5G connected events
Transforming the event experience
5G event use case

New experiences inside and outside the stadium

This year, we demonstrated our Nokia 5G event use case. It shows how 5G is the only viable solution for meeting the increased data demands required to create immersive experiences for tens of thousands of live event spectators.

In this eBook, we look at the challenges live events are facing, and the opportunities that 5G creates. We demonstrate how 5G enables event organizers to provide new digital experiences for two distinct audience groups - those inside the venue and those viewing at fan parks, at home or on the move. And we show how 5G benefits four different groups of stakeholders:

- Spectators
- Organizers and venue owners
- Emergency services
- Communications service providers (CSPs).

Finally, we provide examples of how Nokia is working with CSPs to make 5G a commercial reality for live events.
5G can dramatically enhance the experience of live events for two distinct audience groups:

- People inside the stadium viewing the action live
- Those who want to experience the event remotely: at home, in bars or on the move.

However, this desire to consume live events in different ways poses a series of new challenges for the different stakeholders involved in hosting and broadcasting.

**Inside the stadium**

No longer are event attendees content to simply be passive viewers. They want access to additional views, extra content and real-time updates and information. And they want to be able to share pictures and videos with their friends and family as the event takes place.

All this activity means visitors expect dependable connectivity within the stadium. It also leads to massive increases in data transfer, often in unexpected and dynamically changing ways. Major events can generate terabytes of communications. 50,000 people in a stadium can equal a density of one million people per square kilometer. Traffic can dynamically change, for example it can be sporadically dominated by uplinks from user-generated social media content. Further, the stadium IT and communications infrastructure architecture may need to be drastically reconfigured between events. A football match and a rock concert present very different stakeholders and user requirements.

Protecting event visitors can be challenging. Emergency services teams are increasingly dependent on affordable and easy-to-obtain communications equipment. However, they still need fast, reliable, informed responses over an ultra-resilient communications infrastructure.
Outside of the stadium

The quality of modern ultra-high-definition TVs means people are frequently choosing to enjoy sporting or entertainment events (concerts, festivals etc.) from the comfort of their own home. And with broadcasters and people in the stadium sharing content on social media, viewers can even catch the latest action or performance on the go, via smartphones or other connected devices.

In addition, the practicalities of broadcasting can be challenging. Traditional TV cameras are connected with large, heavy cables which are costly to operate and also limit the number and variety of camera angles that can be captured. So, stadiums need to find ways to deliver the kind of content viewers expect.
Advances in augmented reality (AR) and virtual reality (VR) present a number of opportunities to provide transformed experiences for event attendees inside the stadium. They also make it possible to provide new, different experiences for those who want to enjoy it remotely – either at home or in other venues, such as bars or fan-zones.

New camera technologies, such as miniature portable webcams or ‘bullet-shot’ camera arrays, help event organizers to enhance the event experience. By filming events in new immersive ways, it’s possible to create new content that truly recreates the on-location experience for those elsewhere.

Events are the perfect way to test and trial large-scale 5G deployments, as the technology needs to work perfectly on the spot, but is limited geographically. Events are also helping to prepare the market for the technology, just as they have before. In the past, events have been a catalyst for many trends in media, entertainment and communications – such as developing new breathtaking camera perspectives and enabling large-scale uploading of ‘special moment’ content to social media.

As the way we experience events – both inside the venue and in other locations – continues to evolve, we’ll also see the accelerated development of 5G-enabled applications in other areas, such as social and pastime uses of VR and AR.

Big sports events: showcases for 5G

Nokia is partnering with Korea Telecom (KT) to create the world’s first 5G mobile network at the beginning of 2018. KT has already presented a clear roadmap of 5G applications that will be present at a large event, including 360-degree VR and time-sliced video.

We see it as the perfect opportunity to demonstrate a 5G network that enables advanced services and delivers enhanced experiences. And we are able to show how we can overcome the specific challenges of 5G planning and deployment.
A global football tournament in Korea has already featured a preview of these new possibilities. In May 2017, KT – supported by Nokia – demonstrated innovative immersive content creation and consumption scenarios running over Nokia’s 5G FIRST solution.

KT equipped Jeonju World Cup arena – where the FIFA U-20 championship opening ceremony and the initial game for the Korea national team took place – with 3D VR multimedia recording equipment. Among it was the Nokia OZO Virtual Reality Camera.

KT created a public 5G demo area in front of the venue, where anyone could experience how 5G will redefine spectator user experiences. With the 3D VR Remote Viewing service, spectators could be at the heart of the action on the football field – at the same time as seeing a VR experience augmented to provide additional information about the players and the game.

Interactive multi-view (aka time slice) was also used in the demo experience. Several high-definition cameras were used to record the action, so a spectator could select any angle for replays, or could click for enhanced experiences, with insights provided through AR (e.g. information about the player, or the angle or expected path of the ball).
In order to meet the challenges of hosting and broadcasting live events, and to take full advantage of the opportunities they present, venue owners, organizers and service providers need to invest in 5G networks.

**5G is indispensable**

Only 5G has the ability to replicate reality across time and across locations at scale. The new video technologies required to create a truly immersive experience for spectators, combined with the high density of users, demand extreme throughput and low latency. These demands cannot realistically be met by Wi-Fi or LTE.

Similarly, only 5G can support more than 500 users per cell simultaneously and provide around 100Mbps at the cell edge. It’s also the only technology capable of delivering an end-to-end latency of not more than 5ms, which is required to prevent VR motion sickness.

**5G is reliable**

The wireless delivery of 5G offers the same level of reliability as wireline connections. In fact, its air interface offers 99.999% reliability without sacrificing latency. It also offers inherent, transparent support for multi-connectivity, which adds to the resiliency. This opens up the stadium’s wireless networking infrastructure to new critical communications applications for emergency services, enhancing public safety.

**5G is flexible**

5G has the versatility to offer very different levels of experience for a diverse range of stakeholders, from TV broadcasters to emergency responders reacting to public safety incidents. And it does this while simultaneously connecting tens of thousands of event attendees. For example, mass downloads and uploads generated by thousands of spectators will not affect the responsiveness of the network to critical safety communications, since the different services are handled by separate virtual network slices. The advanced network slicing enables the creation of multiple network architectures which can be tailored for the specific requirements of different user groups (e.g. spectators, VIP users, safety personnel, franchisees) and virtually separated from each other. These virtual networks can operate on a single common physical infrastructure.
Who benefits from 5G at events?

There are four key stakeholder groups who will benefit from the introduction of 5G into live events in a number of different ways:

- Spectators – the audience enjoying the event (either at the venue or viewing remotely)
- Organizers and venue owners – the companies that put on events
- CSPs – the mobile operators
- Critical communicators – emergency services, event security and crowd control.

How does 5G benefit spectators?

See more, experience more: the best seat in the house

The high throughput, low latency of 5G is ideally suited to delivering services that transform event experiences in a number of different ways. With 5G, every visitor can access the same choice of high-quality experiences, regardless of which seat they have.

They can select from a choice of cameras on their smart device or VR headset – from 360-degree VR views to player perspectives – to see what’s happening from any angle. They can even virtually ‘beam’ themselves into different areas of the venue, to experience what it’s like to be track-side for critical moments, like pit-stops in Formula One races, or on the goal line to see the winning shot go in. They can be at the heart of the action.

The low-latency capability of 5G, coupled with mobile edge computing, enables visitors to access AR within the stadium. So, they can also request to see instant replays, or access live commentary and behind-the-scenes interviews. They can also further enhance their experience with extra insights, such as player stats, referee decisions or real-time game analytics. With low-latency AR, it’s all effortlessly accessed and presented with seamless integration into the attendee’s field of view. AR also makes it easier to get around the venue, with easy-to-access directions to concessions stands and toilet facilities, or real-time information on start times or queues.

And it doesn’t end there. With increased, always-assured connectivity inside the stadium, visitors can take home a high-definition, 360-degree view as a souvenir clip. They can enjoy seemingly unlimited access to mobile data and networks, so they can upload video clips or update social networks. And they can easily access other value-added services, like pre-ordering food and drink, buying merchandise or online betting.
Be there when you can’t be there: the event experience at home

Spectators no longer need to actually be in the venue to enjoy live events. Organizers and CSPs can utilize the power of 5G to offer the same experience outside the venue. Using VR headsets, fans can enjoy their favorite sporting or music event from the comfort of their own home – but still experience the atmosphere in real time, as if they’re actually there.

The low-latency, high-capacity, wireless capabilities of 5G networks make it easier for venue owners and organizers to broadcast events. So, spectators can watch them in a variety of locations. Or enjoy them on the move, tapping into the same exclusive content that in-venue viewers can see on their smart devices.
How does 5G benefit event organizers and venue owners?

**Make broadcasting simpler**

5G wireless networks spell the end for the wired connections previously required by high-definition cameras, or the large number of cameras it takes to provide increased user content. The broadcasting of events is more flexible, as cameras can be operated wirelessly.

Network slicing provides the dedicated and isolated virtual networks that enable content producers to reliably upstream video content, even if the rest of the network is heavily loaded. It dramatically improves the economics of creating new content for VR, using ‘bullet-shot’ cameras and Nokia OZO cameras for 360-degree views.

**Increase fan loyalty to the in-stadium experience**

By meeting their ever-increasing connectivity expectations, and by providing new ways to experience events, stadium owners and event organizers can continue to attract massive demand from fans and more casual attendees for live events. They can further leverage that customer loyalty, with pre- and post-event offers and experiences enabled by 5G, to open up new revenue streams.

**Increase venue bookings**

Venue owners can attract a wider variety of event types, by providing for a range of IT and communications needs through the flexibility of 5G networks. Live broadcasts for sports events need low-latency communications and ultra-resilient connectivity. Recording for music events needs significant local processing of high-fidelity audio and high-definition video feeds. Smaller corporate events in adjacent conference facilities built into the stands require sophisticated virtual private network capabilities.

**Cater for corporate clients**

With 5G, event organizers can cater for corporate visitors by creating digital connectivity zones, offering a greater quality of connectivity experience and avoiding congested Wi-Fi frequency bands.

**Increase advertising and retail revenues**

The increased connectivity of 5G creates new ways to offer and sell advertising and sponsorship opportunities, with increased revenues available from moveable, digital advertising spaces. Additionally, independent secure links can be offered to support back-office connectivity and point-of-sale (POS) systems for on-site retail concessions.
How does 5G benefit service providers?

**More capacity for more customers**
As venues offer more immersive experiences, the level of connectivity required will certainly increase. 5G offers up to 40 times more capacity than 4.5G, enabling operators to meet this demand and provide visitors with a perception of infinite capacity.

**New business models by new entertainment options**
With a flexible network infrastructure, 5G enables service providers to take advantage of new revenue streams – both online and offline. Operators can offer visitors increased entertainment options, like enhanced views and VR. For such advanced services, 5G offers a take-rate (the percentage of the total audience the operator can support) of up to 30 percent, compared with just two percent offered by 4.5G. In addition, by offering these services, operators can maximize their brand perception with sport enthusiasts.
How does 5G benefit critical communicators?

**Respond in an emergency**

The increased connectivity of 5G makes it possible to react to emergency situations in near-real time. So, it’s easier to quickly identify and prevent crime, such as theft, malicious acts or violence.

The exceptional reliability of 5G gives emergency services the flexibility to place cameras and sensors around the venue, so they can spot incidents faster and respond to them accordingly. And with rapid drone deployment – with 5G uplinks for video feeds – responders can access an extra level of surveillance when responding to emergency situations.

With this technology, venue operators can quickly identify the location of any incident, the associated hazards and how many people are affected. And they can command and control any situation, delivering time-sensitive critical information to response teams.

**Take control of crowds**

5G’s low latency provides more flexibility in the types and amount of data venue operators can analyze. Using multiple video feeds and physical sensors, they can employ smart analytics to deploy staff to where they’re needed most. With these insights, it’s possible to help people move efficiently around the venue and respond quickly to incidents.

5G networks guarantee the network resources for these cameras and sensors using network slicing, even while using a physical infrastructure that’s shared with tens of thousands of users. So, there’s ultra-high assurance of network performance, and emergency services can be confident of spotting any problems.
5G use case – Camp Nou Stadium, Barcelona

At the 2017 Mobile World Congress, we explored the value that 5G brings for a particular venue, the Camp Nou Stadium in Barcelona. We highlighted a number of key challenges, including:

- Connectivity needs of tens of thousands of users in this 99k-seater stadium
- Extreme network flexibility required by TV broadcasters with multiple high-definition cameras
- Need for absolutely guaranteed resilient communications for public safety services.

With our demonstrator, we proved how the huge, raw capacity of 5G, coupled with its extreme versatility through network slicing, help to meet these challenges.

We also demonstrated how we can replicate the stadium experience for home viewers. Using 5G-connected 360-degree cameras, we transformed the basic experience of a sports event – in this case a soccer match – to provide a VR experience of the match for home consumption. In short, 5G brings the reality of a soccer match directly into people's living rooms, making it possible for the venue to offer additional 'virtual seats' for sold out events.

The clear message of our use case is that a 5G infrastructure provides multiple game-changing scenarios for the various users of a sports stadium like Camp Nou.
Nokia 5G event use case – covering all the angles

We analyzed how a sporting event could provide a much more immersive experience for viewers both in the venue and watching remotely. This required live feeds from six different camera sources:

- Main event coverage
- Individual player feeds
- Bench camera
- Aerial feed
- Other locations within the stadium
- Single camera for the VR feed.

We showed how this would work with three different deployments:

- 4.5G using sub-3 GHz bands with carrier aggregation of bandwidth up to 70 MHz and with up to 4x4 antennas
- For 4.9G, the simulation used sub-6 GHz spectrum bands with a bandwidth of up to 110 MHz and up to 8x8 antennas
- The 5G deployment was based on using the 28 GHz spectrum band with 800 MHz bandwidth and massive MIMO to provide higher spectral efficiencies.

Edge video orchestration through multi-access edge computing (MEC) is assumed for all three technologies.

Results

The key findings include:

- **Capacity**: 5G provides up to 40 times more capacity in the stadium than 4.5G.
- **Overall cost**: The cost of providing the video services is up to 20 times lower with 5G than with 4.5G.
- **Penetration**: When delivering high-definition video, 4.5G achieves a take-rate of just two percent, compared to almost 30 percent for 5G.

Due to the high-capacity density required, 5G is the only feasible solution for delivering this level of immersive experience to the masses. Other technologies would require more small cells than is possible when taking interference impairments into account. However, we achieve better results with 5G as it offers more spectrum, much higher spectral efficiency using massive MIMO, and advanced techniques in interference mitigation and receiver technology.
At Nokia, we understand the immense challenge that lies ahead with 5G. We’re at the forefront of research and development. And we’re helping businesses realize the value of their investments. Our 5G Acceleration Services can help CSPs:

• Create their own strategies and use cases to maximize the business potential of 5G
• Design and implement networks to realize the full technical benefits of 5G

Creating strategies for 5G

Our 5G Acceleration Services help CSPs to create their own path to 5G. We work with operators to explore the various considerations of high-level technology and business strategy.

Developing use cases

At Nokia, we help operators explore the business possibilities that 5G creates. We start with a 5G Transformation Discovery Workshop, which uses business modeling and other tools to provide detailed insights into 5G use cases, such as the event-related scenarios discussed here. This then forms the basis of a strategy which helps us to guide the operator. This all helps operators to take the guesswork out of 5G business planning.

A Nokia business case has shown that a US-based CSP delivering services at five events per month at a major stadium could achieve $7.7 million in net present value (NPV) over 10 years, when it invests in 5G.

In another use-case analysis, we showed that a CSP could break even on their investment within two years by supporting five events per month at a major London stadium. If the CSP were to support six events per month, with an event rental fee of €10 for the VR headset, they could break even during the first year. Therefore, the choice of venue is a critical consideration.
Designing and implementing 5G networks

Our Nokia 5G Acceleration Services can help operators create and roll out their own 5G networks. We work with them to create detailed 5G radio network plans and help put them into operation. We’ve already provided initial network plans for the world’s first mobile 5G network with KT. With our in-depth expertise in mmWave propagation and radio network topologies, we created a radio network design to optimize the Quality of Experience for sports fans.

Where next?
Find out more about Nokia 5G Acceleration Services and Nokia 5G.