Perfect Transport of Real-time Video and Data Over *any* IP Network:
DOZER™ ARQ Automated Packet Recovery Protocol

Protocol and Use Cases
April 6, 2017 (v4.5)
Growth of Global Internet Video

- Globally, Internet video traffic will grow 4-fold from 2015 to 2020, a compound annual growth rate of 31%
- Globally, Internet-Video-to-TV traffic will increase 4-fold between 2015 and 2020 (29.3% CAGR)

Source: Cisco VNI Forecast and Methodology, 2015-2020
Globally, 3 trillion minutes (5 million years!) of video content will cross the Internet each month in 2020.

So: What does Everybody Need...?
Reliable Real-Time Video Transport!

Not this!  This!

Video Protected by DVEO

Eliminates Packet Loss & Jitter For Any Bitstream
Everybody Needs: **Reliable Video Transport over the Internet!**

- No Packet Loss
- No Jitter
- Built-in Multipath Routing
- AES-encryption for Secure Transmission

Who Would Benefit?

- Real-time Video (UDP)
- Public Internet
- DOZER Rack IP/IP Transmitter with ARQ
- Virtual DOZER Tunnel
- DOZER Rack IP/IP Receiver with ARQ
- Live Video
- Perfect Live Video Stream
Beneficiaries of

Reliable Video Transport over the Internet

- Cable, IPTV and OTT Operators
- Live Event Producers and Electronic News Gathering
- Studios, Content Providers and Aggregators
- Special-interest Content Producers and Distributors
- Enterprises
- Education and Government Institutions

→ How can that be Achieved?
Moving Live Video the Traditional Way

- Live content sent to studio via costly (occasional-use) link:
  ① Satellite, or ② Microwave, or ③ Dedicated Line
- Production video distributed to viewers and business partners
- B2B via managed networks: Affiliates, cable/IPTV head-ends
- CAPEX and OPEX intensive
Moving Live Video the DVEO Way

- Live content transmitted to studio flawlessly over the Internet
  - DVEO DOZER™ ARQ Protocol ensures Perfect Picture
  - Video transport at fraction of occasional-use link cost
- Production video distributed over the Internet: OTT and B2B
- Faster and easier while also CAPEX & OPEX friendlier
Reliable Transmission of Live, Studio-Quality

UDP Video over the Internet

(and other unreliable data links),

maintaining the Ingested Video Quality 100%

while Saving Big $$$ (and Time too)
Next Steps: Get Your

- Call +1 858 613-1818 to discuss your actual application
- Learn about DOZER ARQ Patent Licensing
- Available: DOZER loaner pair for 30-day evaluation
  - Choose between DOZERbox or DOZER Rack IP/IP + AES128
    - “Try before you buy”
    - Fix UDP packet loss now!
    - Deliver gorgeous video every time
- Join the ranks of satisfied DVEO and DOZER customers!

www.dveo.com

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DVEO DOZER™ ARQ:
FLAWLESS REAL-TIME DATA TRANSMISSION

Winner of Society of Broadcast Engineers (SBE)
Technology Award 2014 for
DOZER IP video traffic smoothing technology
The Ideal-World Business Proposition

- Streaming Video over the Internet and private IP networks:
  - A compelling proposition with great potential pay-offs
  - Reach anybody anywhere around the globe
  - Big savings compared to fixed links and managed networks

1011000101110

Internet or IP Network

1011000101110
The Real-World Technical Proposition

- Real-time video is extremely time sensitive
  - Even low rates of packet loss or delays will cause problems

- Protocols
  - TCP/IP: Not designed for the real-time demands of video
  - UDP: Real-time protocol but no built-in packet recovery

- The Need
  - UDP with TCP-like robustness but without the fixed TCP/IP overhead = “Reliable UDP”
DOZER ARQ (Automatic Repeat reQuest) delivers real-time video and data error-free over unreliable network segments.

- DVEO patented ARQ protocol will:
  - Fix UDP packet loss
  - Correct for jitter
  - Discard duplicate packets, and
  - Reorder packets that arrived out of sequence

- Built-in Multipath Routing
DVEO-patented*) dynamic, low-latency ARQ protocol adds reliability to UDP and automatically fixes packet loss

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 – flawlessly, maintaining the ingested quality
- Point-to-multipoint delivery saves on satellite/fiber cost


DOZER ARQ = Awesome – Reliable – Quality
What is ARQ?

- ARQ = Automatic Repeat reQuest, or Automatic Repeat Query
  - ARQ protocols aim to guarantee delivery of every packet
- Some variants not intended for real-time applications
  - Packet recovery overhead is too great for streaming video
- Selective Repeat ARQ / Selective Reject ARQ
  - Dynamic Error Correction with lowest possible latency
  - Use of Negative ACKs and single packet retransmission
  - Designed for real-time applications
  - Pairs perfectly with UDP, designed for real-time demands
- UDP + ARQ = Automatic packet recovery utilizing variable and adaptive packet processing unlike TCP/IP’s fixed overhead
  - Enables real-time data transport over any IP network
Fix Packet Loss: DOZER ARQ Protocol

- OSI Layer 2 packet recovery methodology, developed and patented by DVEO, to enable *flawless real-time* data delivery
- Minimum protocol overhead = lowest possible latency
  - Transmit data
  - Receiver sends Negative ACKs to indicate missing packet(s)
  - Fast re-transmit of missing packet(s) keeps Live Video live!
  - Automatic packet de-duplication and reordering
  - Guaranteed data 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
Who Benefits from DOZER ARQ?

- Cable, IPTV and OTT Operators
- Live Event Producers and Electronic News Gathering
- Studios, Programmers, Content Providers and Aggregators
- Special-interest Content Producers and Distributors
- Enterprises
- Educational Institutions
- Government

⇒ Anybody concerned with High Costs and Inflexibility of typical Occasional-use and Managed Networks
Hardware agnostic, cross-platform protocol, offered as:

- **DOZER™ ARQ: LIC** – SDK/Permanent Software License
  - For integration in third-party devices: encoders and transcoders, decoders, streamers, routers, CDN media servers, IP gateways, etc.

- **DOZER™ Rack IP/IP + AES128** – 1 RU

- **DOZER™ Rack IP/IP: TELCO**
  - 1 RU, with Redundant Power Supplies and Ports

- **DOZERbox™ IP/IP + AES128** compact box
  - Easy to transport and install – Perfect for field-use

DVEO-Embedded DOZER ARQ options:

- DOZER ARQ embedded in **ARQ Link™** Encoders/Decoders
- Option in other DVEO **video encoders and transcoders**, streamers, **media servers** and decoders
DOZER is:

- **Robust**: Flawless MPEG-2, H.264, H.265 (SPTS/MPTS) and File Delivery
- **Cross-platform**: SDK and Permanent License for Linux and Windows
- **Flexible**: Point-to-point or Point-to-multipoint Functionality
- **Secure**: Transmissions are AES-128 Encrypted by DOZER
- **Remote Management**: SNMP, and Secure Web Access (SSH)
- **Easy to Configure**: “Set-and-Forget!”
- **CAPEX and OPEX Friendly**: No Annual or Usage Fees
- **Proven**: Used by hundreds of DVEO clients 24x7x365 around the world

DOZER = *The Real-time Video over IP Game Changer!*
DOZER Transmitter Tasks

- Accept incoming datagrams from external data source
- Tag each of the datagrams with two pieces of additional information:
  - A Sequence Number, and
  - A Virtual Packet Size, consisting of a specific number of bytes required to fill a private data line, or a set of point-to-point virtual circuits, of a predefined bitrate capacity set by the user, in a time equal to an inter-packet interval between the datagrams.
- Store each of the tagged datagrams
- Transmit the tagged datagrams to a Virtual DOZER Tunnel
- Upon receiving a Negative ACK notification, re-transmit a specific datagram as stored earlier

DOZER Receiver Tasks

- Receive, from the Virtual DOZER Tunnel, datagrams transmitted by DOZER Transmitter
- Detect, based on Sequence Number, loss of one or more datagrams, and send Negative ACK notification
- Insert datagrams received into a buffer based on Sequence Number with the exclusion of any duplicate datagrams received
- Maintain the buffer at a limited size by releasing datagrams from the buffer on a FIFO (first-in, first-out) basis, at a rate determined by the Virtual Packet Size and a user-determined fixed delay and the predefined bitrate capacity
- Remove the Sequence Number and Virtual Packet Size from released datagrams
- Output released datagrams to external target application/device
1. The protocol implements a method for preservation of the instantaneous bitrate and packet spacing for transmission with zero-added-jitter without relying upon the datagram contents, while adding a pre-configured time delay for error correction of OSI model Layer 2 datagrams. It does this between two edge network devices connected over packet switched networks with varying error rate and latency.

2. The protocol works at Layer 2*) and can transport any type of UDP data including standard MPEG-2 Transport Stream (TS).

3. The protocol, when used for MPEG-2 TS transmission, does not rely upon the embedded Program Clock Reference (PCR) of the TS like other techniques do. Therefore, it is not susceptible to glitches caused by normal discontinuities and jumps in the PCR timestamps, which otherwise are common.

4. The protocol works only on Layer 2, like a switch. It does not modify, inspect or rely upon the contents of the packets for its error correction, interpacket spacing, or instantaneous bitrate preservation.

*) Compare to protocols implemented at Layer 3 of the OSI model:
Such a protocol must be targeted at the specific Layer 3 UDP data format and is often restricted to a particular transmission format; in most cases MPEG-TS.

The DOZER protocol is implemented at Layer 2, which is the most flexible approach to transmit video and data. The nature of the underlying datagrams can be ignored making it possible to transmit any stream independent of its format.
<table>
<thead>
<tr>
<th>Protocol Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guarantees error-free real-time video transport on DOZER ARQ protected network segments</td>
</tr>
<tr>
<td>Uses patented and highly sophisticated ARQ management algorithms to optimize UDP video that traverses congested switches and routers</td>
</tr>
<tr>
<td>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</td>
</tr>
<tr>
<td>DOZER ARQ protocol eliminates packet loss and corrects for jitter and packet reordering</td>
</tr>
<tr>
<td>Supports HD and SD MPEG-2, H.264 and H.265 Transport Streams, SPTS and MPTS</td>
</tr>
<tr>
<td>Supports IP UDP unicast and multicast, in or out</td>
</tr>
<tr>
<td>Will not alter the internal structure of the transport stream (PAT, PMT, etc.)</td>
</tr>
<tr>
<td>Underlying traffic is AES-128 encrypted by DOZER, but not examined</td>
</tr>
<tr>
<td>All inter-DOZER communication is AES encrypted</td>
</tr>
<tr>
<td>Dynamic DOZER buffer auto-adjusts to network conditions, and maintains a buffer of optimal size to recover from packet loss up to 50%</td>
</tr>
<tr>
<td>Inputs/Outputs: 2 each Gig/E ports</td>
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<tr>
<td>Configurable destination port on listener for firewall traversal</td>
</tr>
<tr>
<td>Can be configured for point-to-point or point-to-multipoint functionality</td>
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<tr>
<td>Supports up to four destinations in primary-backup or split transmission configuration for redundant or load balanced setups</td>
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<tr>
<td>Each device configurable as a sender, receiver, or both</td>
</tr>
<tr>
<td>One DOZER transmitter can send 50+ streams to up to 32 different DOZER receivers</td>
</tr>
<tr>
<td>Each receiver device can output UDP on a local network to one or many different devices using second Ethernet port on unit</td>
</tr>
<tr>
<td>DOZER Transmitter-Receiver connections are authenticated with user name and password for additional security</td>
</tr>
<tr>
<td>Faster content and VOD file transfers over long distances compared to TCP-based protocols</td>
</tr>
<tr>
<td>Remote Management: SNMP, SSH</td>
</tr>
<tr>
<td>UDP packets may contain arbitrary data</td>
</tr>
</tbody>
</table>
Applications where the low-latency DOZER ARQ protocol is a great tool to overcome unreliable links and ensure flawless video transport:

1. Reliable Content Transport over the Internet
2. Long Distance Content Transport – Intercontinental and Country-to-Country
3. Telco Grade Media Delivery Networks
4. Internet TV
5. Flawless Live Events Contribution Video Transport for CDN or Studio Ingest
6. (Private) CDNs and Virtual Managed Networks using the Internet
7. Broadcast Quality Studio-to-Transmitter Links and Studio-to-Affiliate Interconnects
8. Backup or Substitute for Managed Networks and Satellite Links
9. Global and Enterprise HD Content Delivery
10. Integrated Live, Recorded and File-Based Communications
11. Health Care, e.g. Video-based Collaboration including Tele Surgery
12. Video Conferencing
13. Internet Video Gaming
14. VoIP
15. And more
USE CASES

DOZER™ ARQ
Eliminates Packet Loss & Jitter For Any Bitstream
Point-to-Point Content Delivery

- Save money with DOZER video transport over the Internet!
- Replace or complement point-to-point managed networks:
  - Microwave and other Studio-to-Transmitter Links (STL)
  - DSNG, Satellite Backhaul and Occasional-use Networks
  - Dedicated point-to-point Fiber Links
- High quality, error free live video for CDN ingest
Live Video Contribution

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

2️⃣ = Another Old Way: Costly dedicated line or microwave transmission

3️⃣ = The DVEO Way: Encoder with DOZER ARQ, transmit UDP over the Internet, Decoder with DOZER ARQ Receiver
“I installed the DOZER system as a backup STL to protect my leased lines. The ASI transport is accurate and very reliable. The DOZER system makes the Internet act like a leased line and saves considerable money in the process. I will be ordering another system for a different station very soon.”

Peter A. Douglas, Director of Engineering, NRJ/Titan Broadcast Group (USA)
STL via Microwave with DOZER ARQ

- Contribution microwave link for DVB-T2 transmitters between two islands
- Tx and Rx are separated by 40 miles of sea
- While the microwaves were powerful enough to transmit the signal, the operator experienced packet loss because of the sea interference
- By adding a pair of DOZERs inbetween, the problem was solved
IPTV operator in New Caledonia (S. Pacific) sources 25 channels from Paris – H.264/AVC
Transcoded to H.265/HEVC in Paris, saving 50% of bandwidth for long haul transport
Longhaul multi-network content transport (14,000 miles!) protected by DOZER ARQ
Content received flawlessly at the INTERNETNC NOC in Noumea, New Caledonia
Content transcoded back to H.264/AVC and streamed to viewers’ IP-STBs
Viewers enjoy perfect video quality
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-to-Many!)
- Flawless live video for (multiple) CDN ingest
- Save $$$ with DOZER ARQ video transport over the Internet!
Live Multi-CDN First-Mile Contribution

Live Content

MultiStreamer w/DOZER ARQ Transmitter

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

Public Internet

DOZER ARQ

Perfect Live Video Stream

Atlas Media Server w/DOZER ARQ Receiver *)

Shared Host / Co-Location / Cloud

DOZER ARQ

Perfect Live Video Stream

Atlas Media Server w/DOZER ARQ Receiver *)

Private Delivery Infrastructure

DOZER ARQ

Perfect Live Video Stream

Atlas Media Server w/DOZER ARQ Receiver *)

*) 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 – “London to Africa”

LONDON: Live Event
MultiStreamer DIG/IP w/DOZER ARQ Transmitter

Public Internet

AFRICAN COUNTRIES - DISTRIBUTION LOCATIONS:
D-Streamer Decoder w/DOZER ARQ Receiver

Terrestrial and Cable Head-end: Re-broadcasting
Live/Linear Content to Cable Head-ends

TV Station
- Live Content
- Master Control
  - H.264/AVC
  - H.265/HEVC
- DOZER Rack IP/IP Transmitter with ARQ
- Playout Server

Public Internet
- Live Video (UDP)
- DOZER ARQ
- ARQ Selective Repeat Requests

Cable TV Head-end
- DOZER Rack Receiver w/ARQ
- DOZER ARQ

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Content to Cable Head-ends + Transcoding

TV Station

Live Content

Master Control
H.264/AVC
H.265/HEVC

DOZER Rack IP/IP Transmitter with ARQ

Playout Server

Cable TV Head-end

Brutus I:
DOZER RX &
H.264 to MPEG-2 Transcoding

Robust and Error Free Live Video Content Distribution over The Internet

Public Internet

Live Video (UDP)

DOZER ARQ

ARQ Selective Repeat Requests

DOZER ARQ

DOZER ARQ

DOZER ARQ
DOZER ARQ takes the encoded output, transmits video UDP error-free over the Internet to multiple transmitter sites, where the DOZER ARQ Receiver passes the video to the transmitter for broadcasting in the local coverage area.

“I installed the DOZER system as a backup STL to protect my leased lines. The ASI transport is accurate and very reliable. The DOZER system makes the Internet act like a leased line and saves considerable money in the process. I will be ordering another system for a different station very soon.”

Peter A. Douglas, Director of Engineering, NRJ/Titan Broadcast Group (USA)
Live/Linear Content to Affiliate Stations

TV Station
- Master Control
  - H.264/AVC
  - H.265/HEVC
- DOZER Rack IP/IP Transmitter with ARQ
- Playout Server
- Live Content

Public Internet
- Live Video (UDP)
- Robust and Error Free Live Video Content Distribution over The Internet

Affiliate 1
- DOZER Rack Receiver w/ARQ

Affiliate 2
- DOZER Rack Receiver w/ARQ
- ARQ Selective Repeat Requests

Affiliate 3
- DOZER Rack Receiver w/ARQ

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www.dveo.com
Affiliates/Primary Station Interconnects

TV Station

- Master Control
- DOZER Rack IP/IP Receiver with ARQ

Public Internet

Robust and Error Free Live Video Content Distribution over The Internet

Live Video (UDP)

Affiliate Stations

- Live Content
- DOZER Rack Transmitter w/ARQ
- ARQ Selective Repeat Requests
- DOZER ARQ

Live Video (UDP)

- Live Content
- DOZER Rack Transmitter w/ARQ
- DOZER Rack Receiver w/ARQ
Terrestrial Content Distribution

Teleport

HD-SDI/SDI/ASI

DOZER Rack IP/IP Transmitter with ARQ

Real-time Video (UDP)

Robust and Error Free Live Video Content Distribution over The Internet

DOZER ARQ

DOZER Rack Receiver w/ARQ

Affiliate 1

DOZER ARQ

ARQ Selective Repeat Requests

DOZER Rack Receiver w/ARQ

Affiliate 2

DOZER Rack Receiver w/ARQ

Affiliate ‘N’

DOZER Rack Receiver w/ARQ

Public Internet

Affiliate 1

Affiliate 2

Affiliate ‘N’

DOZER Rack IP/IP Transmitter with ARQ

DOZER ARQ
KVZK-TV uses DVEO equipment to distribute content to the 5 main islands:

“Our TV network was having major inter-island communications issues with IPTV. The DVEO encoders with built in DOZER ARQ saved us large amounts of money by not having to use Satellite Links between islands.”

Daniel Langkilde, Director, KVZK-TV, American Samoa
Multipoint Reception to Single Point

APPLICATION
- Monitoring and Archiving of National or Regional OTA Broadcasting
- Reception and Transcoding at Regional Input Points
- Streams are Protected by DOZER and AES-128 Encrypted
- Archiving Data Center Receives and Decodes Streams for Storage

EQUIPMENT AND FUNCTIONS
- GEARBOX: DVB-T/RF Input + Transcoding + DOZER Sender
- DOZER ARQ: Automatic Packet Recovery + AES-128 Encryption
- STREAMBUCKET: DOZER Receiver + Archive Video
- ATSC/8VSB or ISDB-T can be substituted for DVB-T in GEARBOX

CDN or the Internet

Large Scale Storage Array

DVEO StreamBucket with DOZER ARQ Receiver

DVEO Gearbox IRD & Transcoder with DOZER ARQ Transmitter

INPUT POINT #1

INPUT POINT #2

INPUT POINT #N
Network diversity is supported by DOZER through powerful packet de-duplication and reordering capabilities

Possible to create **multiple independent paths** 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

DOZER Transmitter GUI: Select whether a stream is to be sent as Load Balanced Stream (split) or as Duplicated Stream
Two scenarios for network diversity:

1. Create an effective (virtual) link across multiple cellular modem connections for load balancing and maximum throughput
2. Create an active redundancy path using two separate ISPs (on one or both ends), and transmit packets in duplicate across both links

Whatever paths packets take to the destination, the DOZER Receiver will de-duplicate and reorder packets on-the-fly
Fast Massive File Transfers

- Massive file transfers over unreliable and multi-hop networks go much faster with DOZER compared to using TCP/IP
- The TCP/IP windowing mechanism will slow down transfers when packet loss is detected
- DOZER literally bulldozes through congested networks
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

A corporate VMN can be an order of magnitude more cost effective when compared to third-party CDNs, managed and conditioned networks
Each Origination Point may address more than one End Point for content distribution.
Mesh: Multipoint to Multipoint

- Each DOZER unit can double as both Transmitter and Receiver in a multipoint to multipoint deployment
- Each unit can transmit to and receive from 32 other units within the total bandwidth capacity
- Mesh topologies enable maximum throughput and reliability
Any Network Type

- Optimizes throughput for any link, latency and network type
  - High speed but bursty fiber connections
  - Congested unmanaged IP network links
  - Lossy Wi-Fi and microwave links
  - Even 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
  - Self-adjusting sub-second latency buffer: DOZER ARQ is the right protocol regardless of prevailing network conditions
Application Summary

- 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 – flawlessly
- Replace or complement costly managed networks
  - Studio-to-Transmitter Link, DSNG/Satellite Backhaul, etc.
- Multi-country delivery over networks of varying reliability
- DOZER-accelerated file transfers over long distances
- Point-to-point and point-to-multipoint transport
DOZER ARQ protocol is cost-effective for various deployment scenarios by making real-time applications immune to:

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

Save $$$ with DOZER ARQ
Video Transport over the Internet!
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.
Next Steps: Get Your

- Call +1 858 613-1818 to discuss your actual application
- Learn about DOZER ARQ Patent Licensing
- Available: DOZER loaner pair for 30-day evaluation
  - Choose between DOZERbox or DOZER Rack IP/IP + AES128
    - “Try before you buy”
    - Fix UDP packet loss now!
- Join the ranks of satisfied DVEO and DOZER customers!
- Download Application Note: *Using WAN Emulation to Demonstrate DOZER Automated Packet Recovery*
- Coming soon: DOZER Users Group
Awesome – Reliable – Quality

Thank You!

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STREAMING VIDEO – PRIMER ON PROTOCOLS AND PROBLEMS

internet or IP Network
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 Duplication: Same packet arrives twice
  - Packet Delay Variation (PDV), also known as “jitter”
    - Variations in network latency, i.e. variable end-to-end delay between received packets instead of constant latency
    - Video playback experiences gaps due to delayed or lost packets
    - Often a result of long distances and multi-network “hops”
  - Related problem: Packet arrives but data is corrupted
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: Higher level protocol or application task
Why Not TCP/IP?

- TCP/IP offers built-in packet loss recovery by design
  - Originally designed for data applications: email, web, FTP
  - Focus on delivery of every packet, however long it takes
  - Slows throughput when network congestion detected

- 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

<table>
<thead>
<tr>
<th>TCP/IP</th>
<th>UDP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type:</strong> Connection-oriented protocol; it knows who the receivers are.</td>
<td><strong>Type:</strong> Connection-less protocol; it does not care who the receivers are.</td>
</tr>
<tr>
<td><strong>Reliability:</strong> Guaranteed delivery of every packet; will retransmit if ACK not received within a defined time-out period.</td>
<td><strong>Reliability:</strong> No guarantee of delivery since there is no ACK mechanism; hence no retransmit if a packet is lost.</td>
</tr>
<tr>
<td><strong>Ordering:</strong> Packets guaranteed to arrive in correct order.</td>
<td><strong>Ordering:</strong> May arrive out of sequence, or duplicated; no automatic reordering.</td>
</tr>
<tr>
<td><strong>Overhead:</strong> Heavyweight protocol. Positive ACKs required for every packet (block) adds overhead, together with resend requests for lost and wrong-order packets.</td>
<td><strong>Overhead:</strong> Lightweight “fire and forget” design without requiring positive ACKs, and no connection tracking, keeps protocol nimble; ideal for real-time tasks.</td>
</tr>
<tr>
<td><strong>Streaming:</strong> Multiple packets per read call.</td>
<td><strong>Datagrams:</strong> One packet per read call.</td>
</tr>
<tr>
<td><strong>Routing Protocol:</strong> Unicast only.</td>
<td><strong>Routing Protocols:</strong> Unicast and multicast.</td>
</tr>
<tr>
<td><strong>Uses:</strong> World Wide Web, email, File Transfer Protocol (FTP), Secure Shell (SSH).</td>
<td><strong>Uses:</strong> Streaming (real-time) media, live video, VoIP, online multiplayer games.</td>
</tr>
</tbody>
</table>
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
INTRODUCTION TO DVEO
Focused on broadcast and telecoms industry

- Sales Channels
  - Direct sales
  - Private Label/OEM
  - Resellers
    - Making products that do not compete with our channel partners

DVEO Today – 2016

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

➢ Talented Team
  o 4 Teams with Graduate Degrees
    • 20 staff: 14 in San Diego + offices in Florida, Princeton NJ and Boston MA

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

➢ DVCare™ Extended Warranty & Customer Care Plans
  o Peace of mind and Priority Support