

Nokia Content Delivery Network (CDN) for Live

Optimize video streaming for live sports and events over any access network, directly to OTT and IPTV subscribers



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Abstract

The Nokia Content Delivery Network (CDN) for Live solution is designed to ensure scalable, ultra-reliable, near real-time, low-latency IP video streaming over any type of network, including broadband, mobile, fixed wireless, satellite, and 5G high-altitude-platform systems. This video broadcast distribution solution provides a single platform that can deliver over-the-top (OTT) IP video directly to OTT and IPTV subscriber devices, and efficiently multicast IP video over a managed network.

This paper describes how broadcasters, service providers and content providers can use the CDN for Live solution to:

- Eliminate excessive content delivery costs
- Minimize environmental impacts
- Improve network utilization efficiency
- Establish a new benchmark in real-time video streaming.

Contents

Abstract	2
The evolution of live event streaming: Rising consumer expectations	4
Elevating the viewing experience for IPTV and OTT live event services	4
Overcoming the challenges of live event streaming	5
Nokia CDN for Live solution elements	7
Nokia CDN for Live solution architecture	8
Case studies: Live latency compared with traditional OTT streaming, DTT/DTH and betting website	11
Summary	13
Learn more	13
Supported standards and protocols	14

The evolution of live event streaming: Rising consumer expectations

Today's consumers expect live streaming of news and sports events, including in-game betting, to be seamless, with instant channel switching between events, real-time viewing, and minimal latency. However, meeting these rising expectations poses significant challenges for service providers, broadcasters, and content providers who rely on traditional content delivery networks (CDNs) or enhanced video on demand (VOD) technologies. These legacy solutions often result in frustrating visual distortions, slow channel switching times of up to four to five seconds, and difficulties in maintaining low latency during live streaming – all common drawbacks of conventional CDN-based delivery.

Elevating the viewing experience for IPTV and OTT live event services

The Nokia CDN for Live solution represents a groundbreaking advancement that transforms and enhances the traditional linear live broadcast TV experience. By overcoming the challenges of conventional CDN-based delivery, this innovative video broadcast distribution solution is designed to cater to the needs of both over-the-top (OTT) and IPTV subscribers simultaneously, marking a significant evolution in the streaming of live entertainment.

The Nokia CDN for Live solution ensures ultra-reliable, near real-time, low-latency IP video streaming over any type of IP access network, including broadband, mobile, fixed wireless, satellite, and 5G high-altitude platform systems. It efficiently delivers multicast IP video over a managed network, providing a more responsive and reliable IP video streaming experience than traditional Digital Live Broadcast TV. Leveraging patented ultra-fast channel change technology (~90 ms to <500 ms), while minimizing visual distortions, it guarantees ultra-reliable RTP streaming and a seamless viewing experience with near-zero live latency. These capabilities elevate the viewing experience, making it the ideal solution for meeting the streaming requirements of a wide range of live sports and events at scale.

The solution utilizes the broadcast Moving Picture Experts Group transport stream (MPEG TS) encapsulated in the Real-Time Transport Protocol (RTP). It efficiently employs routed unicast and multicast RTP over User Datagram Protocol (UDP) technologies, adhering to IETF and Digital Video Broadcasting (DVB) standards.

Overcoming the challenges of live event streaming

Broadcasters, service providers, and content providers face significant challenges when offering live streaming services for sports and events over IP access networks. These challenges include:

- Finding a cost-effective and environmentally sustainable way to achieve a consistent quality of experience (QoE) and maintain immersive video and audio quality for live streaming at scale over any access network.
- Minimizing latency of the live stream compared to the actual event. Traditional OTT video delivery typically experiences latency ranging from 21 to 180 seconds.
- Implementing the best video and compression technologies to handle network congestion and packet loss, and reduce video distortions.

CDN for Live: A Solution from Nokia Bell Labs

CDN for Live addresses these challenges using innovative IP product capabilities and video technologies from Nokia Bell Labs. By immediately delivering arriving IP packets to the end user at the video headend (VHE), the solution maintains a high-quality viewing experience and keeps viewers engaged.

Key benefits

Eliminate excessive content delivery costs: By leveraging simple packet replication and forwarding through the IP router's data plane, this solution removes the need for complex caching infrastructure, significantly reducing overhead, maintenance, and licensing costs.

Minimize environmental impact: Reducing reliance on power-hungry servers and cooling systems in data centers leads to lower energy consumption, aligning with sustainability goals by minimizing carbon footprint.

Improve network utilization efficiency: Optimize bandwidth usage by delivering a single copy of the stream to millions of users via routed multicast, significantly reducing duplicate traffic. In network segments that do not support multicast, the system intelligently switches to routed unicast with dynamic packet forwarding, ensuring efficient delivery without overwhelming the network. The IP router provides deterministic performance, ensuring superior performance for all video flows, regardless of network congestion.

Establishing a new benchmark in real-time video streaming

The Nokia CDN for Live solution establishes a new benchmark in real-time streaming by surpassing traditional OTT and IPTV platforms in latency, scalability, resilience, and overall quality of experience. It achieves live latency comparable to broadcast systems such as DTT, DTH, and DVB-C, delivering a true real-time viewing experience at scale. The platform intelligently switches between routed multicast and routed unicast, depending on network segment capabilities, to ensure optimal delivery efficiency and broad compatibility.

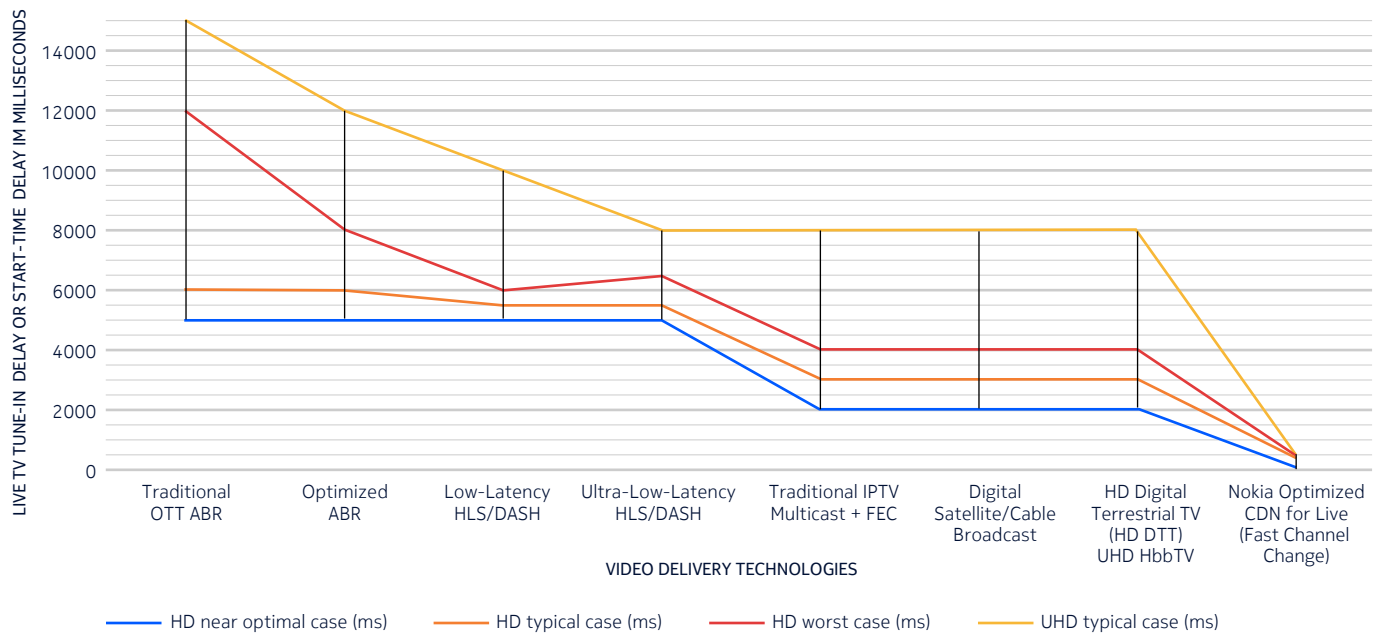
Packet loss recovery and reducing video distortions

Through dynamic packet replication and forwarding, the system can recover from packet loss of 40% (random) or 50% (timed and periodic) without interrupting the service or degrading its quality, thereby reducing the typical distortions associated with the fast-paced nature of live sports.

Ultra-fast channel delivery and changes

The solution reduces video delivery or video channel switching time to as low as 90-350 ms (typical). As shown in Figure 1, this is approximately eight to twenty times faster than traditional CDN video services, digital terrestrial television (DTT), and direct-to-home (DTH) technologies. The figure is based on empirical measurements and publicly available data.

Figure 1. Comparing live content tune-in or video startup time delay for different distribution technologies



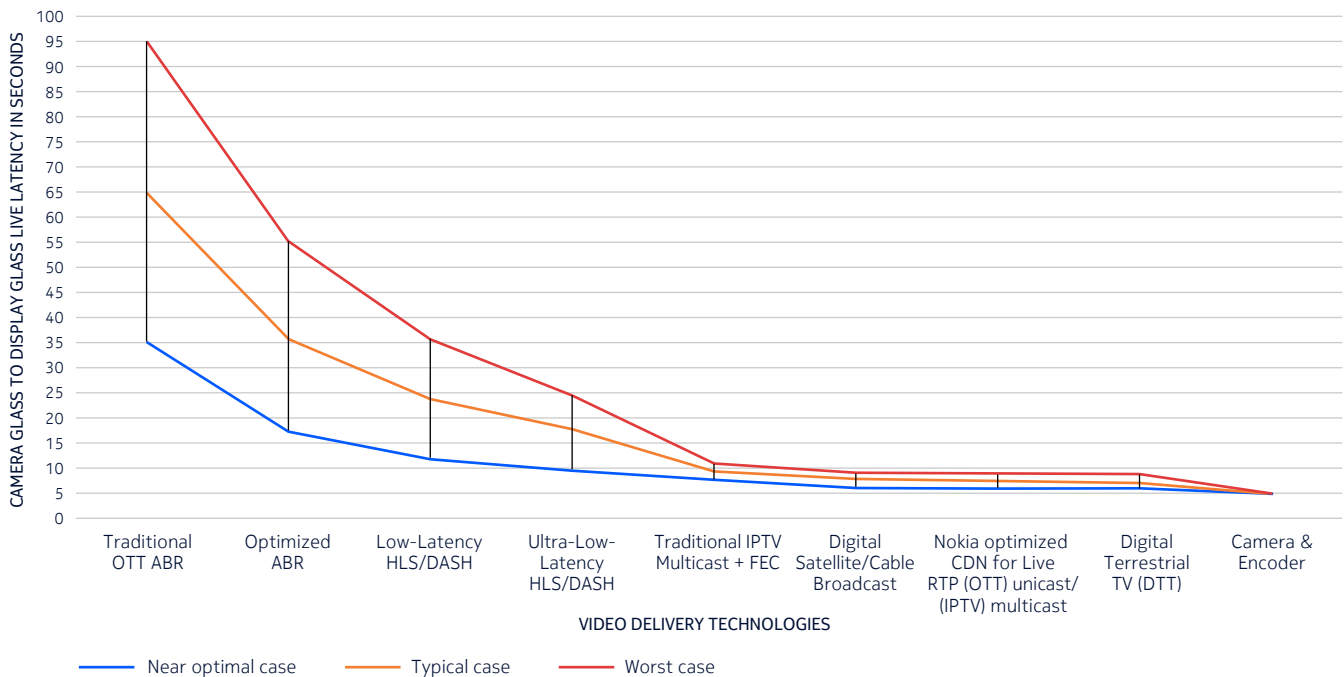
This approach also enables real-time delivery of live events to end-user screens without traditional CDN buffering and caching. CDN for Live offers the unique ability to switch between live content and multiple camera views in 90 ms to less than 500 ms. This creates the best QoE for channel surfing on linear TV.

The solution utilizes RTP streaming to ensure reliable video delivery in challenging network conditions or less stable network environments. For example, it can maintain uninterrupted streaming in environments that have sustained up to 40 percent packet loss or are experiencing temporary localized network congestion with a network round-trip time (RTT) of 150 ms or more.

UDP delivery technologies such as Media over QUIC (MoQ) can provide reliable video delivery in challenging conditions. However, MoQ can currently only sustain up to 2 percent random packet loss without audio and video degradation. Noticeable video and audio degradation occur after 3–5 percent random packet loss. Video and audio quality become very poor when random packet loss exceeds 20 percent. This occurs because MoQ uses retransmission timeout (RTO), which has a limited ability to reorder packets and limited control over retransmission.

Figure 2 shows how CDN for Live compares to other video distribution technologies when it comes to live streaming latency. The graph is based on empirical measurements and publicly available data.

Figure 2. Comparing live latency for different video distribution technologies



Nokia CDN for Live solution elements

CDN for Live is made up of three principal elements: the Nokia Video Broadcast Optimizer (VBO) appliance, the Nokia 7750 Service Router (SR) and a VBO client software library.

Nokia VBO appliance

The Nokia Video Broadcast Optimizer (VBO) helps deliver low-latency, high-quality video and audio for IPTV and over-the-top (OTT) platforms, reducing visual distortions, minimizing channel delays, and optimizing bandwidth. The VBO appliance is deployed in the VHE or video peering point. It is responsible for optimizing MPEG TS, standard-definition (SD), high-definition (HD) and ultra-high-definition (UHD) content for live IP video transmission. It supports a variety of video profiles and codecs (for example, H.264, H.265 UHD/HDR/NGA/HFR), any audio codec and DVB SimulCrypt-compatible conditional access systems. The VBO appliance also supports encrypted ingress or SimulCrypt Advanced Encryption Standard (AES) 128-bit encryption of the content and file playout to multicast streams via Web API integration with a third-party content management system (CMS).

Nokia 7750 SR

The Nokia 7750 SR router, equipped with the Nokia 7750 SR Extended Services Appliance (ESA) or Integrated Services Adapter (ISA), brings a cost-effective and environmentally sustainable solution to the market. In contrast to alternative setups that depend on PC servers with storage caching at the data center and separate routers for the wide area network (WAN), the 7750 SR enables optimized IP video delivery and routing across the IP network in a single system.

The Nokia 7750 SR is highly scalable with compact and chassis-based system options, a wide range of high-density interfaces and low energy consumption to optimize any network location. Leveraging Nokia FP5 silicon, it delivers leading energy efficiency and deterministic performance. Even in a full-featured configuration and under any network condition, video services with stringent quality of service (QoS) requirements are not compromised. This innovative solution eliminates the need for costly server racks with dedicated storage caching and contributes to substantial energy savings by reducing the power and cooling requirements associated with maintaining a multitude of individual servers. These capabilities make the 7750 SR an exceptionally sustainable choice for IP networking and optimized video streaming needs.

The Nokia 7750 SR supports the full suite of IP routing protocols, including routed unicast and multicast, to accommodate IP video routing transport and streaming for any network architecture, deployment model and design. The Nokia 7750 SR ESA and ISA process video packets for subscriber streaming distribution and repair video packets. They are fully integrated into the 7750 SR architecture to enable the direct extraction of video IP packets to the data forwarding plane for efficient video processing.

The feature-rich Nokia 7750 SR provides a single video broadcast distribution platform, delivering high-performance edge and core routing for the IP network and enabling Fast Channel Change (FCC), Retransmission (RET), Perfect Stream, Video Quality Monitoring (VQM), enhanced QoS, multicast, and routed unicast streaming for both managed and unmanaged networks. For details on the the video processing capabilities of the 7750 SR, refer to the [7750 SR Extended Services Appliance \(ESA\)](#) and [Integrated Service Adapter \(ISA\)](#) data sheets.

The Nokia 7750 SR, leveraging advanced Nokia Bell Labs patented technologies, provides real-time, end-to-end monitoring and repair of packet impairments, from the video headend to subscriber end devices, ensuring seamless and instant video streaming with near-zero live latency from any distribution feed or peering point.

Nokia VBO client software library

The VBO client software library can be integrated with the video player application or as a standalone module on managed or unmanaged service provider devices. It enhances the performance and functionality of the video player and is compatible with various platforms and operating systems, including Linux OS, AOSP, Android TV, Tizen OS, RDK-V, Raspbian, WebOS and iOS (available upon request).

The advanced packet loss and repair capability is performed primarily by the VBO client and 7750 SR. The VBO appliance assists by optimizing the MPEG TS to allow the downstream user device to achieve the required performance.

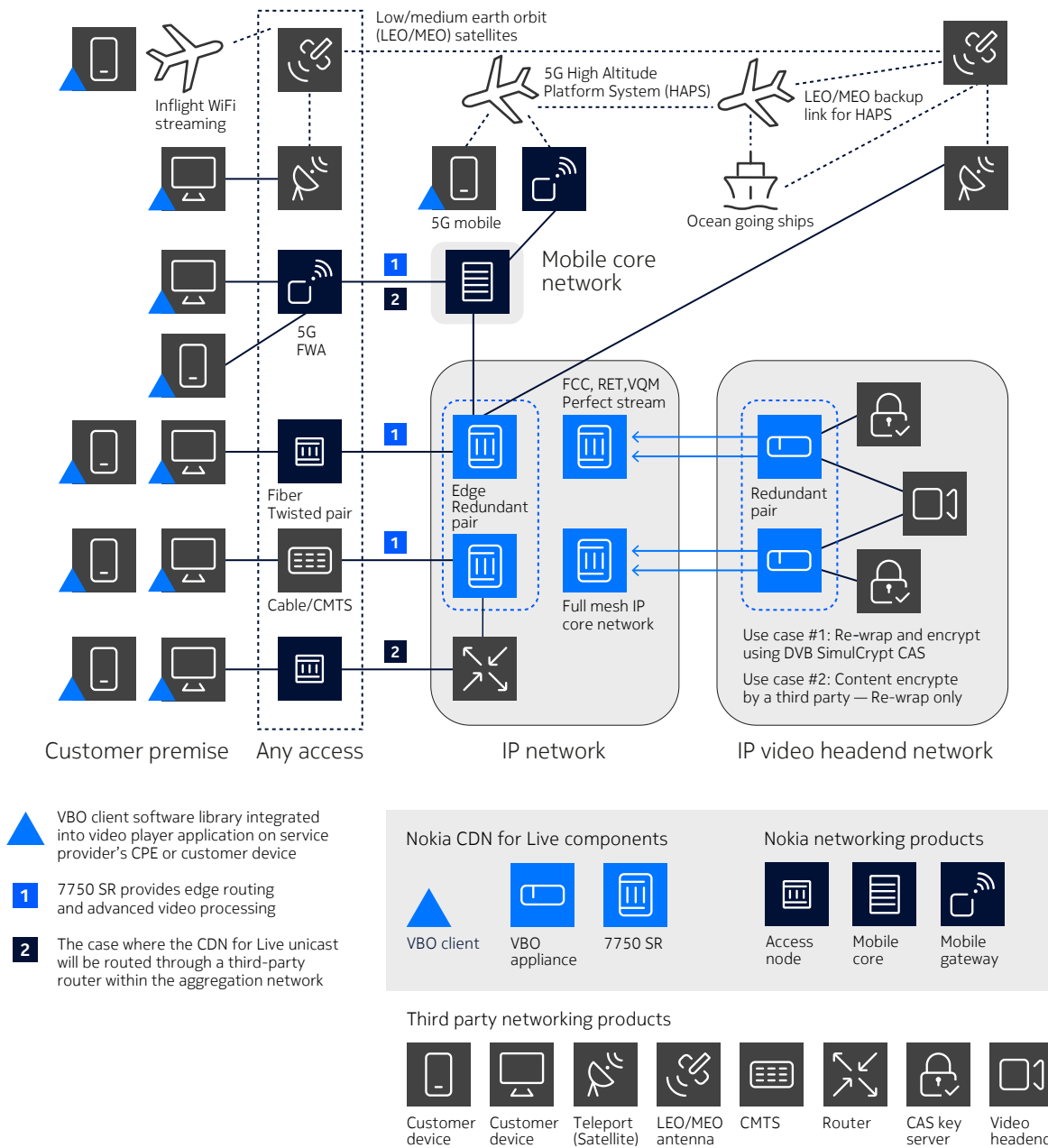
Nokia CDN for Live solution architecture

Figure 3 illustrates the key elements of the CDN for Live solution. The 7750 SR flexibly delivers live IP video streaming across any access network —broadband, mobile, fixed wireless, satellite, and 5G high-altitude platform systems — directly to OTT and IPTV subscriber devices.. A single 7750 SR system can stream the same content to subscribers through a traditional layer 2 multicast network, OTT over layer 3 networks and even mobile networks.

The Nokia VBO appliance is deployed at the video headend or peering point where it supports redundancy and works in conjunction with the 7750 SR to enable service delivery and optimize the video format for transport and streaming over any access network and directly to end users.

The VBO client software library is located at the customer premise and can be integrated with the video player application or as a standalone module on managed service provider device (e.g. set top box), unmanaged device (e.g, smart TV) or a mobile phone.

Figure 3. Nokia CDN for Live solution network architecture



At the VHE or video contribution/distribution peering points, the solution receives MPEG TS content in SD, HD or UHD format as clear or encrypted multicast UDP or RTP packets. The VBO appliance encrypts clear content as required using SimulCrypt AES 128 and optimizes encrypted content for IP streaming. Nokia Bell Labs-patented technologies enhance the MPEG TS for IP transmission to ensure efficient rapid channel acquisition and reliable live video streaming at near-zero live latency from any contribution or distribution feed. This performance is better than can be achieved by broadcast TV from the same feeds.

A video distribution solution for any IP core network

Nokia 7750 SR routers equipped with video quality monitoring and PerfectStream capabilities distribute egress multicast RTP streams from the VBO appliance. The routers support many standard multicast protocols and can enable multicast distribution over the internet or through third-party routers. They can be centrally located or distributed at the network edge to bring the video source closer to subscribers.

The VQM capability of the Nokia 7750 SR detects impaired video. The PerfectStream capability repairs impaired video packets over network transmission. RTT between the 7750 SR and the video player application typically ranges from approximately 20 ms up to 240 ms.

A video distribution solution for any access

The Nokia CDN for Live solution can serve subscribers over any IP access network, including fixed broadband networks (copper, fiber or cable), fixed wireless access networks (FWA), public Wi-Fi, home Wi-Fi and wireless networks such as 4G/LTE, 5G and 5G high-altitude platform systems (HAPS), and satellite.

For all streaming requests, the video player application sends Real-Time Control Protocol (RTCP) requests to the Nokia 7750 SR routers. These routers can be located within internet service provider (ISP) networks (managed networks that are capable of supporting multicast) or outside ISP networks (off-net, unmanaged networks without multicast support).

In off-net scenarios, the CDN for Live solution supports RTCP/RTP packets that transverse Carrier-Grade Network Address Translation (CGNAT) and Residential Gateway Network Address Translation. When they receive the RTCP request, the Nokia 7750 SR routers unicast the requested RTP stream directly to the video player application. The solution immediately streams the video and corresponding audio to the end user. For encrypted content, the solution also sends Entitlement Control Messages (ECMs).

The Nokia 7750 SR routers convert the IP multicast stream arriving from the VHE to a unicast stream for the end device. The end-device video player application buffers the encoder buffer (PTS-PCR) in accordance with MPEG TS standards, so it has minimal live latency compared to the actual live event.

The Nokia CDN for Live solution has an additional feature to inform the video player application when it should switch to the live multicast stream from the VHE. This enhancement uses multicast technology to reduce network resource consumption and achieve the most efficient video delivery for the access network. If the video player application detects that the access network supports multicast, it ensures the transition to multicast streaming is seamless to the end user. If multicast is not supported in the access network, the video player application will prompt the 7750 SR to continue with streaming through routed unicast.

Retransmission

If packets are lost during live channel streaming because of temporary localized network congestion or other factors, the video player application uses advanced machine learning algorithms in the VBO client to request the missing RTP sequence numbers. This error recovery mechanism efficiently recovers up to 40 percent of randomly lost packets and supports a round trip time (RTT) of up to 3500 ms through RTP packet retransmission. It ensures seamless streaming and the best QoE.

Case studies: Live latency compared with traditional OTT streaming, DTT/DTH and betting website

Use case: Sports event live latency comparison

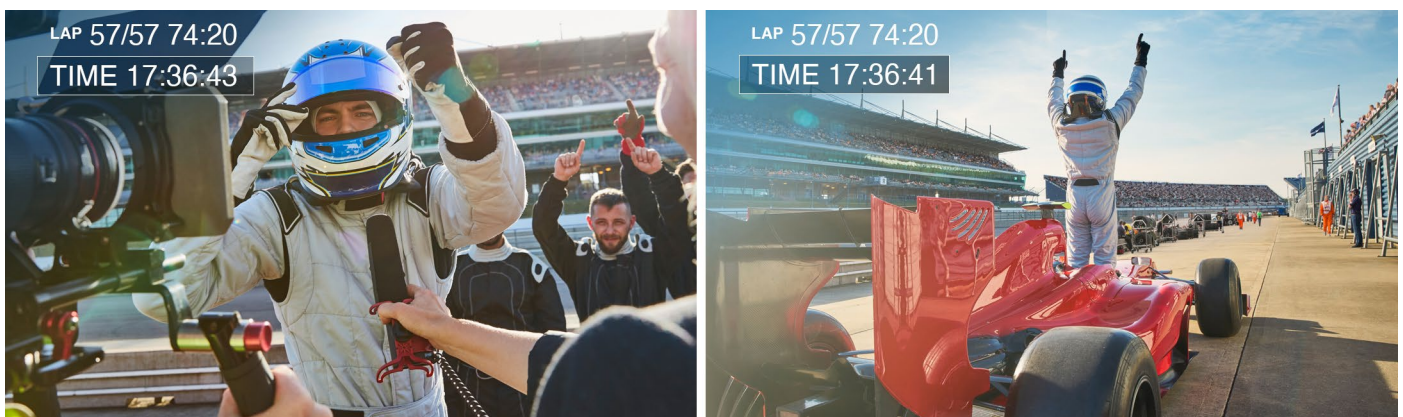
Figure 4 compares the live latency performance of the CDN for Live solution and a traditional OTT platform for a live event. The photo on the left shows CDN for Live. The photo on the right side shows a traditional OTT platform using a global CDN. As the timestamps indicate, the CDN for Live solution outperforms conventional OTT and global CDN streaming by a remarkable margin of 67 seconds.

Figure 4. Nokia CDN for Live is 67 seconds ahead compared with traditional OTT



Figure 5 compares live latency performance of the CDN for Live solution with that of Digital Broadcast TV (DTT or DTH) for the same live event.

Figure 5. Nokia CDN for Live is 2 seconds ahead compared with DTT or DTH TV



The photo on the left shows that CDN for Live provides near-zero live latency for OTT streaming when compared to traditional broadcast TV on the right. This sets it apart from conventional OTT streaming in unmanaged networks. Traditional OTT CDNs utilize TCP/IP for transmission, which relies on window size to decrease the transmission rate in dealing with congestion. They also require video segments to be progressively downloaded before the video is decoded on screen. All these factors contribute to higher live latency.

Whether streaming to mobile or fixed network devices, the CDN for Live solution achieves low latency comparable to that provided by set-top boxes (STBs) through multicast in managed networks or DTT and DTH TV.

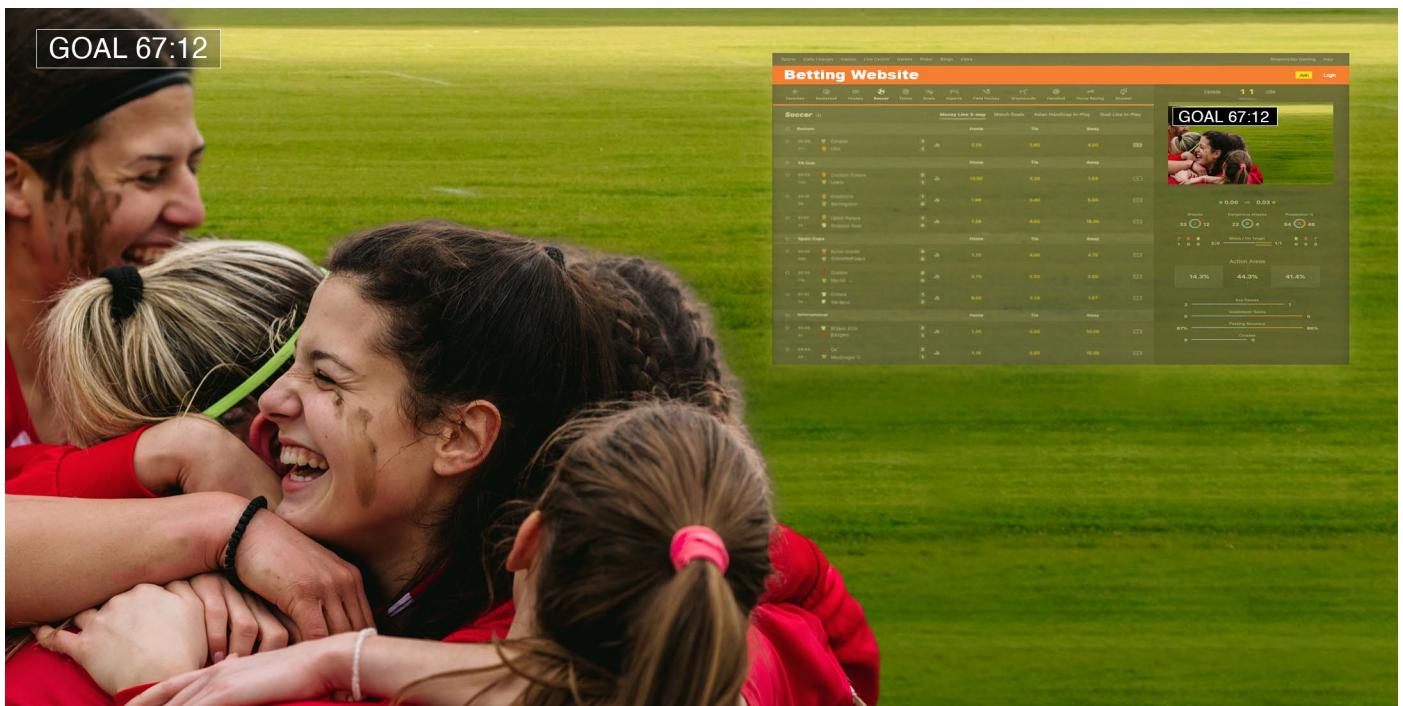
With CDN for Live, the focus is on immediately delivering video to the consumer's screen. The solution utilizes RTP over UDP for transport, which does not require the establishment of a handshake connection. It simply takes the latest video packet received at the VHE and redirects it to the end device requesting the stream. This ensures the end device can start decoding (and displaying) the video as soon as it receives the first video and audio packets. A patented solution also ensures that the corresponding audio is sent with the video. This approach results in latency a magnitude lower than that of traditional CDNs.

In multicast-enabled networks, the video player application smoothly switches to multicast for scalability, which eliminates extra CDN delivery costs and their associated environmental impacts. This is achieved using ISP multicast-enabled distribution networks. By removing the reliance on on-net or off-net OTT CDN servers, this approach makes live streaming more sustainable and efficiently scales to support millions of devices concurrently. For consumers, the results are excellent QoS and QoE.

Use case: Enhanced in-game betting

Betting websites display real-time feedback, data and play-by-play descriptions. The CDN for Live solution ensures that the live stream closely mirrors the actual event, as shown by the matching timestamps for the live stream and live betting site text updates in Figure 6.

Figure 6. Nokia CDN for Live provides near-zero live latency compared with an international betting website text feed



CDN for Live enhances the fan experience by ensuring that the CDN for live video streams is synchronized with the live updates on the betting website. This synchronization enables fan engagement through watch parties, in-game micro-betting and live or group chats.



Synchronization between the live stream and betting website also eliminates the disruptive effects of variable live latency that often come with traditional OTT streaming. It ensures an uninterrupted and enjoyable viewing experience for fans.

The Nokia CDN for Live solution facilitates targeted advertising with 100 percent concurrency, offering opportunities to enhance the viewing experience and implement effective monetization strategies. It enables broadcasters, service providers and content providers to maximize engagement and revenue potential by delivering personalized and relevant advertisements to the audience in real time.

Summary

The Nokia CDN for Live solution helps broadcasters, service providers and content providers address the challenges of delivering streaming video content for live sports and events by offering:

- Cost-effective live video streaming distribution to subscribers on a large scale
- Near-zero live latency compared with digital live broadcast TV
- Ultra-fast channel delivery and change (approximately 90 ms to <500 ms)
- Ultra-reliable RTP streaming, five-nines or above
- Live IP video streaming over any access
- Simultaneous support for multicast and routed unicast streaming
- Video repair over transit network with PerfectStream.

Broadcasters, service providers and content providers can confidently rely on this cost-effective solution to deliver live events with efficiency and reliability over IP networks, ensuring an exceptional streaming experience for their audiences.

Learn more

To learn more about the Nokia CDN for live solution, visit:

- [Nokia IP networks](#)
- [Nokia Video Broadcast Optimizer](#)
- [Nokia 7750 Service Router](#)
- [Nokia 7750 SR Extended Services Appliance data sheet](#)
- [Nokia Integrated Services Adapter data sheet](#)
- [Nokia Bell-Labs Overview of High-Altitude Platform Stations \(HAPS\): Connect the unconnected](#)



Supported standards and protocols

The Nokia CDN for Live solution supports a variety of standards and protocols, including:

- ETSI TS 102 034 V1.4
- Protocol independent multicast – source-specific multicast (PIM-SSM)
- RFC 2236, 3376, 4604 Internet Group Management Protocol, Version 2 and 3 (IGMP v2, v3)
- RFC 2250, MPEG-2 TS mapping in RTP
- RFC 3550, RTP: A Transport Protocol for Real-Time Applications
- RFC 4445, A proposed Media Delivery Index
- RFC 4585, RFC 4588: Retransmission
- RFC 6285, Unicast-Based Rapid Acquisition of Multicast RTP Sessions
- SCTE-143/ETSI TR 101 290, Digital Video Broadcasting (DVB); Measurement guidelines for DVB system
- Segment routing draft-ietf-bess-mvpn-evpn-sr-p2mp-07, Multicast and Ethernet VPN with Segment Routing P2MP and Ingress Replication – MVPN
- SMPTE ST 2022-7 Seamless Protection Switching of RTP Datagrams

About Nokia

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As a B2B technology innovation leader, we are pioneering networks that sense, think and act by leveraging our work across mobile, fixed and cloud networks. In addition, we create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

Service providers, enterprises and partners worldwide trust Nokia to deliver secure, reliable and sustainable networks today – and work with us to create the digital services and applications of the future.

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