually to both eyes. Unsurprisingly, dual streams require a lot of bandwidth. A 720p VR stream takes at least a 50 Mbps connection to avoid motion sickness from low latency. The problem, however, according to Akamai's State of the Internet Report, is that the average US household only has an average of 12.6 Mbps. However, as 5G infrastructure becomes more highly proliferated in the years to come, VR adoption will take on even greater adoption. In fact, according to ABI Research, 5G will bring about a "10x improvement in throughput, a 10X decrease in latency, a 100X improvement in traffic capacity, and a 100X improvement in network efficiency," over 4G.

SCENARIO 2 LOCATION-BASED SOLUTIONS: BRINGING THE SOCIAL ASPECT TO REMOTE FANS

Another option would be to host live viewing events in physical locations for fans to gather and interact with each other.

This could take the form of holographic projections of live events at big venues. Similar to watch parties where the home teams open up the stadium for fans to sit and watch the game on the jumbotron while the team is away, fans could go to a local stadium or arena to view the live event in person and have a social experience of interacting with other fans in the same location—and, importantly, without having to wear an HMD. Japan was ahead of the game in thinking this way: Its 2010 bid for the 2022 World Cup proposed broadcasting games live with holographic visuals to stadiums across the world.⁸

While this may sound like futuristic, far-fetched science fiction, it really isn't. Now-available edge computing technology can collect the real-time motions and sounds of players or performers from volumetric data and transmit the data in the form of holograms populated by voxels, which are pixels in a 3D space to other sites. The holographic visuals will look like the real players and performers—offering the perfect combination of social interactions and real-time live entertainment.

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A second location-based option would be VR/AR "viewing parties" at smaller-scale venues such as movie theaters.

Fans would wear higher-end VR devices—more sophisticated than the HMDs they have at home to view the event. **IMAX**, for one, is convinced this future is here. The big-screen movie theater giant has set aside \$25 million to fund the creation of new content for its IMAX Experience Centers.⁹

The concept of using movie theaters for live streaming is nothing new. It was pioneered by the **New York Metropolitan Opera** back in 2006, which since has been broadcasting to more than 2,000 theaters around the world to about 2.7 million people each year.¹⁰ Opera fans pay \$20 to watch the performance broadcast live at their local participating theater—much less than any in-person standing-room ticket (if they could even get one).

The repurposing of the movie theater for VR/AR "viewing parties" is the logical next step for movie theaters looking to enhance patrons' viewing experience and provide a more social, engaging atmosphere. In this scenario, fans would pay around \$30 to use high-end VR equipment to immerse themselves in a fully digital experience. Quickly advancing VR technology, with the ability to toggle between virtual reality and reality with the simple press of a button, will enable fans to interact with their friends and family sitting by them without having to remove the HMD each time they want to talk to each other. And patrons will be able to order food and beverages while they fully immerse themselves in the live game or performance. Again, edge computing drives the experience, gathering data on how the user moves in real time and processing it to create zero-latency interactions. Screen-time or being "plugged-in" were once believed to be taboo in social interactions, however, now go handin-hand with social experiences, helping to compliment and elevate social interactions.

Besides simply offering fans the chance to attend an event they otherwise couldn't because of geographic constraints (most people can't simply fly to the Big Apple every weekend to see the Met live), there's the economic upside: **People can have a near-lifelike experience at a fraction of the cost of seeing it live.** For instance, the least-expensive ticket for this year's World Cup final game is \$455 (the most-expensive is \$1,100).¹¹ For less than one-tenth of that, people can experience the game with other fans in a highly social, virtual setting.



\$63.5 billion in Value Generated from Remote Viewing

Analysis shows that by 2030, \$63.5 billion in revenue will be generated from VR/AR streaming, holographic projections, and VR "watch parties" of live entertainment and sports events. A majority of this is generated from streaming fees, but a substantial amount comes from auxiliary sources including concession stand sales and targeted advertising.

WHAT'S THE VALUE?

There's clearly far more demand—in fact, at least 13 times more—for live events that currently can't be met because of space and geographic limitations.¹²

But a combination of edge computing and VR/AR could enable promoters, artists, and sports teams to capture a large chunk of the billions of dollars of untapped revenue from fans who are willing to pay to experience live entertainment events, but can't. Not only that, they could significantly boost advertising revenue associated with their events: With millions of people strapped to a VR headset, brands can deliver highly targeted ads to an entirely new (and massive) audience.

HERE'S HOW THIS NEW REVENUE POTENTIAL BREAKS DOWN:

O1 At-home Viewership: \$40.5 billion

O2 Location-based Participation: \$22.9 billion

AT-HOME VIEWERSHIP: \$40.5 BILLION

Research shows that 59% of sports fans prefer to watch sports in the comfort of their own home.¹³

This segment of fans presents a huge opportunity for at-home usage of VR/AR devices. Using the eSports industry¹⁴ as the baseline for VR adoption and NFL viewership¹⁵ for the overall in-person and remote viewership, we estimate live sporting events could drive \$30 billion in revenue from streaming fees. Similarly, with the music festival industry as the baseline, our analysis projects \$9.8 billion in revenue for at-home VR streaming revenue from live music events. Targeted ads could generate an additional \$740 million in incremental advertising revenue, based on Facebook's average CPM.¹⁶ The potential benefits of VR/AR adoption for at-home viewership are significant:



We estimate live sporting events could drive **\$30 billion** in revenue from streaming fees.



Our analysis projects **\$9.8 billion** in revenue for at-home VR streaming revenue from live music events.

POTENTIAL 2 LOCATION-BASED PARTICIPATION: \$22.9 BILLION

As mentioned earlier, location-based solutions could take the form of holographic projections or VR/AR viewing parties.

As mentioned earlier, location-based solutions could take the form of **holographic projections or VR/AR viewing parties.** The former comprises a subset of remote viewers who want to attend an event live, but can't purchase a ticket due to limited availability. Combining the number of global sporting events and the number of top stadiums and arenas around the world, with the conservative end of the cost of live-VR experiences, we estimate \$3.7 billion in ticket sales could be generated through life-like holographic projections in local stadiums and arenas. Given the nature of the venue, concession revenue could bring in an additional \$1.8 billion. All in, holographic projections of live games stand to generate north of \$5.5 billion.

The other form of location-based experience, **VR/AR viewing parties,** promise to transform VR viewing from an isolated, solo experience into a completely social experience on par with what people want and would encounter at a live-entertainment event (assuming VR technology continues to progress at its current pace). This, in turn, can be a lifeline for traditional movie theaters that are struggling to keep pace with changing customer expectations to reverse declining revenue. In fact, VR is perfectly positioned to become an important part of theaters' current efforts to transform movie-goers' experiences—which to date have centered on installing reclining chairs and adding amenities such as food and drink service. As previously mentioned, movie theaters around the world already broadcast live shows. Adding VR to enhance the overall viewing experience is the logical next step.

Location-based experiences also have incredible potential:



Holographic projections of live games stand to generate over **\$5.5 billion**.



\$3.7 billion in ticket sales could be generated through life-like holographic projections in local stadiums and arenas. Applying the average ticket cost to watch a movie in a luxury theater to percentage of theaters adding new innovations and upgrades, we estimate VR live streaming in theaters could drive \$11.7 billion in fees. And there's more in concessions. According to the <u>North American Cinema</u> <u>Exhibitor Report</u>, average concession food spend accounts for roughly 48% of the average ticket price.¹⁷ Applying this proxy, movie theaters offering live entertainment events in VR/ AR could see \$5.6 billion in additional revenue uplift. A further \$196 million from advertising revenue could come from targeted ads delivered during VR watch party experiences.

All told, that's a conservative estimate of **\$17.5 billion in untapped revenue**—clearly an attractive proposition for event promoters, artists, and sports teams.

But other parties also stand to benefit. For example, VR headset companies such as Google, Oculus, HTC, and Samsung can expect their sales to jump as adoption of both consumer- and commercial-grade VR headset gear accelerates. Additionally, not only will jobs be created for technical employees who will be needed to manage and run location-based VR technology, existing employees who work at local stadiums and arenas will be in greater demand as these facilities augment their traditional live events with virtual ones—thus cutting the number of days the venues sit idle.

Finally, of course, there are the fans, who will have many more opportunities to experience their favorite artists or sports teams in ways they couldn't before—and in settings that still offer the social connectedness they value. While that's a boost for all fans, it's especially important to disabled fans, who typically lack dedicated seating at live events and, on the rare occasion they are offered such seating (if they're even able to leave their home), usually have to sit apart from the people they've come with.

Thanks to advancements such as Oculus Venues, which recreates the in-person experience of watching a live event together,¹⁸ this community will finally have equal access to live entertainment events that otherwise weren't available to them—and be able to experience them with their friends and family.

Fans will have many more opportunities to experience their favorite artists or sports teams in ways they couldn't before—and in settings that still offer the social connectedness they value.

BRINGING LIVE, SOCIALLY RICH EVENTS TO THE WORLD

It's certainly true that the internet has brought the world much closer together.

One highly visible manifestation of that is how local phenomena can grow into a worldwide obsession. This means performing artists and sports teams can now have fans in far-flung corners of the world eager to connect with, learn about, see, and hear those they follow, and share their experiences with other like-minded people.

Edge computing-driven VR/AR solutions can meet that demand, as well as overcome the constraints of limited ticket availability (and typically high costs) for live events. This is certainly a boon for fans—such as the disabled teenager who can't leave the house or the cash-strapped family who wants to attend a big game but simply can't swing it financially. And for artists, teams, and promoters, it opens up incredible potential to tap new revenue streams that simply don't exist today.

Of course, investments will be required. Both in-home and location-based solutions will require investments in much more computing and storage firepower. Storage needs, for instance, could grow exponentially based on an estimated 21,000 petabytes of data being transmitted by VR devices in 2021 and as much as 136.500 petabytes by 2030.¹⁹ Furthermore, 5G infrastructure, 5G radios, and GPUs will need to be widely proliferated and drop considerably in cost in order for these edge-enabled technologies to be widely adopted. There also will be additional costs associated with location-based solutions, which will include local venue rental (e.g., stadiums, arenas, or movie theaters), associated labor, and technology infrastructure. Still, for major, globally popular events, the revenue potential far outweighs the added costs.

With great(er) computing power, comes great data responsibility:

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According to Juniper Research, data consumption from wireless VR/AR headsets will reach **21,000 petabytes** in 2021—equivalent to the amount of data from streaming 3 billion hours of 4K video. And there's another reason beyond revenue that can make these solutions so attractive: With fans anywhere in the world being able to experience the same event at the same time, in the same way as if they would live, it could eliminate the need for long, physically demanding tours that take their toll on performers. That would seem to appeal to Adele, who announced after doing 107 shows on three continents in 10 months that she was taking a 10-year hiatus from touring.²⁰ She might reconsider if "touring" meant playing a single show once a year that tens of millions of her fans around the world could share with her.

Maybe she should ask ABBA what it's like. The legendary Swedish musical group has announced plans to tour Australia in 2019 as holographs of themselves as they looked during their 1970s heyday. The potential to entertain hundreds of millions of fans around the world in a socially engaging, immersive experience from the comfort of home is certainly attractive to the band's Benny Andersson. "We can be on stage while I'm home walking the dogs," he noted. "I don't have to leave my house."²¹

That sounds like a win for everyone involved.



APPENDIX: THE VALUE OF EDGE PROCESSING IN LIVE ENTERTAINMENT

ASSUMPTIONS

- VR adoption rate is extrapolated from eSports baseline of VR adoption for live streaming at 0.74%
- Global number of in-person sports attendees based on attendance of top 20 global sporting events in 2016

VALUATION APPROACH

- Global number of in-person music concert attendees based on the total tickets sold from the top 100 music tours of 2017
- Average seating capacity of top global stadiums is 70,000
- Average seating capacity per movie theater screen is 250
- Average streaming ticket price based on a percentage of the in-person live ticket price and adjusted based on premium of viewing experience

Number of global remote viewers of live sporting/music event			
Number of global remote viewers of live sporting/music event			
x % of viewers who prefer to watch at home			
x % of online streamers willing to pay for live content			
x % VR adoption			
x \$ per VR live stream			
Total Revenue from At-Home VR Streaming + Ad Rev.			
Number of top global sporting events per year			
x # Average capacity per stadium/arena			
x # of stadiums/arenas participating			
x % occupancy rate			
x \$ per holographic ticket			
Total Revenue from ticket sales + Concession Revenue			
Number of movie theater seats globally			
x % of theaters adopting new innovations/upgrades			
x % of seats equipped with VR capability			
x % occupancy rate			
x \$ per VR viewing ticket			
Total Revenue from ticket sales + Concession Revenue			

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