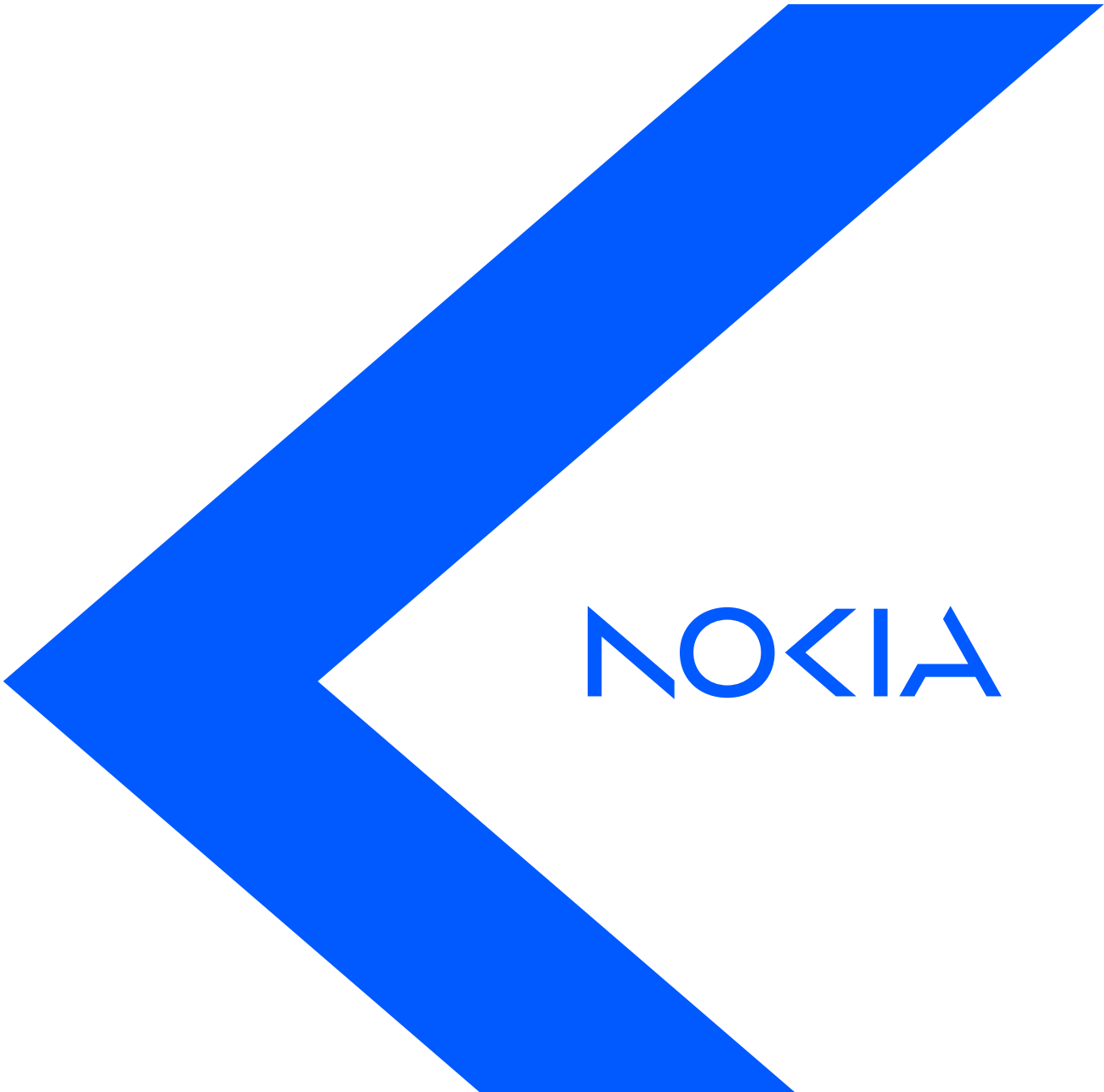
Nokia Content Delivery Network (CDN) for Live

Optimize video streaming for live sports and events over any access network



Abstract

The Nokia Content Delivery Network (CDN) for Live solution is designed to ensure ultra-reliable real-time IP video streaming over any type of network—broadband, mobile or fixed wireless. This video broadcast distribution solution provides a single platform that can deliver over-the-top (OTT) IP video directly to end-user 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
- Surpass real-time streaming experiences provided by traditional OTT and IPTV services.

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Introduction

The expectations for live streaming of news and sports events differ significantly from those associated with streaming on-demand movies or clips. Consumers anticipate that they will be able to seamlessly switch between live events, watch in real time with minimal latency and enjoy reliable, uninterrupted streaming. These expectations present a unique set of challenges for broadcasters, service providers and content providers that rely on traditional content delivery networks (CDNs) or enhanced video on demand (VOD) technologies to support live event services.

The Nokia CDN for Live solution represents a groundbreaking advancement that transforms and enhances the linear live broadcast TV experience. This innovative solution is designed to cater to the needs of over-the-top (OTT) and IPTV subscribers simultaneously, marking a significant evolution in the streaming of live entertainment.

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

The solution provides a more responsive and reliable IP video streaming experience than Digital Live Broadcast TV. Based on patented ultra-fast channel change (~90 ms to <500 ms) technology, it ensures ultra-reliable RTP streaming and a seamless viewing experience with zero live latency. It is ideal for meeting the streaming requirements of a wide range of live sports and events at scale.

Addressing the key technical challenges of live event streaming

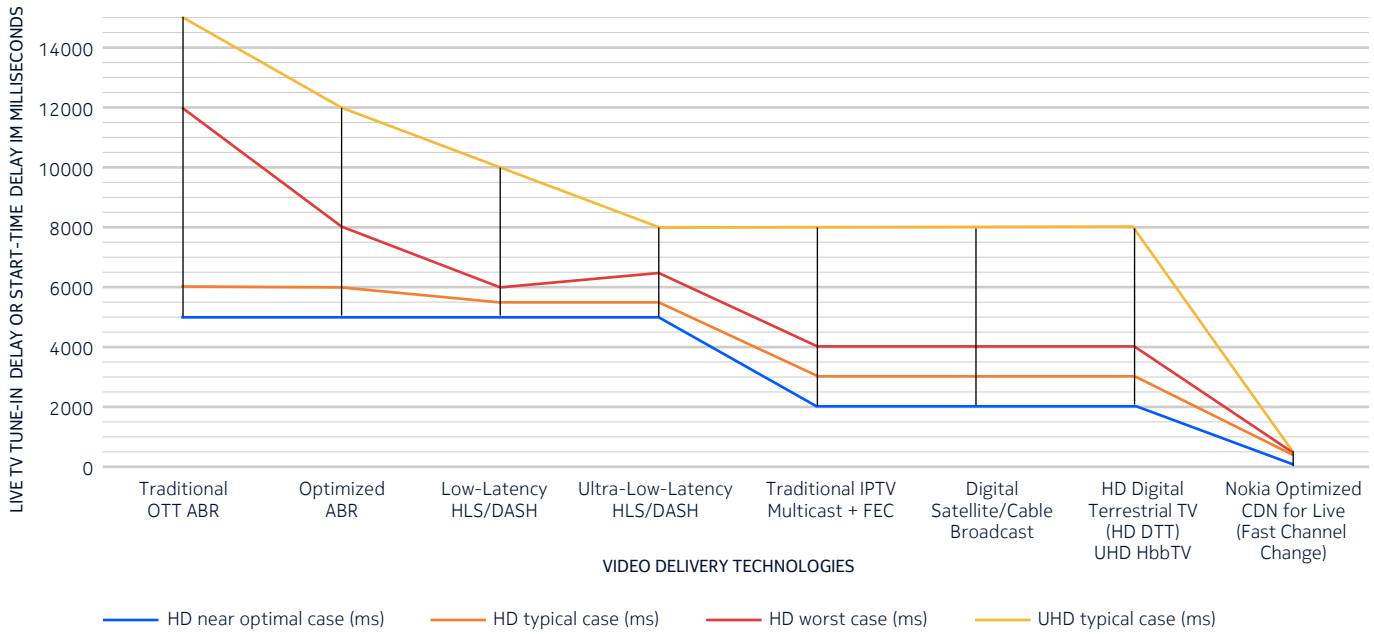
Broadcasters, service providers and content providers face significant technical challenges in offering live streaming services for sports or events over IP access networks. The main challenges are:

- 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.
- Minimizing the latency of the live stream compared to the actual event. The average live latency of traditional OTT video delivery ranges from 21–180 seconds.
- Implementing the best video and compression technologies to handle network congestion and packet loss to maintain a high-quality viewing experience and keep viewers engaged. This is particularly challenging given the fast-paced nature of live sports.

CDN for Live addresses these challenges using innovative video technologies from Nokia Bell Labs. As live events are broadcasted as IP packets at the video headend (VHE), the solution immediately delivers the arriving IP packets to the end user.

This approach 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 20 times faster than traditional CDN video service, 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



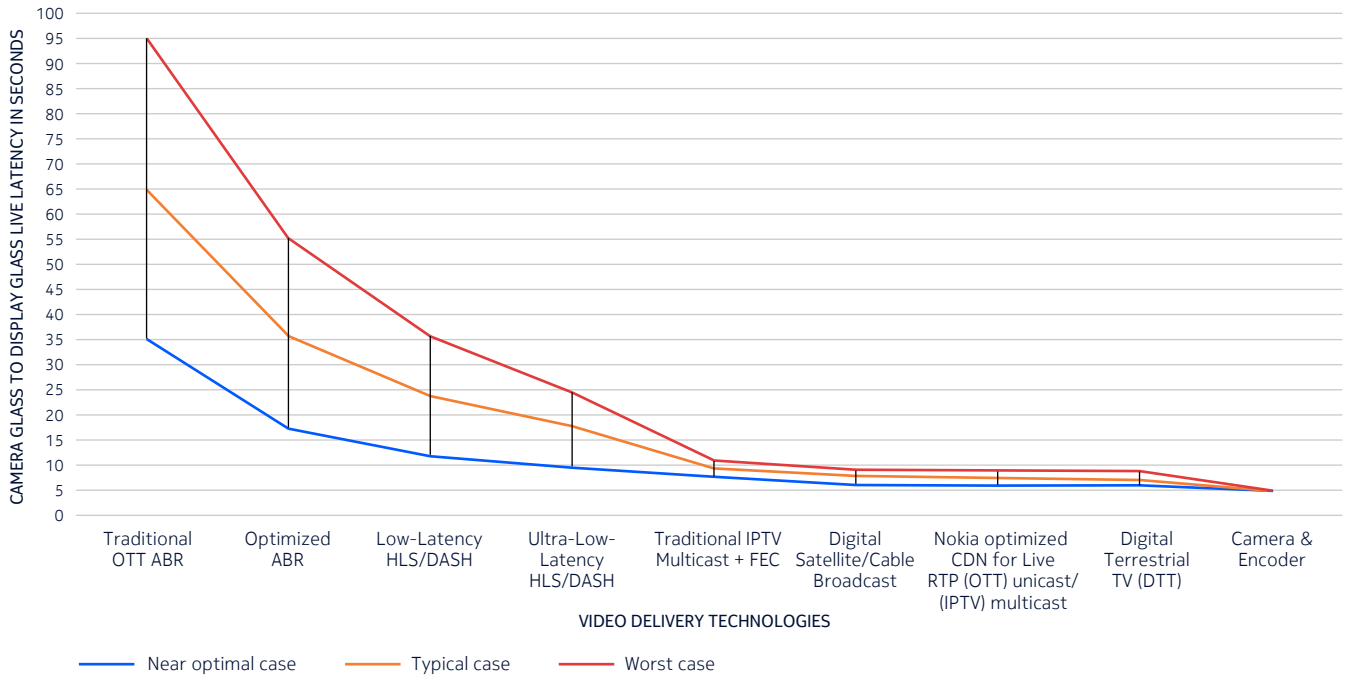
This approach also enables real-time delivery of live events to end-user screens without traditional CDN buffering and caching. CDN for Live offers the unique ability to switch between live content and multiple camera views in 90 ms to less than 500 ms. This creates the best QoE for channel surfing on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



Essential elements to transform live streaming

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.

VBO appliance

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 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 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 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 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 7750 SR ESA and ISA are designed to support IPTV multicast and routed unicast (OTT) streaming simultaneously. They provide responsive channel delivery, fast channel change and packet retransmission capabilities. They can also monitor video packets delivered from the VHE using Video Quality Monitoring (VQM) and repair any impaired packets using the PerfectStream solution.

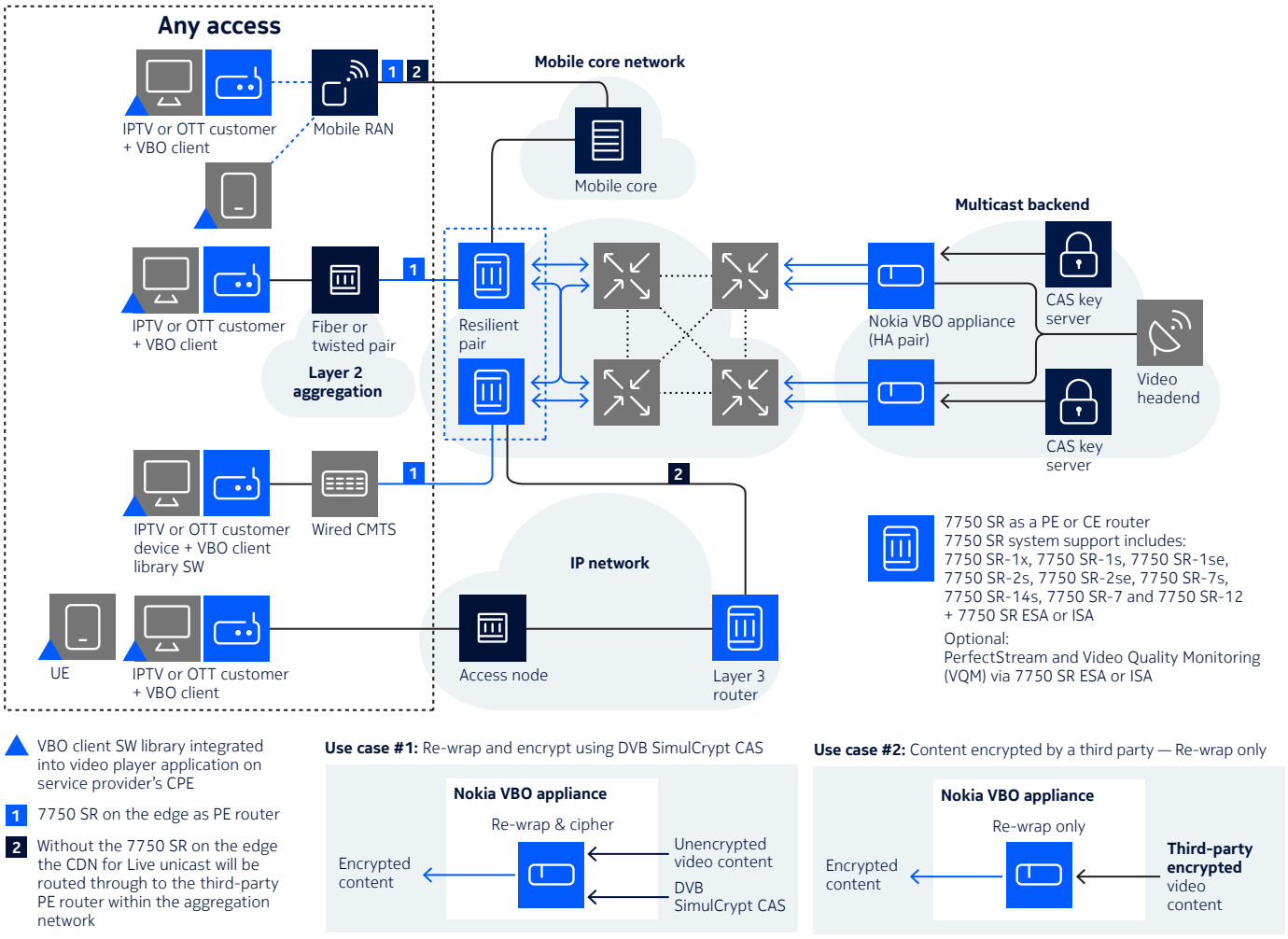
VBO client software library

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).

Nokia CDN for Live solution architecture

Figure 3 illustrates all the elements that enable the CDN for Live video solution. It shows how the 7750 SR can flexibly deliver live video streaming to any access network. 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.

Figure 3. Nokia CDN for Live solution network diagram



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 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 solution for any 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 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 solution for any access

The CDN for Live solution can serve subscribers over any IP access network, including fixed networks (copper, fiber or cable), Ethernet connections, fixed wireless access networks (FWA), public Wi-Fi, home Wi-Fi and wireless networks such as 4G/LTE or 5G standalone (SA).

For all streaming requests, the video player application sends Real-Time Control Protocol (RTCP) requests to the 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 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 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 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 3000 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 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.

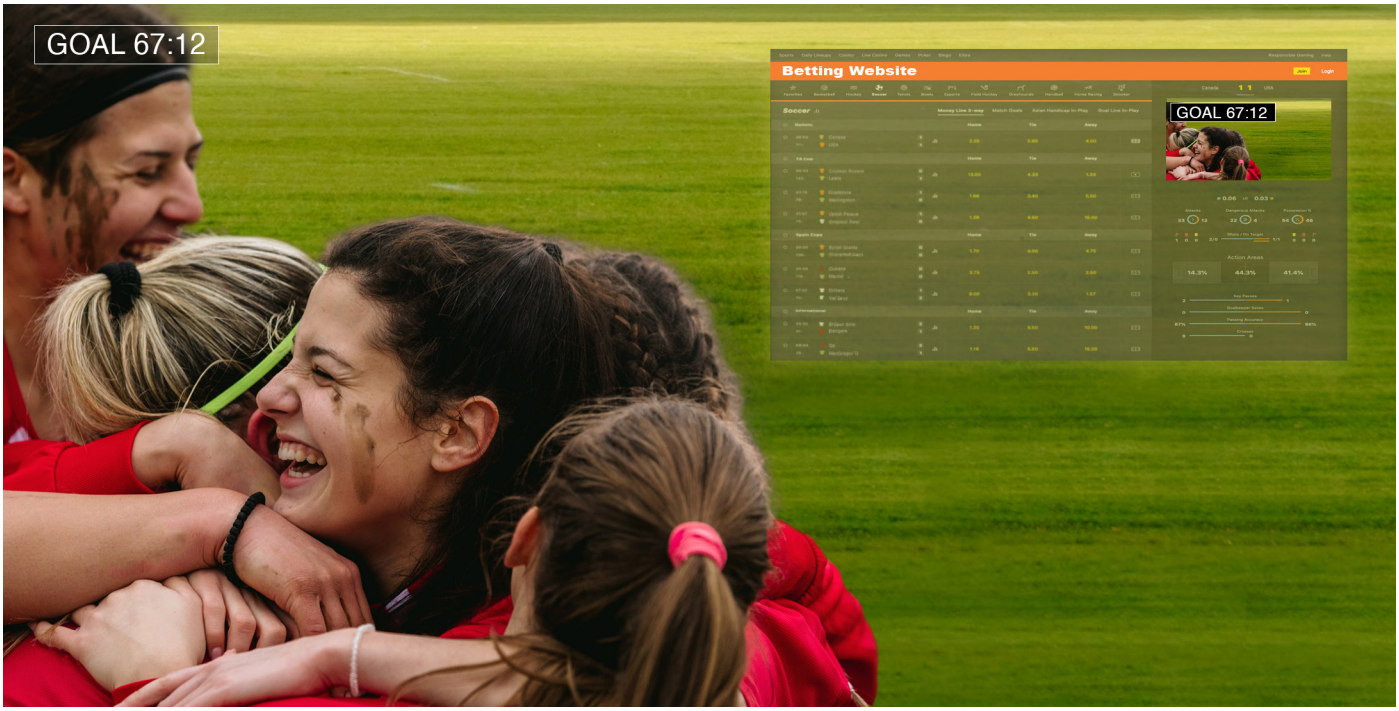
With CDN for Live, the focus is on immediately delivering video to the consumer's screen. The solution utilizes RTP over UDP for transport, which does not require the establishment of a handshake connection. It simply takes the latest video packet received at the VHE and redirects it to the end device 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 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 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
- 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: https://www.nokia.com/networks/ip-networks/
- Nokia Video Broadcast Optimizer: https://www.nokia.com/networks/ip-networks/video-broadcast-optimizer/
- Nokia 7750 Service Router: https://www.nokia.com/networks/ip-networks/7750-service-router/
- Nokia 7750 SR Extended Services Appliance data sheet: https://onestore.nokia.com/asset/207452
- Nokia Integrated Services Adapter data sheet: https://onestore.nokia.com/asset/157673

Standard and protocol support

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
- SMPTE ST 2022-7 Seamless Protection Switching of RTP Datagrams

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Document code: (July) CID213856