



Fix Packet Loss and Deliver Error-free Real-time IP Video via DOZER™ ARQ Automated Packet Recovery Technology



Executive Overview

August 2016

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Executive Summary: The Problem



- Streaming Live Video over the Internet seems a compelling proposition with great potential pay-offs
 - Major cost savings compared to fixed/managed networks
 - Will eliminate need for satellite transmission, and widespread adoption could diminish need for CDNs
 - Reach clients anywhere reliably
- BUT: Real-time video is *extremely time sensitive*
 - Even low rates of packet loss or delays will cause artifacts
 - TCP/IP: Not designed for the real-time demands of video
 - UDP: Great protocol for live video but no packet recovery
- Goal: Add TCP-like robustness to UDP – without the overhead

Executive Summary: The Solution



- DVEO-developed, patented*) and automated *ARQ technology* adds robustness to UDP and automatically fixes packet loss
- DOZER™ ARQ delivers live video over UDP over any IP network
 - Smooth error-free video, without stutter and rebuffering
- DOZER: Apply it to a multitude of uses to save big money
 - DOZER + the Internet can replace managed networks
 - Streaming studio quality live news and sports events over the Internet – error-free, maintaining the original quality
 - Point-to-multipoint delivery saves on satellite/fiber cost
 - Large-size file transfers go much faster compared to TCP/IP
- DOZER ARQ: Several HW versions and also a SW SDK/License
 - Option in DVEO encoders, streamers and media servers

*) 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”

STREAMING VIDEO – CHALLENGE, PROTOCOLS, PACKET LOSS

Streaming Video – The Challenge



- Live video delivery over the Internet has great potential
 - Much lower transmission cost than dedicated networks
 - Greater reach – to any user or location anywhere on earth
- Live video over the Internet presents technical challenges
 - Real-time video is *extremely time sensitive*
 - Factors such as packet loss and delays, jitter, and network latency affect the quality of streaming (real-time) video
 - Even small packet delivery irregularities cause visible artifacts and prevents a broadcast quality user experience

What Causes Packet Loss?



- IP networks subject video streams to various transport issues
 - Issues may occur even if network hardware and software is bug-free and the infrastructure is otherwise perfect
- The most serious issue is link congestion, which may result in:
 - Packet Loss: The packet does not arrive at all
 - Packets Out of Sequence: Arriving in the wrong order
 - Packet Delay Variation (PDV): Variations in arrival time
 - PDV is often referred to as “jitter”
 - Defined as variations in network latency, i.e. variable end-to-end delay instead of constant latency
 - Leads to variations in the delay between received packets
 - Video playback experiences gaps due to delayed or lost packets
 - Often a result of long distances and multi-network “hops”

Streaming Video – Protocols



- Best protocol for real-time video transmission: UDP
- User Datagram Protocol
 - Core member of the [Internet Protocol suite](#)
 - Designed for time sensitive applications: live video, VoIP
 - Originally intended for uncongested networks
- UDP characteristics
 - Stateless and connectionless transmission model
 - Minimum overhead and latency, essential for live video
 - No inherent packet recovery mechanism – stays nimble
 - Avoids overhead of recovery processing at network interface level
 - But no guarantee of delivery, ordering, or duplicate protection
 - Robustness becomes a higher level protocol or application responsibility

So Why Not TCP/IP?



- TCP/IP offers built-in packet loss recovery by design
 - Originally designed for data applications: email, web
 - Focus on delivery of every packet, however long it takes
 - Slows throughput when detecting network congestion
- TCP/IP recovers lost packets by resending them while reducing the transmission rate to let the network “catch up”
 - Not suitable for time critical applications such as live video

TCP/IP and UDP Comparison



TCP/IP

- **Type:** Connection-oriented protocol; it knows who the receivers are.
- **Reliability:** Guaranteed delivery of every packet; will retransmit if ACK not received within a defined time-out period.
- **Ordering:** Packets guaranteed to arrive in correct order.
- **Overhead:** Heavyweight protocol. Positive ACKs required for every packet (block) adds overhead, together with resend requests for lost and wrong-order packets.
- **Streaming:** Multiple packets per read call.
- **Routing Protocol:** Unicast only.
- **Uses:** World Wide Web, email, File Transfer Protocol (FTP), Secure Shell (SSH).

UDP

- **Type:** Connection-less protocol; it does not care who the receivers are.
- **Reliability:** No guarantee of delivery since there is no ACK mechanism; hence no retransmit if a packet is lost.
- **Ordering:** May arrive out of sequence, or duplicated; no automatic reordering.
- **Overhead:** Lightweight “fire and forget” design without requiring positive ACKs, and no connection tracking, keeps protocol nimble; ideal for real-time tasks.
- **Datagrams:** One packet per read call.
- **Routing Protocols:** Unicast and multicast.
- **Uses:** Streaming (real-time) media, live video, VoIP, online multiplayer games.

Congestion with TCP/IP and UDP Traffic



- When TCP/IP and UDP share a congested node, this happens:
 - When TCP detects congestion (packet time-outs), it slows down the transmission rate to let the network “catch up”
 - Packets are queued within a router buffer before being transmitted but if the buffer fills up, additional incoming packets will be dropped (whether TCP/IP or UDP packets)
 - Buffer only clears when all TCP/IP packets, queued ahead of any UDP packets, have been sent and acknowledged
 - UDP packets behind TCP/IP packets have to wait their turn
 - This wait can become too long for real-time video, which will suffer quality problems from lost or delayed packets
- The Need: Improved UDP packet delivery mechanism without the fixed TCP/IP overhead, i.e. a UDP protocol add-on

FIXING PACKET LOSS: DVEO DOZER™ ARQ

What is ARQ?



- **ARQ** = **A**utomatic **R**epet re**Q**uest, or **A**utomatic **R**epet **Q**uery
 - Dynamic Error Correction with lowest possible latency
- Designed for real-time applications, especially Live Video
 - Perfect complement to UDP, a video centric protocol
- UDP + ARQ = Automatic packet recovery utilizing variable and adaptive packet processing unlike TCP/IP's fixed overhead
- The enabler of reliable video delivery over the Internet

- DOZER ARQ (Automatic Repeat reQuest) delivers real-time video error-free over unreliable network segments



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



- DVEO patented ARQ packet recovery algorithms will fix UDP packet loss, correct for jitter, de-duplicate and reorder packets
- Robust: Reliable MPEG-2, H.264, H.265 (SPTS/MPTS), and file delivery
 - Flexible: Point-to-point or point-to-multipoint functionality
 - Secure: All transmissions are AES-128 encrypted by DOZER ARQ
 - Remote Management: SNMP, and secure web access (SSH)
 - In use by hundreds of DVEO clients 24x7x365 around the world

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, or bursty fiber,
while Saving Big \$\$\$
compared to traditional alternatives

DOZER ARQ: Versions and Options



➤ Hardware agnostic, software-based platform, offered as:

- **DOZERbox™ IP/IP + AES128** compact box (7.5" wide)
- **DOZER Racks™ IP/IP** (1 RU)
- **DOZER Racks™ IP/IP: TELCO** (1 RU)
 - Redundant power supplies and ports
- **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 an available option in DVEO IP video encoders and transcoders, streamers, media servers and decoders



➤ DVEO Hardware: Ultra reliable and CAPEX/OPEX friendly

- Linux OS on Intel platforms for 24/7/365 uptime
- Easy to configure and operate: “Set and Forget!”



Fix Packet Loss: DOZER ARQ Features



- Layer 2 packet retransmission methodology, developed and patented by DVEO, to enable error-free real-time video
- Minimum protocol overhead = lowest possible latency
 - Transmit data
 - Receiver sends negative ACKs to indicate missing packets
 - Fast re-transmit of missing packets keeps Live Video live!
 - Automatic packet de-duplication and reordering
 - Guaranteed delivery without the overhead of TCP/IP
- Dynamic DOZER buffer auto-adjusts to network conditions
 - Monitors round trip time between the two end-points
 - Maintains a buffer of optimal size to recover from any packet loss up to 50% or more

More 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



APPLICATIONS

DOZER ARQ Application Versatility



- Optimizes throughput for any link, latency and network type
 - High speed point-to-point fiber connections
 - Congested internet links
 - Lossy Wi-Fi and Microwave links
 - Even very high-latency satellite connections
- No lower or upper boundary in latency, i.e. buffer size, or packet recovery amount
 - Boundaries predetermined by the round trip packet travel time and available bandwidth
 - Real-time buffer adjusts to changing network conditions
- No. of DOZER Transmitters and Receivers controlled by SW
 - Very flexible DOZER ARQ video distribution combinations

DOZER ARQ Application Examples

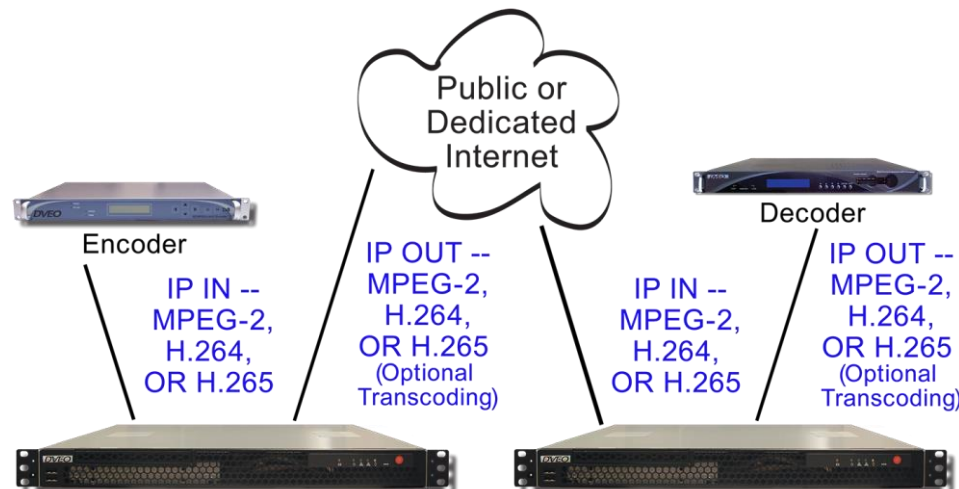


- Smooth, high quality video over any type of IP network
 - LAN, WAN or dedicated and conditioned networks
- Streaming studio quality live news and sports events over congested backbone networks – error-free
- Replace or complement costly managed networks
 - Studio-to-Transmitter Link, DSNG/Satellite Backhaul, etc.
- Multi-country delivery over networks of varying reliability
- Delivery multi-channel content via intercontinental sea cables
- Reliable content and VOD file transfers over long distances
 - DOZER-accelerated file transfers many times faster compared to TCP-based protocols
- Supports both point-to-point and point-to-multipoint delivery

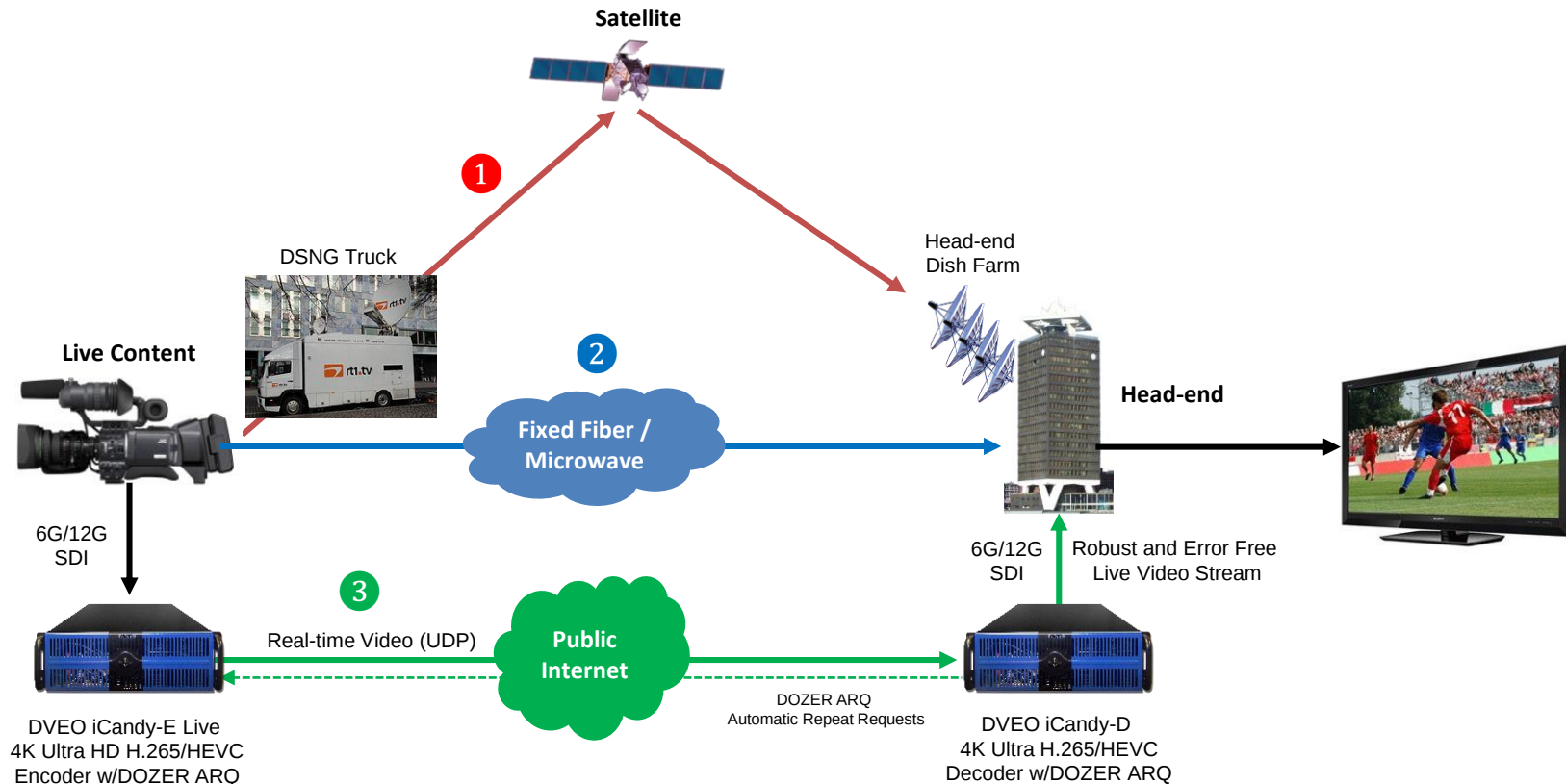
Point-to-Point Content Delivery



- Save money with DOZER video delivery over the Internet!
- Replace or complement 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



Example: Live Video Point-to-Point



1 = The Old Way: DSNG truck with uplink, expensive satellite bandwidth, Head-end dish farm, etc.

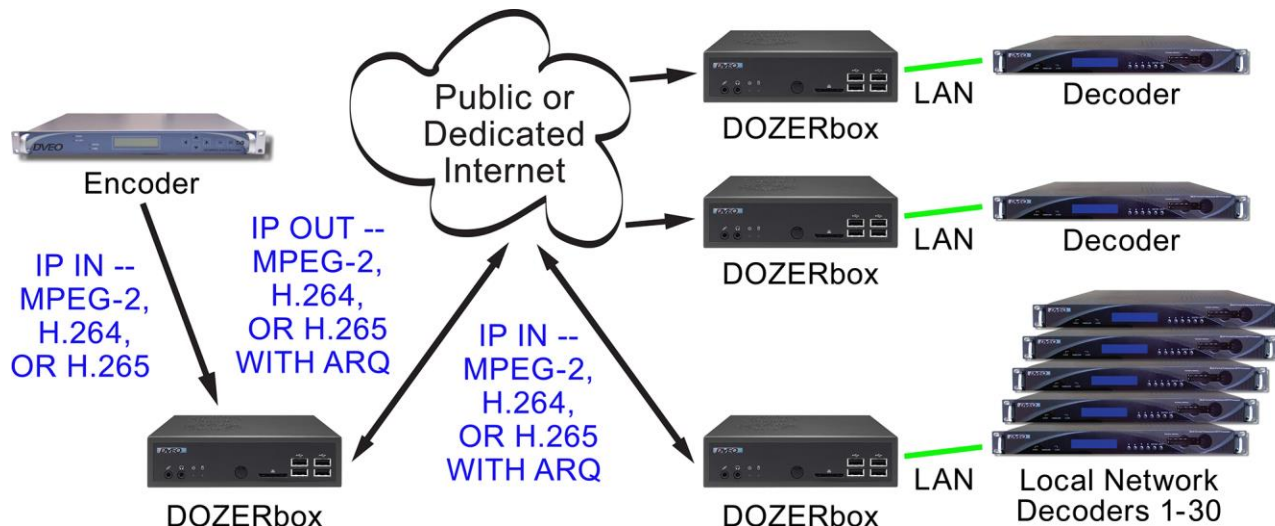
2 = Another Old Way: Costly fixed fiber, or microwave, or other dedicated or managed network

3 = The DOZER ARQ Way: Encoder with DOZER ARQ, UDP over the Internet, Decoder with DOZER ARQ Receiver

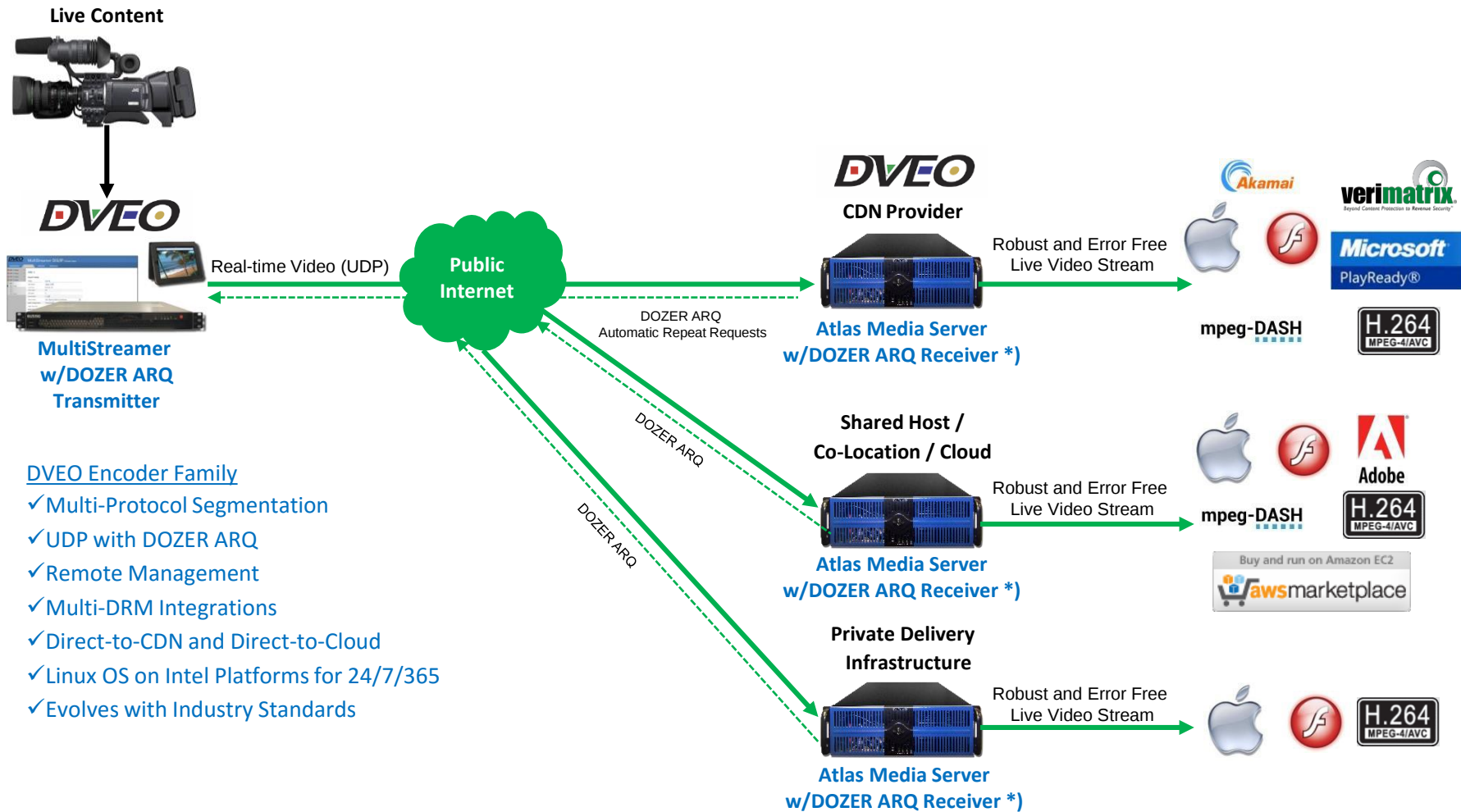
Point-to-Multipoint Content Delivery



- Replace expensive managed distribution networks, e.g.:
 - Multi-country / Multi-city / Multi-island distribution
 - Satellite One-to-Many Distribution Networks
 - Dedicated One-to-Many Fiber Links (One-too-Many!)
- Robust, error free live video for multi-CDN ingest
- Save \$\$\$ with DOZER ARQ video delivery over the Internet!



Example: Live Multi-CDN Distribution

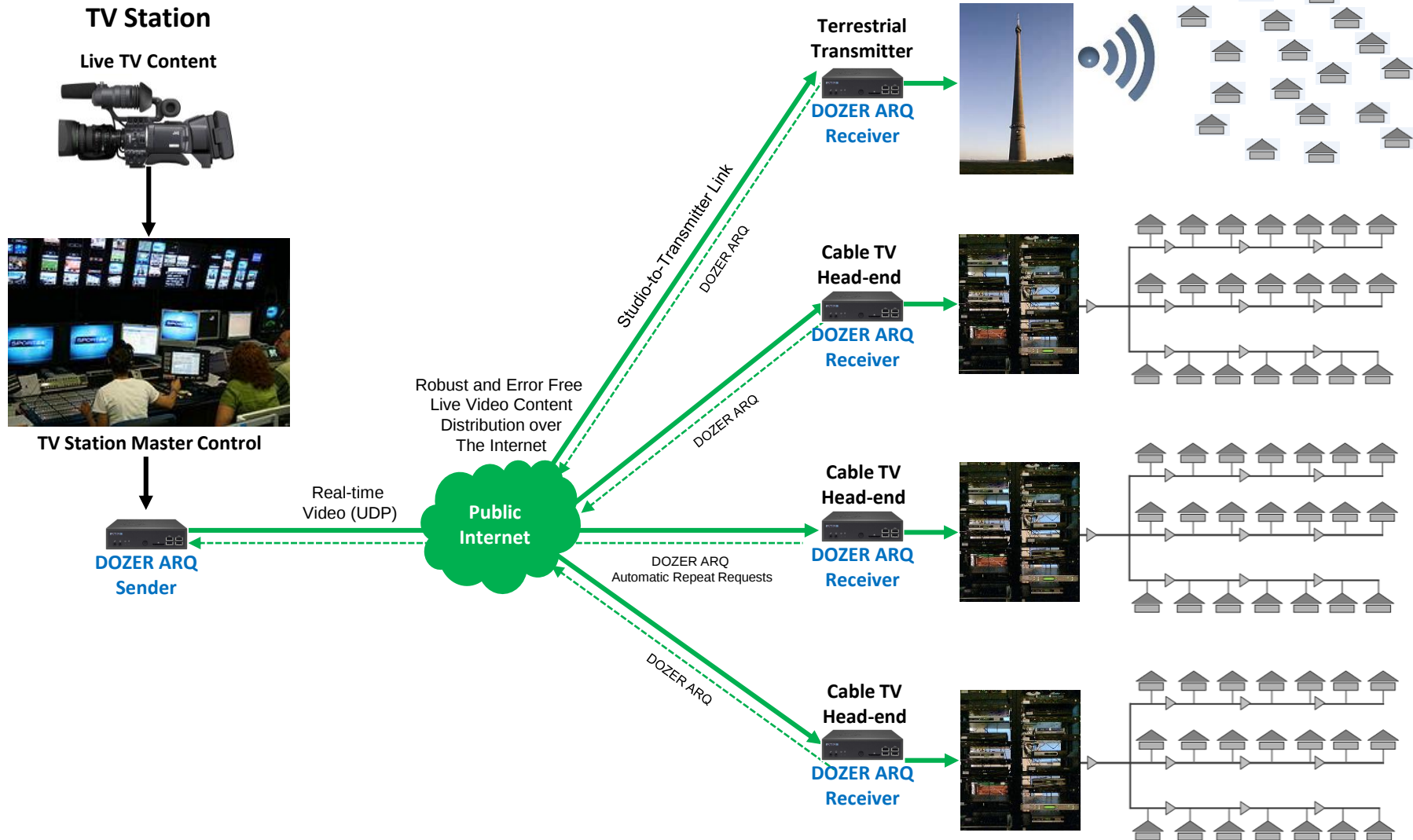


DVEO Encoder Family

- ✓ Multi-Protocol Segmentation
- ✓ UDP with DOZER ARQ
- ✓ Remote Management
- ✓ Multi-DRM Integrations
- ✓ Direct-to-CDN and Direct-to-Cloud
- ✓ Linux OS on Intel Platforms for 24/7/365
- ✓ Evolves with Industry Standards

*) Alt.: DVEO D-Streamer w/DOZER ARQ Receiver and third-party servers, or DOZER ARQ: LIC software license integrated in other devices

Live TV Content to Cable Head-ends



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DOZER ARQ Packet Recovery Multipath

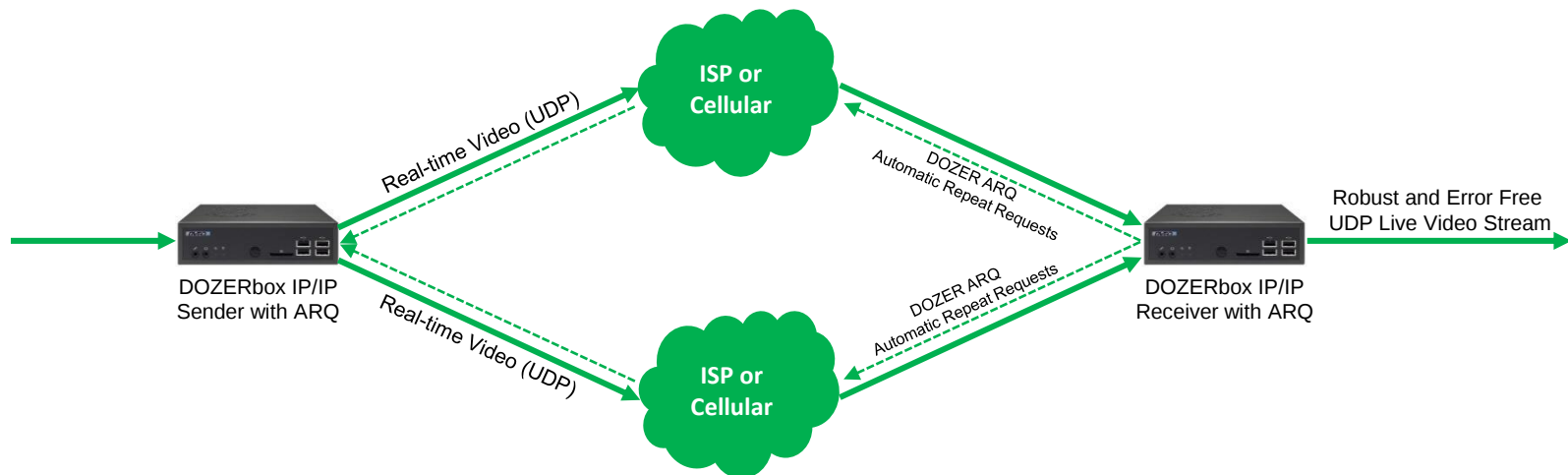


- Powerful packet de-duplication and reordering capabilities
- Possible to create multiple independent paths going from one DOZER ARQ transmitter to one DOZER ARQ receiver
 - The receiver will recombine the multiple streams properly even in case of complete duplication of streams, and different latency or bandwidths in the multiple paths
- In DOZER transmitter GUI, choose if a stream is going to be split as Load Balanced Stream (split) or as Duplicated Stream
 - For each, select a “weight” of the Secondary Stream compared to the Primary Stream

DOZER ARQ Multipath Use Cases



- Create an effective link across multiple cellular modem connections, or
- Create an active redundancy path on an internet link using two separate ISPs on one or both ends
- Whatever paths the packets take to arrive at the destination, the DOZER receiver will de-duplicate and reorder



Build a Virtual Managed Network

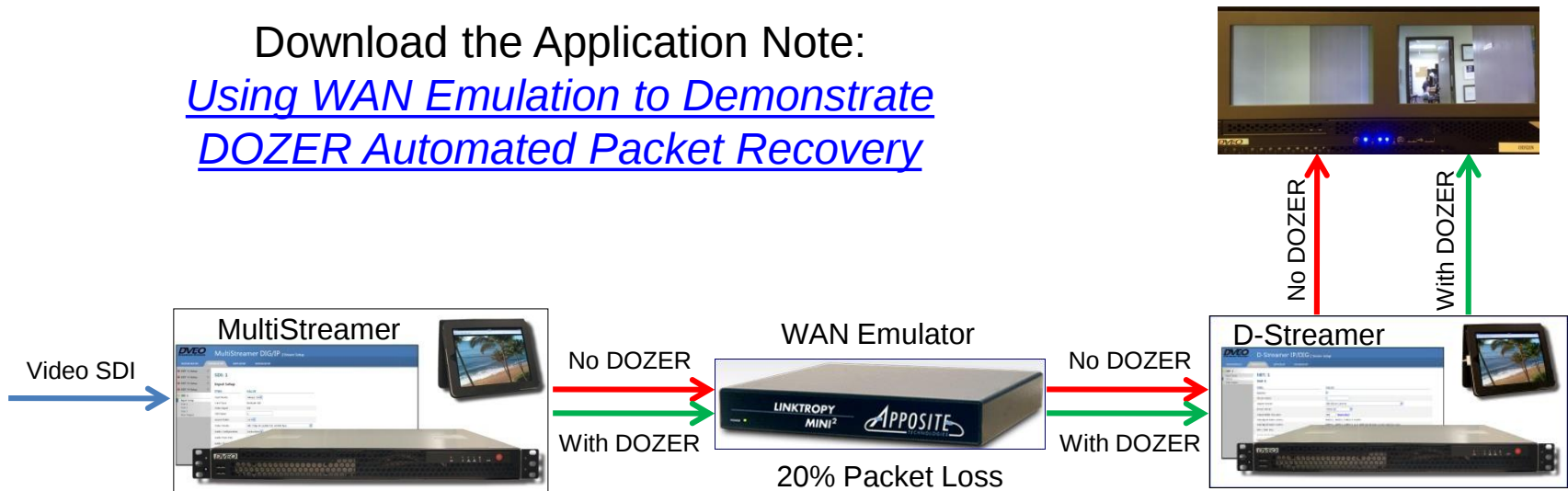


- The Multipath use cases demonstrate how multiple DOZER based routers can be combined to build low-cost:
 - Virtual Managed Networks (VMN)
 - (Private) Content Delivery Networks (CDN)
- The VMN can establish multiple primary and secondary paths using a combination of, for example:
 - Dedicated lines 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

DOZER ARQ: WAN Emulator Testing



Download the Application Note:
[Using WAN Emulation to Demonstrate DOZER Automated Packet Recovery](#)



- DVEO MultiStreamer and D-Streamer are both configured with DOZER software options.
- D-Streamer shows output streams from WAN Emulator dropping packets per packet loss and BER settings. Testing shows:
 1. First output stream, not using DOZER protection, shows video artifacts on the monitor.
 2. Second stream, which is DOZER enabled, recovers missing packets and plays video smoothly without any artifacts.
- The WAN Emulator packet loss was varied from 0.5% (starting to cause artifacts on the non-DOZER stream), up to 30%. In all cases the DOZER protected stream played perfectly while, as expected, the unprotected stream had issues from temporary artifacts at lower packet loss rates to becoming unwatchable as the packet losses percentage was increased.

Fix Packet Loss: DOZER ARQ Conclusion



- DOZER ARQ is cost-effective for a variety of deployment scenarios by making live video transmissions immune to:
 - Packet loss
 - 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:
 - Live broadcasting over the Internet
 - Live contribution feeds to TV stations, CDNs and uplinks
 - Replacement of costly managed networks
- Self-adjusting sub-second latency buffer makes DOZER the right choice regardless of challenging network conditions
- Save \$\$\$ with DOZER ARQ video delivery over the Internet!

Next Steps: Get Your



- Contact DVEO to learn more and get a quote
 - Call +1 858 613-1818 to discuss your actual requirements
- Application Note: [Using WAN Emulation to Demonstrate DOZER Automated Packet Recovery](#)
- Available: DOZERbox loaner pair for 30-day trial
 - “Try before you buy”
 - Fix packet loss now!
- Join the ranks of satisfied DVEO and DOZER customers!
- Coming soon: DOZER Users Group





Thank You!

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- Strong supplier to broadcasters, cable, satellite, IPTV & OTT operators globally with well-priced technology and client-first customer care



- Leader in Linux® based Video Encoding and Transcoding, Grooming and Streaming, Ad Insertion, Transport Stream Analysis, niche Test Equipment



Patented IP video smoothing via UDP ARQ Automated Packet Recovery

- Winner of SBE Technology Award 2014 with DOZER IP/IP™

Strength from Within – Here to Stay



➤ Firm Financial Foundation

- Privately held and self funded
 - No outside investors or financial partners; no debt
- Profitable since inception



➤ Talented Team

- 4 Teams with Graduate Degrees
 - 20 staff: 14 in San Diego + offices in Florida, Princeton NJ and Boston MA



➤ Blue Chip Customer Base

- Broadcasters, manufacturers, and systems integrators, e.g.:
 - ABC, CBS, Fox, NBC, PBS, Sinclair Broadcast Group, Time Warner
 - Arris, Cisco, Harmonic, Intel, Lightsquared, Sony
- IPTV and OTT operators across USA, Europe, Middle East

➤ DVCare™ Extended Warranty & Customer Care Plans

- Peace of mind and Priority Support

