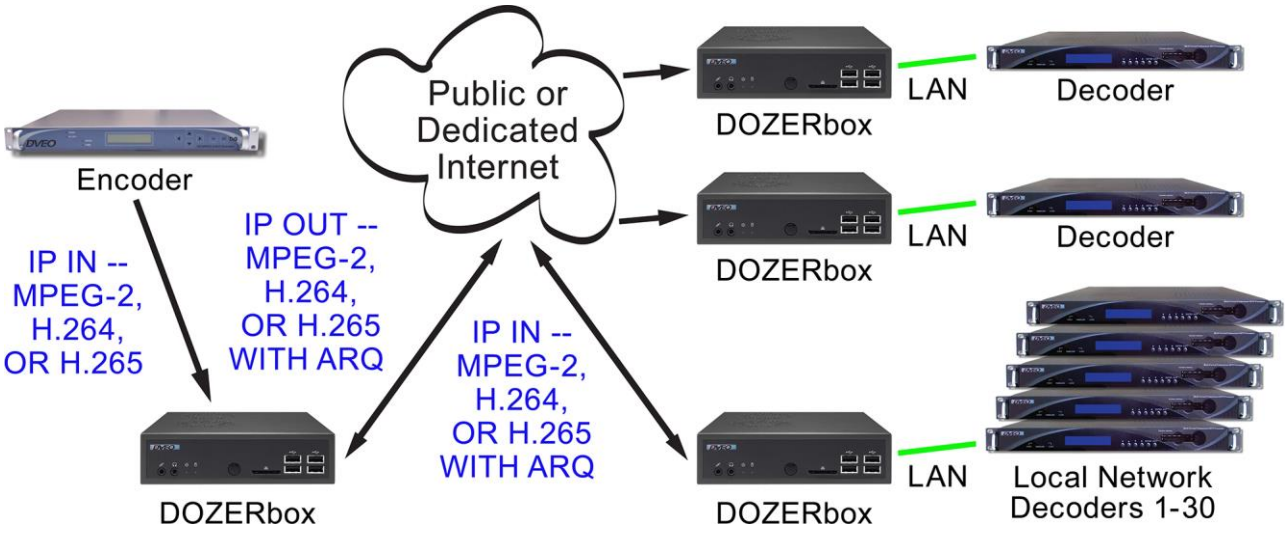
DVEO Perfects Real-time IP Video Delivery and Improves Quality of Experience via DOZER Automated Packet Recovery Technology

Overview

(Rev 3.5 – Nov 8, 2016)



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Internet Protocols and Packet Loss: Cause and Effects

This Document

To stream high quality video, i.e. to transmit real-time video streams, over IP networks is a demanding endeavor and, depending on network conditions, may result in packets being dropped or "lost" for a variety of reasons, thus negatively impacting the quality of user experience (QoE). This document looks at issues around "packet loss" and how to fix it.

The purpose of this document is to inform operators and enterprises experiencing streaming video quality problems that proven technology exists, which enables transmission of real-time video completely error-free over all types of IP networks. It is even possible to perform live broadcasting of studio quality content over the "unmanaged" Internet!

Core Protocols of the Internet Protocol Suite

The Internet Protocol (IP) is the foundation on which the Internet was built and, by extension, the World Wide Web, by enabling global *internetworking*. The protocol embodies the ability to deliver or route datagrams ("packets") from source to destination across multiple IP network boundaries, traversing regions, countries and entire continents, based on a relatively simple addressing concept (the "IP address"). The role of IP is to deliver a packet from the sender ("source host") to the receiver ("destination host") based on the IP address in the packet header.

IP is by design a "connectionless" datagram protocol, and it is complemented by the connection-oriented Transmission Control Protocol (TCP), together referred to as TCP/IP. IP and TCP are the core protocols of the Internet protocol suite. Together they are the communications protocols at the heart of the global Internet as we know it.

TCP/IP vs. UDP: Two Vastly Different Protocols

TCP/IP emphasizes reliability over latency, which means that it will eventually deliver all packets regardless of network conditions and the time taken to accomplish it. Major applications such as the World Wide Web, email, Secure Shell (SSH) and File Transfer Protocol (FTP) rely on TCP/IP, since reliability is more important to all than timeliness.

On the other hand, there are several types of time critical applications where low-latency delivery is of higher importance, and which simply cannot afford the protocol overhead of TCP/IP that may cause variable and unacceptable delays in packet delivery. Such applications may benefit from the lightweight User Datagram Protocol (UDP), a connectionless datagram service with minimum protocol overhead that puts reduced latency ahead of reliability. UDP lends itself very well for time critical applications such as streaming video, Voice over IP (VoIP), and online multiplayer games. However, UDP works best in uncongested networks or where real-time UDP traffic is given priority over data-centric TCP/IP ditto.

Packet Loss Effects

Packet loss occurs when one or more packets transmitted over an IP network fail to arrive at their destination, or arrive(s) corrupted. Packet loss is typically caused by what is generally referred to as "network congestion," which in and by itself can have several causes. Packet loss is measured as the percentage of packets lost compared to packets transmitted.

In time-critical applications that use UDP, especially streaming (real-time) video delivery, as well as VoIP and online multiplayer games, packet loss can affect the user experience even when the percentage of packets lost is just a fraction.

As mentioned, TCP/IP by design detects packet loss and performs retransmissions to ensure reliable messaging. TCP/IP will also reduce the throughput of a connection upon detection of packet loss to avoid congestion and let the network "catch up." Therefore, TCP/IP is not a suitable protocol for time critical uses. Unfortunately, TCP/IP's behavior can also cause reduced throughput for real-time protocols like UDP when sharing routers and buffers.

In more concrete terms, video playback may experience gaps due to delayed or lost packets unless there is a low-latency automatic packet recovery mechanism that can manage rapid resending of lost packets, and reorder packets that arrived out of sequence, so that no visible gaps will appear to the viewer. UDP, a nimble protocol ideal for real-time applications in uncongested or video optimized networks, does not have any built-in packet recovery functionality. It would be the responsibility of the application to manage that, and there are technologies available that can do just that.

Network Congestion and Packet Loss

Even if all network equipment, software and cabling is working per their specifications, packet loss may occur if the network becomes congested. Network congestion is a generalized term for issues that cause a disorderly treatment or routing of packets (including no routing at all, i.e. packet loss). If more packets are put through a network node than it can reasonably handle, i.e. when packets arrive continuously at a rate higher than the node can route through, then packets will be dropped. If a single node or link is limiting the throughput, it is known as a "bottleneck."

The resulting node or link congestion may manifest itself in several ways:

- Packet Loss: The packet does not arrive at all, e.g. a router experiencing momentary over-saturation
- Packets out of Sequence: Arriving in the wrong order, e.g. due to taking different paths with different latency
- Packet Delay Variation (PDV): Variations in arrival time. PDV (an ITU term) is more commonly referred to as "jitter," i.e. variations in network latency (variable instead of constant end-to-end delay). Jitter leads to variations in the delay between received packets, often a result of multi-network "hops" that introduce variable latency.

Potential Effects of TCP/IP on Real-time UDP Traffic

The TCP *congestion avoidance algorithm* relies on packet drops to assess available bandwidth. It speeds up the data transfer until packets start to drop, then slows down the transmission rate. Packets are queued within a router buffer before being transmitted but if the buffer fills up, additional incoming packets will be dropped.

When a network node becomes congested, there are various queuing methods used to determine which packets to drop. Most basic networking equipment will use the classical FIFO (First In First Out) queuing mechanism for packets waiting to get routed through the node, and it will drop a packet if the queue is full at the time a new packet arrives ("tail drop"). This is exactly where slow moving TCP/IP data transmissions can cause serious problems for time critical UDP traffic due to a phenomenon aptly called "buffer bloat," which occurs when a congested network link will cause UDP packets to become queued in buffers shared with TCP/IP for too long. In a FIFO queuing system, overly large router buffers result in longer queues, and excess buffering of packets causes high latency and jitter, which reduces overall network throughput.

This problem especially affects datagram protocols such as UDP, because all packets passing through a common buffer (with a single queue) will suffer the same delay or latency. While a higher latency is typically not a problem for TCP/IP applications, it will negatively impact UDP applications such as real-time video by causing visible artifacts, and VoIP.

Ironically, available total bandwidth may end up partly unused since some destinations configured to handle very high bitrates, like live HD video, may not be reached in a timely manner due to large buffers clogged with TCP data awaiting delivery to "slow data destinations", thus causing UDP packet loss or unacceptable delays even though the total bandwidth could have accommodated all traffic if routers were better chosen or configured, or if the overall network was divided into data and video segments.

What has been described here is something that a video operator relying on third-party networks has little control over and will need to resort to other tools to overcome such challenges. Fortunately, there are technologies available today able to deal with even severe UDP packet loss.

Packet Loss Diagnosis

The first step would be to understand why there is packet loss and where in occurs in an end-to-end network. Packet loss is obviously detected by application protocols such as TCP, but a human is often required to diagnose the reason for packet loss. Routers may offer status pages incl. logs of the number or percentage of packets dropped during a specific time-period, but a professional network admin usually prefers a purpose-built tool for remote detection and diagnosis.

The Internet Control Message Protocol (ICMP) is another important protocol of the Internet protocol suite. It is used by network devices to signal, for example, that a requested service is unavailable or that a host or router could not be contacted. ICMP can also send query messages through an "echo" functionality, where a special packet is transmitted that should produce a reply after a specified number of network hops, from whichever node received it. A tool such as MTR (*My traceroute*, a combination of two other tools, *ping* and *traceroute*) uses ICMP to provide a visual representation of the path packets are taking, and to measure response times and packet loss at each hop.

Whatever the diagnosis, some potential remedies are not practical for a video operator that relies on third-party networks and multi-hop segments, since it can't control how individual network devices are configured and so on. That is why the final remedy is to apply a low-latency automatic packet recovery technology for UDP such as ARQ.

Fixing Packet Loss and the Role of ARQ Technology

Automatic **R**epeat re**Q**uest (ARQ), also referred to as **A**utomatic **R**epeat **Q**uery, is a type of technology designed to achieve dynamic and low-latency error correction for the benefit of real-time applications, especially Live Video and VoIP. ARQ is the perfect complement to UDP, a light weight and video centric protocol based on the "fire and forget" principle.

UDP in combination with ARQ is the enabler of reliable video delivery over the Internet. The pair achieves automatic packet recovery utilizing variable and adaptive processing, unlike TCP/IP's fixed overhead, thereby fulfilling the exacting demands of high-quality streaming video.

DVEO DOZER™ ARQ Technology

Introduction

DOZER ARQ delivers real-time video error-free over unreliable network segments. The DVEO patented ARQ packet recovery algorithms will fix UDP packet loss, correct for jitter, de-duplicate and reorder packets. Defining characteristics:

- Robust: Reliable MPEG-2, H.264, H.265 Transport Streams, SPTS and MPTS, and file delivery
- Flexible: Point-to-point or point-to-multipoint functionality
- Secure: All transmissions are AES-128 encrypted
- Remote Management: SNMP, and secure web access (SSH)

Winner of Society of Broadcast Engineers (SBE) Technology Award 2014 for DOZER IP video traffic smoothing technology.

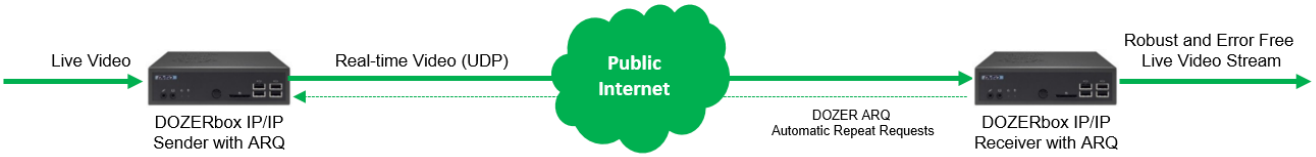

Figure 1: DOZER ARQ Pair Enables Error-free Live Video over the Internet

Who Benefits from DOZER ARQ?

- ✓ Broadcasters and Affiliates
- ✓ Live Event Producers and Electronic News Gathering
- ✓ Studios, Programmers, Content Providers and Aggregators
- ✓ Enterprises, Institutions and Government
- ✓ Anybody tired of high satellite and managed network costs

Anybody who wants to
Transmit Live, Studio-Quality Video over the Internet while Saving Big $$$
compared to traditional alternatives

DOZER ARQ: Versions and Options

A hardware agnostic software-based platform, offered as:

1. **DOZERbox™ IP/IP + AES128** compact box (7.5" wide)
2. **DOZER Racks™ IP/IP** (1 RU)
3. **DOZER Racks™ IP/IP: TELCO** (1 RU), with Redundant power supplies and ports
4. **DOZER™ ARQ: LIC** SDK/Permanent Software License
   - For integration in third-party devices such as encoders/decoders, streamers, network routers, CDN media servers, IP gateways, etc.
   - DOZER ARQ is embedded in the DVEO ARQ Link™ Encoders and Decoders, and it is an available option in other DVEO IP video encoders and transcoders, streamers, media servers and decoders.

The DVEO hardware is ultra reliable and CAPEX/OPEX friendly, based on Linux OS on Intel platforms for 24/7/365 uptime. The products are easy to configure and operate: "Set and Forget!"

DOZER ARQ Functionality

DOZER ARQ is a Layer 2 packet retransmission methodology, developed and patented *) by DVEO, to enable error-free real-time compressed video delivery. It imposes a minimum of protocol overhead, enabling the lowest possible latency:

- Transmit data – no overhead since positive ACKS are not used
- Receiver only sends negative ACKs to indicate missing packets
- Fast re-transmit of missing packets keeps Live Video live!
- Receiver performs automatic packet de-duplication and reordering
- Guaranteed packet delivery without the fixed overhead of TCP/IP

Dynamic DOZER buffer management auto-adjusts to network conditions. It monitors round-trip time between the two end-points, and maintains a buffer of optimal size to recover from any packet loss up to 50% or more.

*) US 9,338,259 B2: "User defined protocol for zero-added-jitter and error free transmission of layer-2 datagrams across lossy packet-switched network links"

DOZER ARQ Features

- Guarantees error-free real-time video transport on DOZER ARQ protected network segments
- Uses patented and highly sophisticated ARQ management algorithms to optimize UDP video that traverses congested switches and routers
- Packet Recovery based on Automatic Repeat Requests: Unlike FEC protocols, it only sends extra data when packet loss is detected by the DOZER receiver and reported to DOZER sender
- DOZER ARQ protocol eliminates packet loss and corrects for jitter and packet reordering
- Supports HD and SD MPEG-2, H.264 and H.265 Transport Streams, SPTS and MPTS
- Supports IP UDP unicast and multicast, in or out
- Will not alter the internal structure of the transport stream (PAT, PMT, etc.)
- Underlying traffic is AES-128 encrypted by DOZER, but not examined
- All inter-DOZER communication is AES encrypted
- Dynamic DOZER buffer auto-adjusts to network conditions, and maintains a buffer of optimal size to recover from packet loss up to 50%
- Inputs/Outputs: 2 each Gig/E ports
- Configurable destination port on listener for firewall traversal
- Can be configured for point-to-point or point-to-multipoint functionality
- Supports up to four destinations in primary-backup or split transmission configuration for redundant or load balanced setups
- Each device configurable as a sender, receiver, or both
- One DOZER transmitter can send 50+ streams to up to 32 different DOZER receivers
- Each receiver device can output UDP on a local network to one or many different devices using second Ethernet port on unit
- DOZER Transmitter-Receiver connections are authenticated with user name and password for additional security
- Faster content and VOD file transfers over long distances compared to TCP-based protocols
- Remote Management: SNMP, SSH
- UDP packets may contain arbitrary data

DOZER ARQ Application Versatility

The DOZER ARQ technology optimizes throughput for any link, latency and network type, making it suitable for almost any kind of network that may exhibit widely different characteristics:

- High speed point-to-point fiber connections
- Congested internet links
- Unreliable Wi-Fi and Microwave links
- Even works for very high-latency satellite connections

There is no lower or upper boundary in latency, i.e. buffer size, or packet recovery amount; instead, the DOZER boundaries are predetermined by the roundtrip packet travel time and available bandwidth, and its real-time buffer adjusts to changing network conditions on-the-fly.

The number of DOZER Transmitters and Receivers is controlled by software, allowing for very flexible DOZER content distribution combinations.

DOZER ARQ Application Examples

The DOZER ARQ technology ensures smooth, high quality video over any type of IP network, whether LAN, WAN or dedicated and conditioned networks:

- Streaming studio quality live news and sports events over congested backbone networks – error-free
- Replace or complement costly managed networks for Studio-to-Transmitter Links, DSNG/Satellite Backhaul, other point-to-point satellite distribution, etc.
- Multi-country delivery over networks of varying reliability, and over intercontinental sea cables
- Fast content and VOD file transfers over long distances; DOZER-accelerated file transfers are many times faster compared to TCP-based protocols
- Supports both point-to-point and point-to-multipoint content delivery

Point-to-Point Content Delivery

Save money with DOZER video delivery over the Internet, by replacing or complementing expensive point-to-point managed networks:

- Microwave Studio-to-Transmitter Links (STL)
- DSNG, Satellite Backhaul and Contribution Links
- Dedicated point-to-point Fiber Links
- High quality, error free live video for CDN ingest

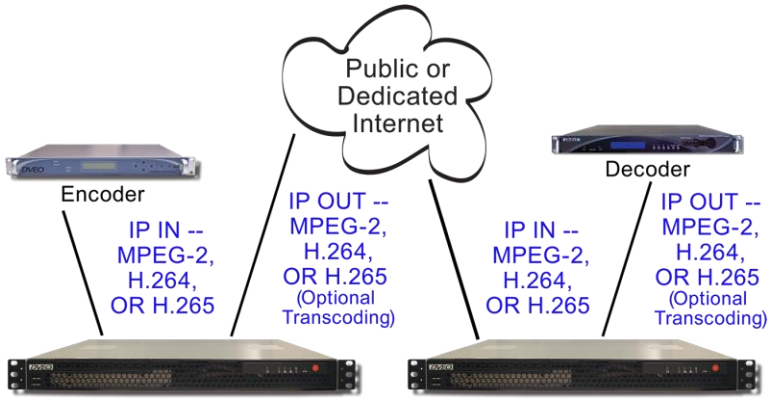

Figure 2: DOZER Racks in Point-to-Point Application

The illustration below shows how the classic DSNG truck with satellite uplink can be replaced by a pair of DOZERS and the Internet – in this case, the DVEO iCandy Live 4K Ultra HD encoder and decoder both have DOZER ARQ functionality integrated, obviating the need for separate ARQ hardware.

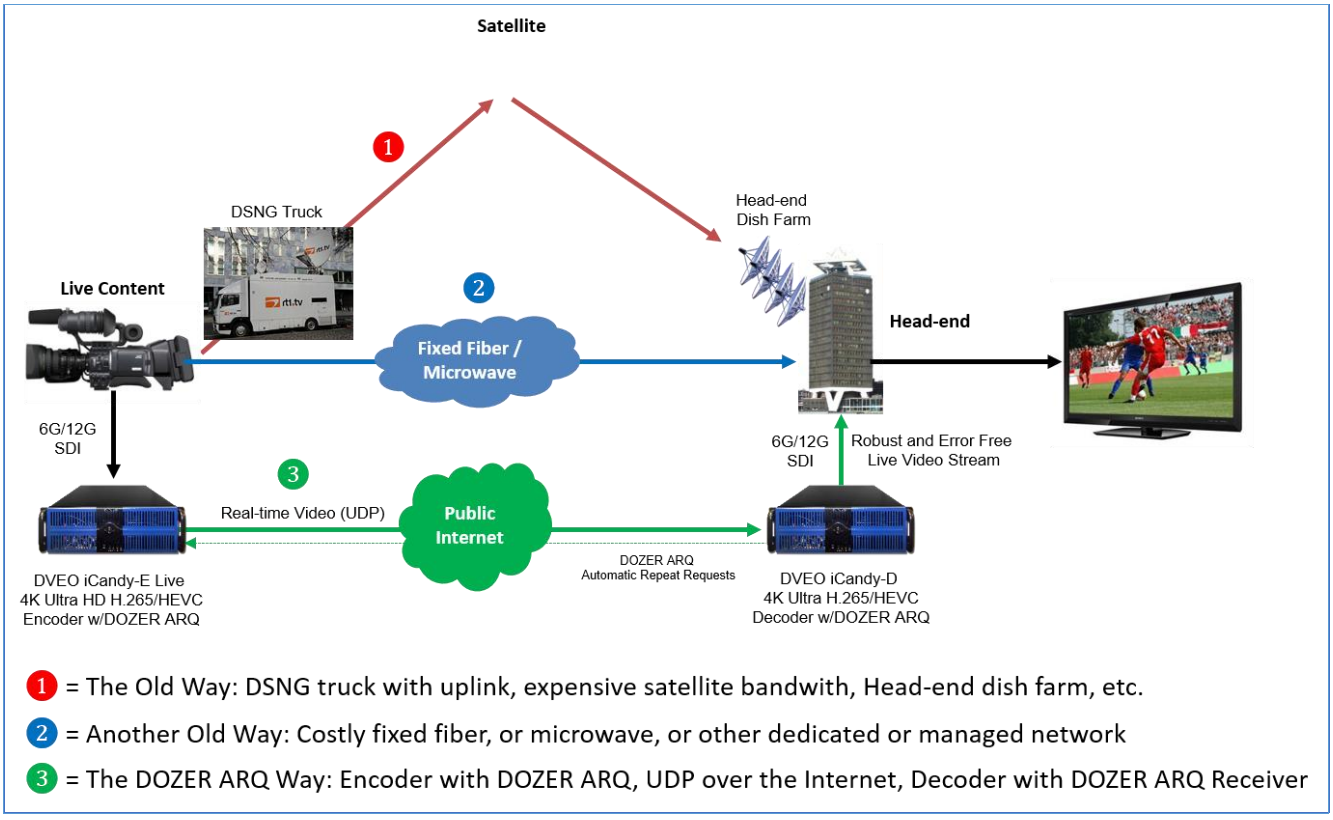

Figure 3: DOZER vs. Satellite and Fiber in Point-to-Point Live Video Application

Point-to-Multipoint Content Delivery

Save money with DOZER video delivery over the Internet, by replacing or complementing expensive point-to-multipoint managed networks:

- Multi-country / Multi-city / Multi-island distribution
- Satellite One-to-Many Distribution Networks, transmit 50+ channels to up to 32 DOZER Receivers
- Dedicated One-to-Many Fiber Links (One-too-Many!)
- Robust, error free live video for multi-CDN ingest

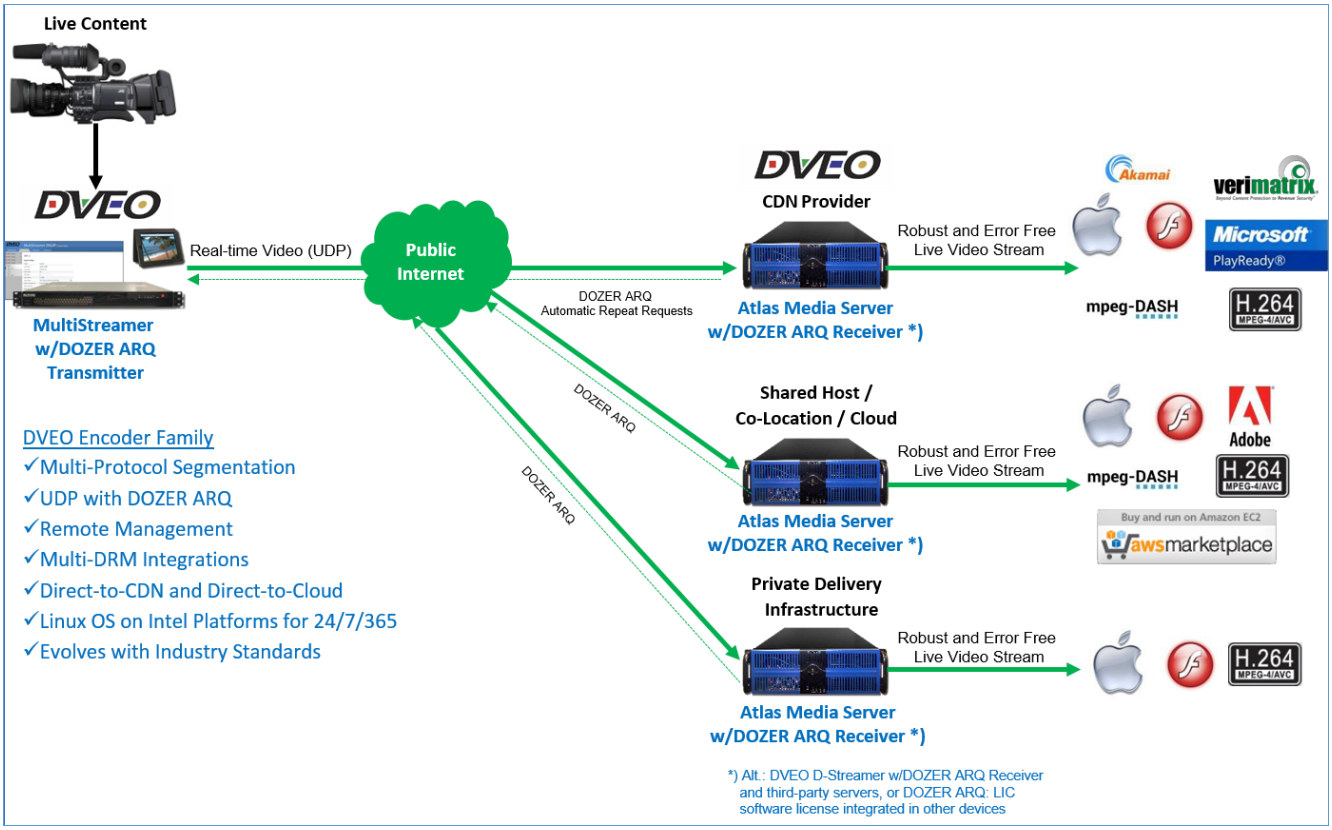

Figure 4: DOZER ARQ Live Multi-CDN Distribution

See also the cover graphic for another DOZER ARQ point-to-multipoint content delivery illustration.

DOZER ARQ Packet Recovery Multipath

The DOZER ARQ embodies powerful packet de-duplication and reordering capabilities, making it possible to create multiple independent paths going from one DOZER transmitter to one DOZER receiver. The latter will recombine the multiple streams properly even in case of complete duplication of streams, and different latency or bandwidths in the multiple paths.

In the DOZER transmitter GUI, the user can choose whether a stream is going to be split as Load Balanced Stream or as Duplicated Stream. For each, a "weight" is selected of the Secondary Stream compared to the Primary Stream.

DOZER ARQ Multipath Use Case

In this case, it is illustrated how an effective link is created across multiple cellular modem connections, or how an active redundancy path on an internet link can be realized by using two separate ISPs at one or both end-points. Whatever paths the packets take to arrive at the destination, the DOZER receiver will de-duplicate and reorder the packets, and an error free video stream is presented to the application.

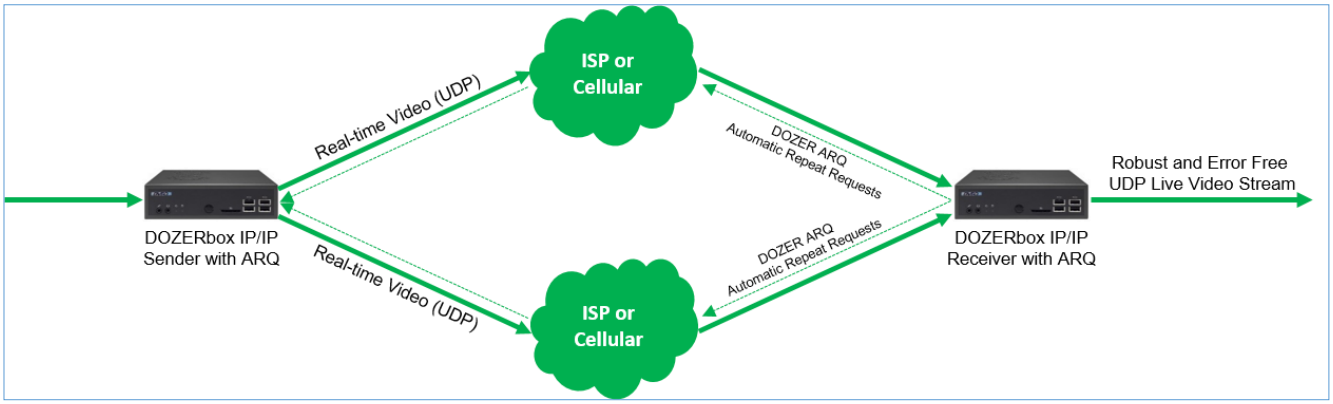

Figure 5: DOZER ARQ Multipath Use Case

Build a Virtual Managed Network

The Multipath use cases demonstrate how multiple DOZER based routers can be combined to build low-cost:

- Virtual Managed Networks (VMN)
- (Private) Content Delivery Networks (CDN)

The VMN can establish multiple primary and secondary paths using a combination of, for example:

- Dedicated lines and the Internet
- Content Caching Servers

The VMN can be local, regional or, like the Internet, global. An in-house VMN can be an order of magnitude more cost effective than third-party CDNs, managed and conditioned networks, and satellite distribution.

Bi-Directional Applications

Since a DOZER can act both as a Sender and Receiver, it can be deployed in bi-directional applications such as VoIP and video conferencing, and live TV multi-location interviews, etc. The UDP packets may also contain arbitrary date, unrelated to video.

Other Applications

- Mobile news gathering: Camera plus encoder with DOZER Sender
- Accelerated file transfer across countries or continents
- Global and large scale enterprise HD video delivery
- Internet TV
- Health care video-based collaboration including tele surgery
- Live webcasts and event broadcasting to CDNs
- Internet Video Gaming
- VoIP
- Video conferencing

Fix Packet Loss: DOZER ARQ Conclusion

DOZER ARQ is cost-effective for many deployment scenarios by making live video transmissions immune to:

- Packet loss and Packet Delay Variation (jitter)
- Out-of-sequence and duplicate packets, and
- Multi-network hops with varying degree of reliability

Guarantees robust and error-free UDP real-time video for:

1. Live broadcasting over the Internet
2. Live contribution feeds to TV stations, CDNs and uplinks
3. Replace or complement costly managed networks

Self-adjusting and dynamic sub-second latency buffer makes DOZER the right choice regardless of challenging and changing network conditions. Save money with DOZER ARQ video delivery over the Internet!

Next Steps: Request DOZERbox ARQ Evaluation Units

Contact DVEO to request a DOZERbox loaner pair for a 30-day trial to see this remarkable technology in action.

Read the Application Note: Using WAN Emulation to Demonstrate DOZER Automated Packet Recovery

About DVEO®

Overview

DVEO® is a privately held entity headquartered in San Diego, California, since 2001. DVEO develops and sells broadcast quality video encoding and streaming products, media servers and ad insertion solutions to leading broadcasters, telco TV/OTT and cable operators around the world. DVEO also designs and manufactures professional video products for OEM sales, and it is a private label marketer for a variety of complementary products from well-known corporations.

Vision & Mission

Our **vision** is to offer innovative and affordable digital video and telco TV grade products for IPTV, OTT, cable and broadcast applications that anticipate the evolving needs of progressive service providers and OEMs globally.

Our **mission** is to enable deployment of high-quality and easy-to-use, yet affordable solutions that enhance our clients' profits and success by reducing CAPEX and OPEX, coupled with outstanding post-sales support.

Since the launch we have focused on fostering long term relationships and this client-first attitude has positioned us as a trusted solutions provider for customers of all types.

Market Approach

In addition to direct sales to video operators of all types, complemented by indirect channels, DVEO provides OEM solutions that shorten time-to-market while reducing project risk and cost. Product volumes range from single and custom units, to thousands of units a month to meet dynamic customer requirements. Above all, we pursue long term partnerships with our customers for sustained mutual benefits.

DVEO continuously pursues advanced R&D efforts in key technologies for IP video and communications, while utilizing formal and *de facto* industry standards whenever possible.

Product Range

DVEO provides broadcast-quality IP video encoders and transcoders, decoders, media servers and ad insertion solutions, together with patented and award winning IP gateway technology ensuring error-free real-time video delivery over UDP. The DVEO solutions enable multi-screen service delivery to any device, anytime, anywhere in the world. Deployment models include turnkey installations and cloud-based service delivery.

All solutions are built on Linux OS and Intel Xeon-based platforms to ensure 24x7 reliability, and feature DVEO-developed software for maximum flexibility and upgradability, ensuring long term investment protection.

These ultra-reliable products are matched by valuable pre-sales consultancy, outstanding post-sales service and support, and – not least – unusual affordability.

Worldwide Customer Base

Customers include ABC, CBS, Fox, NBC, PBS, Sinclair Broadcast Group, Time Warner, Arris, Cisco, Harmonic, Intel, Lightsquared, and Sony. In fact, most major broadcasting organizations worldwide have become our valued customers over the years, together with trail-blazing IP video operators. From traditional broadcasting to the demands of leading-edge IPTV and OTT, we stay at the forefront of the digital and IP video revolution to ensure that our customers can improve their competitive positioning and market share.

Contact Us

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