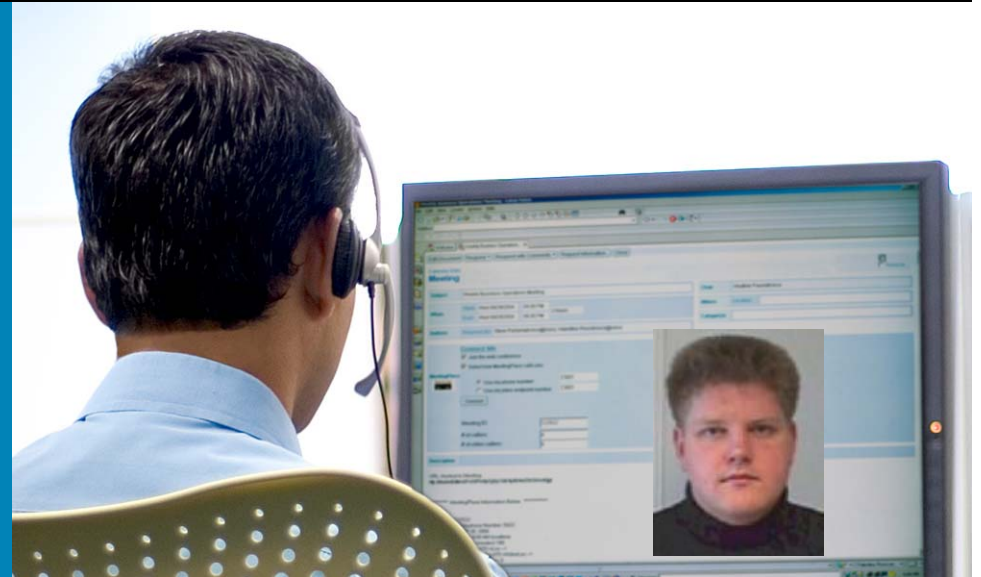




**Cisco Expo  
2009**

## Service Provider videoløsninger i praksis



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CCIE #3252**

# Agenda

- Quality of Experience
  - QoE for IPTV
  - QoE requirements for a Set-top Box (STB)
  - Cisco Visual Quality Experience (VQE) Technology
    - Real-time video error repair
    - Rapid channel change
    - QoE monitoring and reporting
  - Cisco Content Delivery network
    - VOD, Start-over, recording etc in IPTV networks

# Quality of Experience



<http://en.wikipedia.org/wiki/QoE>

**Quality of Experience (QoE)**, some times also known as "Quality of User Experience," is a subjective measure of a customer's experiences with a vendor. It looks at a vendor's or purveyor's offering from the standpoint of the customer or end user, and asks, "What mix of goods, services, and support, do you think will provide you with the perception that the total product is providing you with the experience you desired and/or expected?" It then asks, "Is this what the vendor/purveyor has actually provided?" If not, "What changes need to be made to enhance your total experience?"

# What is QoE for IPTV?

- Perceptual (subjective) quality analysis
  - As perceived by an end-user
- Availability of the IPTV Channel/Service/Program
- Measurement of the channel change time (zapping)
- Video quality metrics
  - Blockiness, Jerkiness, Blurriness
- QoS is a component to enable QoE
- MOS is a component of QoE measurement

# QoE requirements for a STB

- Support for Mpeg2 og Mpeg4 Codec, Mpeg2 pga legacy og Mpeg4 for at opnå bedre compression
- Standard og High Definition (det er vel på tide at få udnyttet det "HD-ready" mærke der står på skærmen)
- Hurtige programskiftetider (tjep, tjep, tjep kom nu!!)
- Perfekt billede kvalitet uden "blokke" og "frysninger" (hva, scorede de!) dvs support for error repair og pakke retransmission
- Brugermuligheder som optage enten lokalt eller i "netværket", filmleje, pause, spol tilbage og start-forfra
- FAF, glem aldrig at den skal være FAF godkendt!

(FAF = Female Approval Factor, den skal være lækker, altså STB ;-)



# Cisco Visual Quality Experience (VQE) Technology

- **Real-time video error repair**

  - Eliminates effects of bit errors in the traffic path

  - Application-Layer Forward Error Correction

  - Re-transmission of dropped IP packets to STB

- **Scalable, standard-based rapid channel change**

  - Maintains consistent user experience

  - Faster channel change time

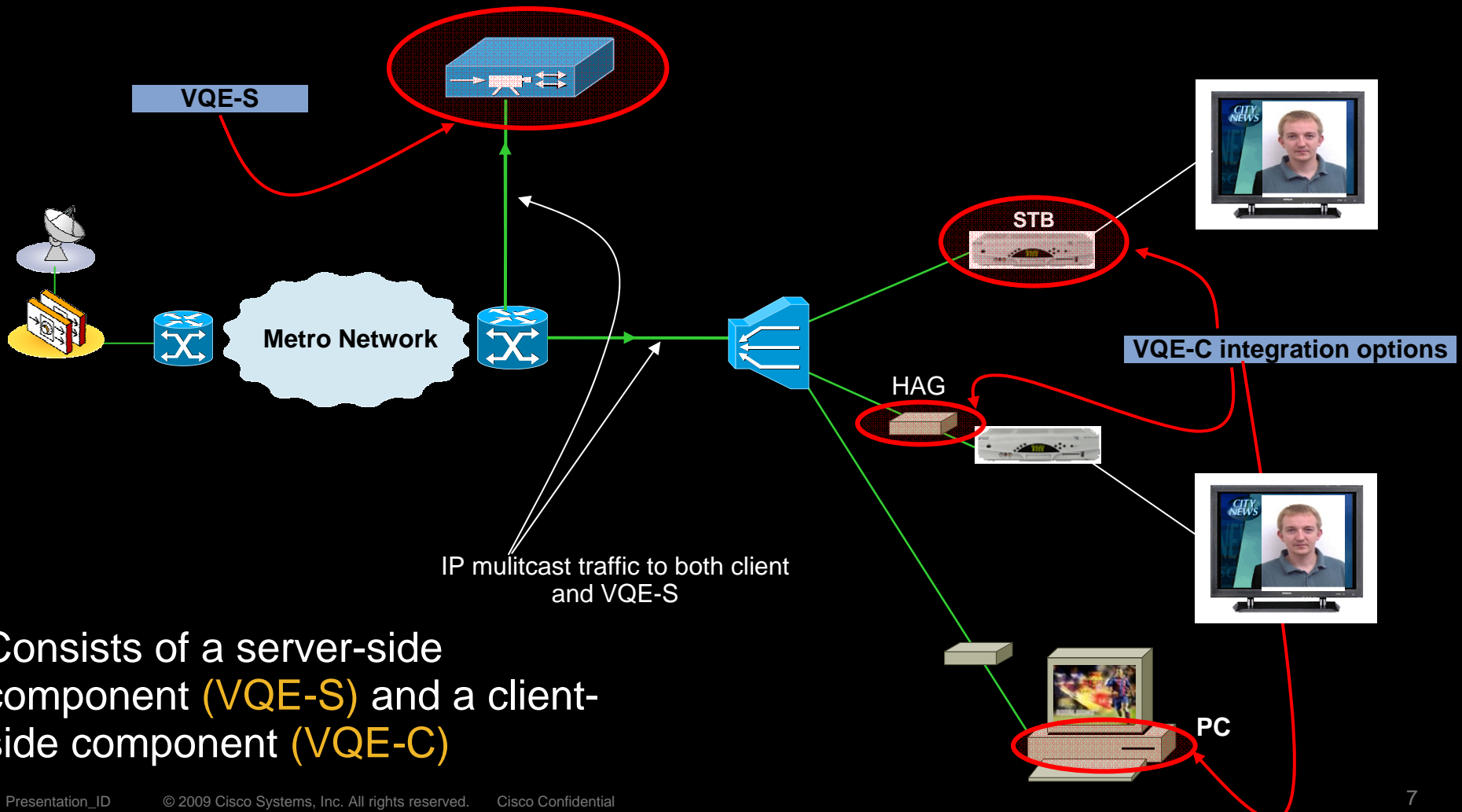
- **Diagnoses problem areas**

  - Monitoring and reporting of faults per user (actually per STB in the home!)



## Protecting IPTV Quality of Experience

# Generic Network Diagram



Consists of a server-side component (**VQE-S**) and a client-side component (**VQE-C**)

# Need for Error Recovery from Packet Loss

- Video Streams highly sensitive to loss

Video is compressed; Each Packet may carry Multiple MPEG Frames

Any loss likely causes visible artifact for a varying amount of time

Rule of thumb is no more than one artifact per 2 hour movie, it translates to:

For MPEG-2 Standard Definition content @ 3.75 Mbps this translates to a

PLR of  $(7 \times 188 \times 8) / (3,750,000 \times 3600 \times 2) = < 0.390 \times 10^{-6}$

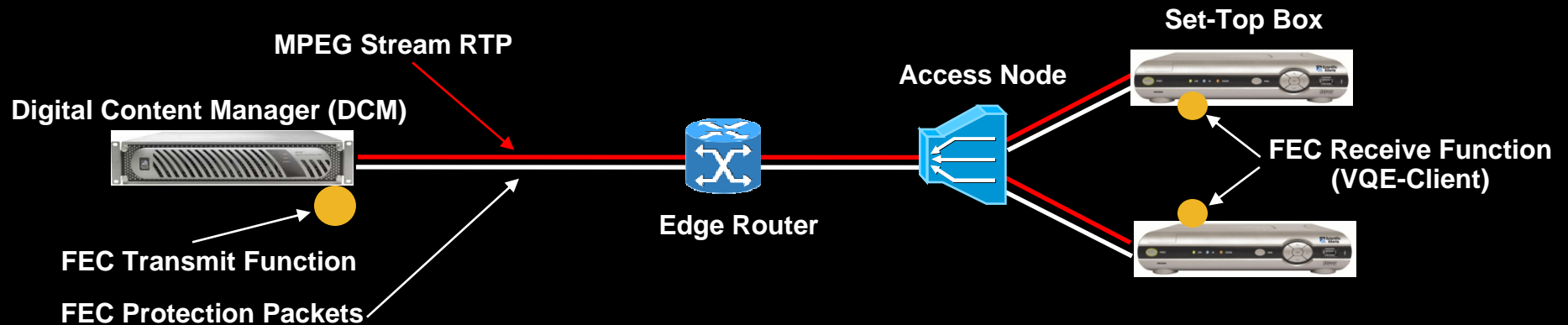
MPEG-4 AVC or SMPTE VC-1 High Definition requires at least 6 Mbps or

PLR of  $(7 \times 188 \times 8) / (6,000,000 \times 3600 \times 2) = < 0.244 \times 10^{-6}$

# Need for Error Recovery from Packet Loss

- Typical causes for packet loss:
  - STB Jitter Buffer Overflow—could be avoided by de-jittering and shaping
  - Router Buffer Overflow—Could be avoided by CAC + network QOS and prioritization
  - Home network, cabling inside the house not always cat5, maybe using Wifi network
  - Most Critical:** Bit Errors on Physical Links (Typical BER in DSL in order of  $10^{-6}$ )
  - Network Reconvergence Events (Application or transport level approaches can be used to recover from loss experienced)
- Bit Errors in IPTV are particular bad since uncorrectable bit errors translate to packet drops due to CRC checks; In the worst case the BER of  $10^{-6}$  can translate to PLR of  $10^{-3}$  (an artifact every minute!!!)

# Application-Layer Forward Error Correction (AL-FEC)



- Employs error correcting codes to cope with bit errors by adding redundancy (parity bits) to packets before they are transmitted. Parity bits used by receiver to detect and correct errors.
- AL-FEC defined by Pro-MPEG CoP3 (SMPTE 2022)
  - Original Stream partitioned into sequential source blocks  $L \times D$ . Defines protection period: the duration of time of the original stream that is used as the source block
  - Constant latency introduced and is proportional to the block size. Adjusted to reduce overhead or increase protection
  - Redundant protection packets are added to the source block (XOR based). FEC overhead: the amount of redundancy introduced by FEC protection

# Forward Error Correction

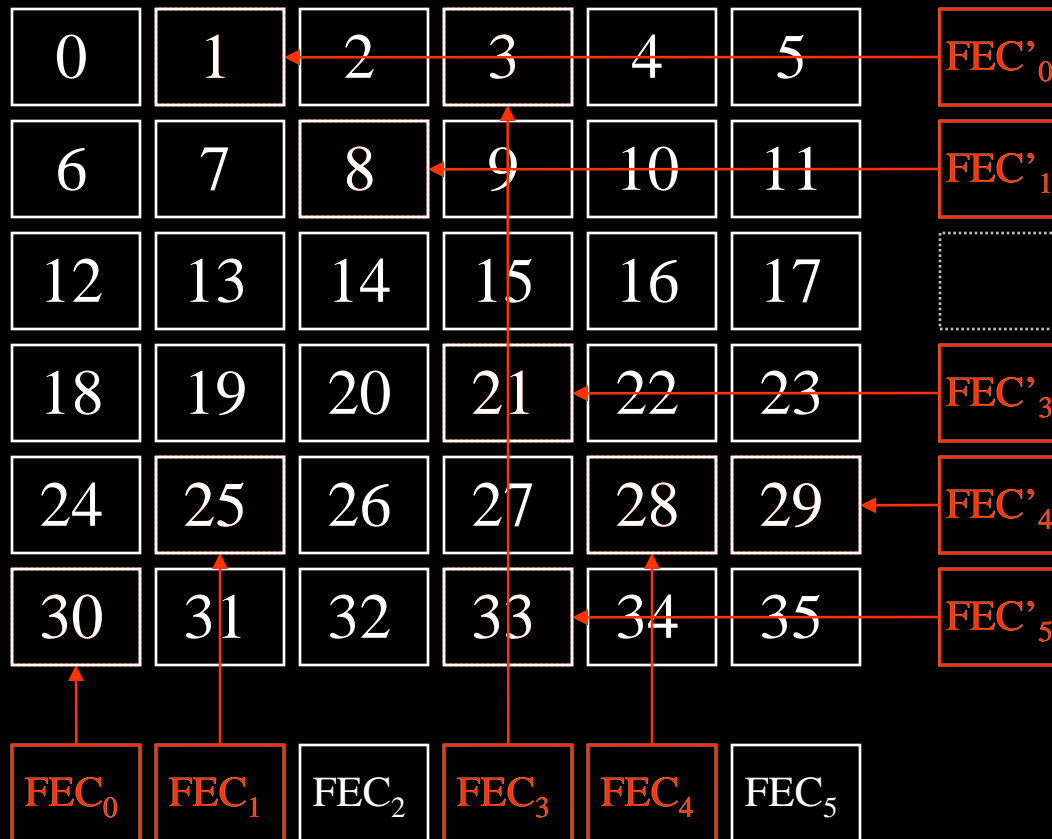
- **What is FEC?**
  - A class of methods for controlling errors in an one-way communication system. FEC sender sends extra information along with the data, which can be used by the receiver to detect and correct the lost data.
- **Cisco's Implementation:**
  - Cisco implemented RFC 2733 and Pro-MPEG CoP #3 release 2 (SMPTE 2022), based on XOR, including 1-D and 2-D FEC.



The FEC packet is sent along with video packets. **Any 1 out of k+1 packets loss in this block can be recovered without any feedback**

# Example of correction success

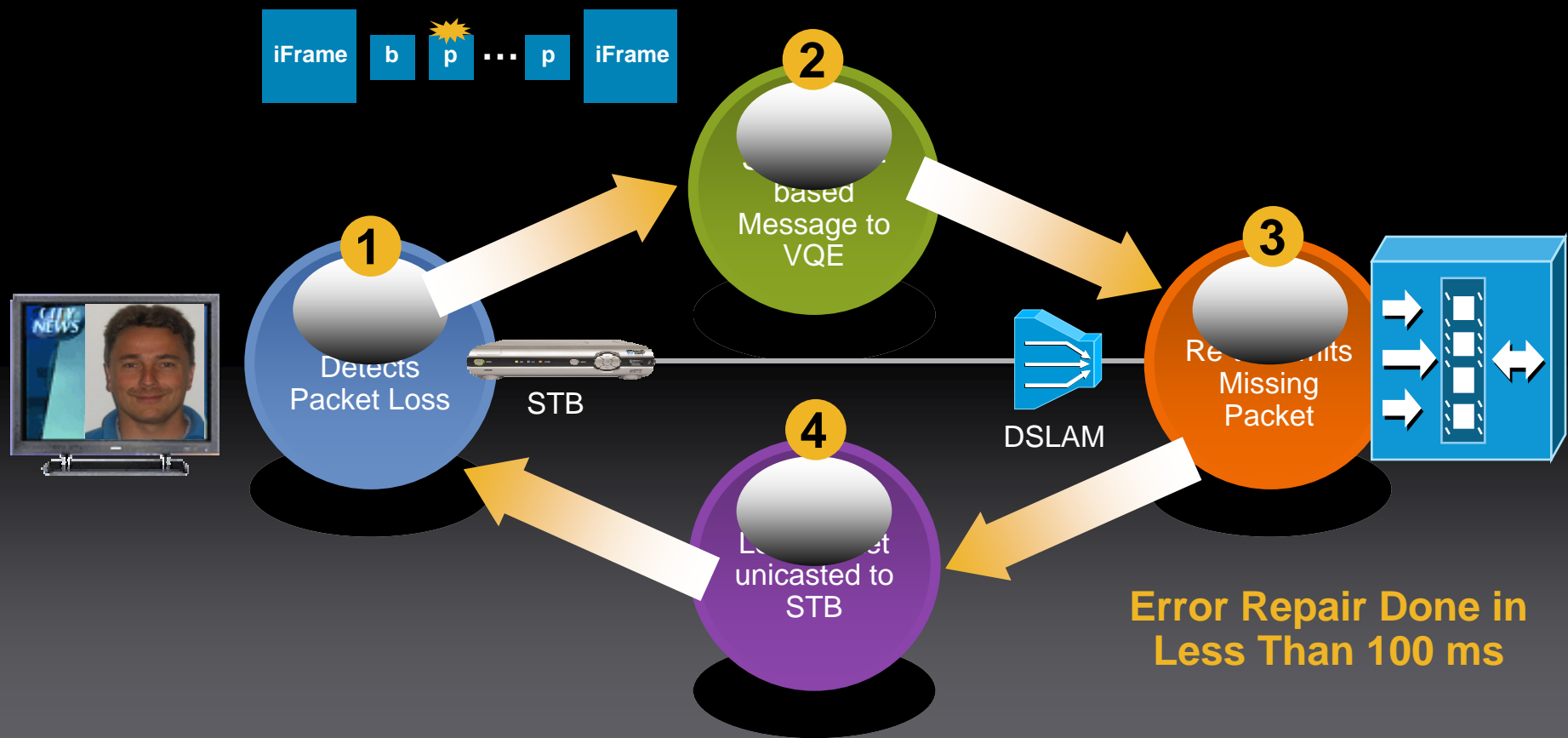
6x6 data matrix with 9 data packets lost and 1 FEC packet lost



**The 9 missing data packets are successfully recovered !!!**

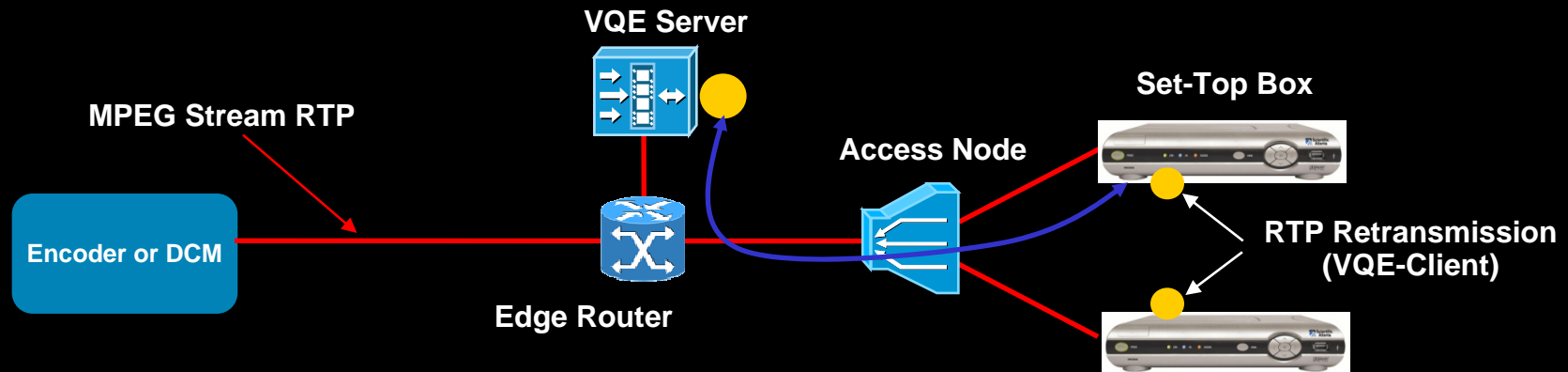
# VQE—Video Error Repair

## Packet retransmission



Reduces SP OPEX and Customer Churn—Avoids Costly help desk calls  
Enhances Customer Video Experience Quality—Delivers better video

# RTP Selective Retransmission (RET)



- Correction applied per on-demand basis – overhead only when errors occur
- Designed to correct errors on access network
- Provides statistics per each receiver and allows planning corrective actions
- Deployment characteristics
  - VQE server scale must be adjusted to the number of receivers & error characteristics



# EANTC and Lightreading Independent Test

## Perfect Video and Voice with VQE with moderate packet drop level

Drop Level	V-Factor before VQE	Visual + Audio quality with VQE
Zero	4.6	Perfect Video and Audio
Drop 1 packet out of 1000	Under 4	Perfect Video and Audio
Drop 2 packet out of 1000	1.1	Perfect Video and Audio
Drop 10 packet out of 1000	1.0	Perfect Video and Audio
Drop 50 packet out of 1000	1.0	Perfect Video and Audio
Drop 100 packet out of 1000	1.0	Perfect Video and Audio
Drop 150 packet out of 1000	1.0	Slightly impaired Video and Audio

V-Factor : A measurement of video quality that looks at packet impairments, program clock and I, B, and P frames for a more accurate quality measurements and frame-based statistics. Range 0 (worst) -5 ( best)

# Error Repair Technologies Compared

## Packet Retransmission

### Advantages

- Retransmit Overhead directly related to channel loss dynamics
- Base Technology can be used for Rapid Channel Change and Packet Statistics
- Effective for long length burst errors
- Per STB configuration / Tuning
- Granular QoS schemes

### Disadvantages

- Unicast scheme not designed for highly correlated error events
- Requires VQE-S - scaled for users\*loss patterns

## Application Layer FEC

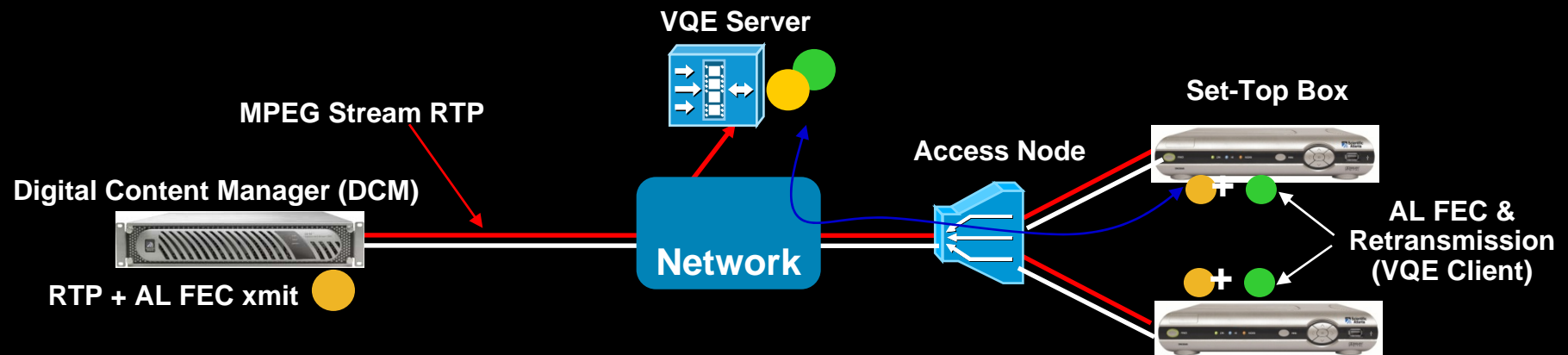
### Advantages

- Upfront Overhead/CBR approach
- No additional infrastructure components (VQE-S) => inherently scalable
- Tunable protection levels (per channel)
- Applicable to Correlated and Uncorrelated Events

### Disadvantages

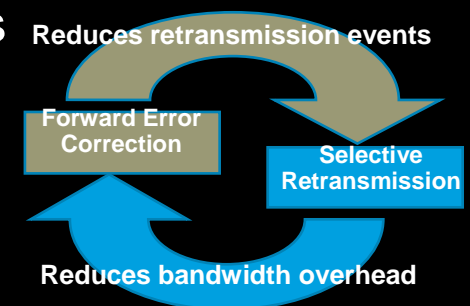
- Overhead can be significant and can challenge tight DSL Bandwidth Budgets
- FEC parameters applied System wide – overprotect clean nodes, under protect dirty nodes.
- Separate FEC code multicast streams require additional administration
- Reduces Reach by burning e-factor

# IPTV Error Repair – Combined Solution



Layered Repair Solution using AL- FEC and RTP Retransmission together!

- 2 Complimentary Technologies Mitigate Packet Loss Impact  
AL-FEC **initial** defense; retransmission **supplementary** defense
- Optimize FEC protection and overhead for majority of clients
- Increase reach through augmentation with retransmission
- Cisco is the ONLY vendor to offer a hybrid solution



# Why Rapid Channel Change (RCC)?

- What is Channel Change Delay?

Time between user's request of a new channel and display of the first picture

- Why Channel Change Acceleration?

Delay is longer for IPTV (typically larger GOP sizes used in IPTV)

A brute-force way to solve the problem is to shorten the GOP sizes, but that has bad side effect of increased BW requirements

Moreover, the channel change delay is variable

Both delay and variability leads to undesirable user Experience

# Rapid Channel Change = Hurtige zappe tider

Hvad betyder zappe egentligt ?

<http://da.wikipedia.org/wiki/Zappe>

“Ordet er afledt af den lyd som de gamle fjernsyn sagde når man skiftede kanal. Det var den statiske ladning af billederøret, som forsvandt, når det slukkede for at tænde den anden kanal. “

Er langsomme kanalskiftetider overhovedet et problem idag og hvorfor skulle det bliver værre ?

Hvorfor er det at det tager længere tid og skifte kanal imellem HD kanaler end imellem SD kanaler?

Svar:

For at spare båndbredde sendes HD typisk i MPEG4 og der bruges typisk en længere buffer og GOP størrelse, længere buffer betyder at det skal mere data ind før der kan vises noget og længere GOP størrelse betyder at der er længere imellem I-frames og dermed vil STB være nødsaget til at skulle vente længere før den kan vise den nye kanal.

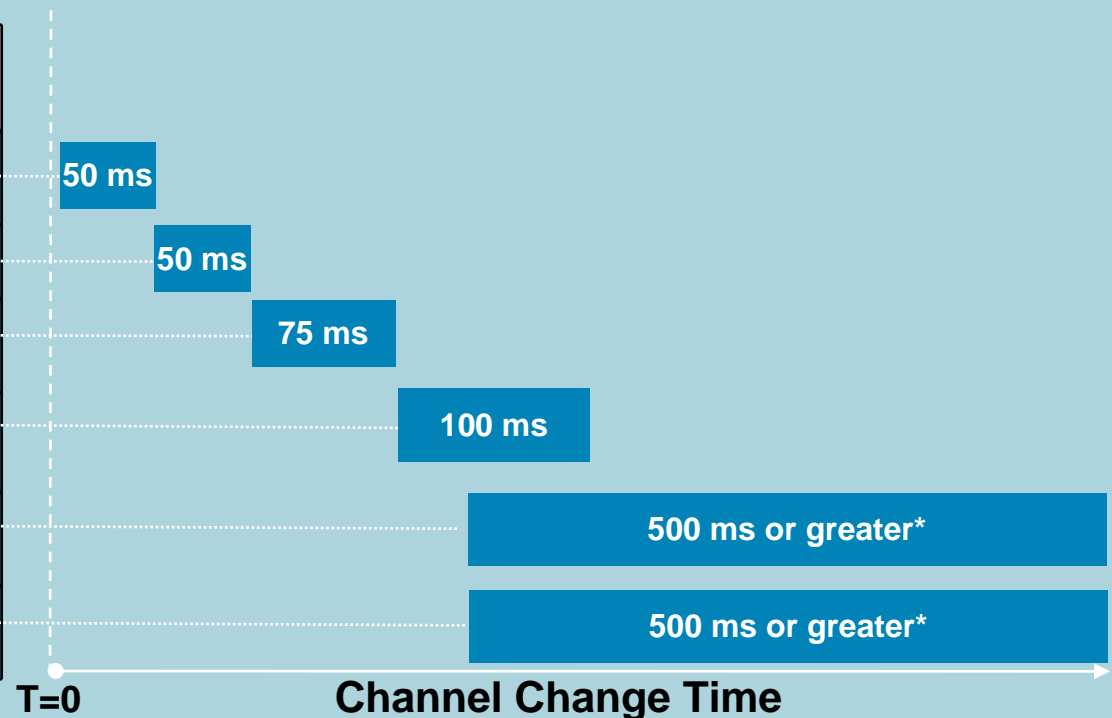
# Hurtige zappe tider

- Common misconception is IP multicast causes slow channel change.
- Main culprits:

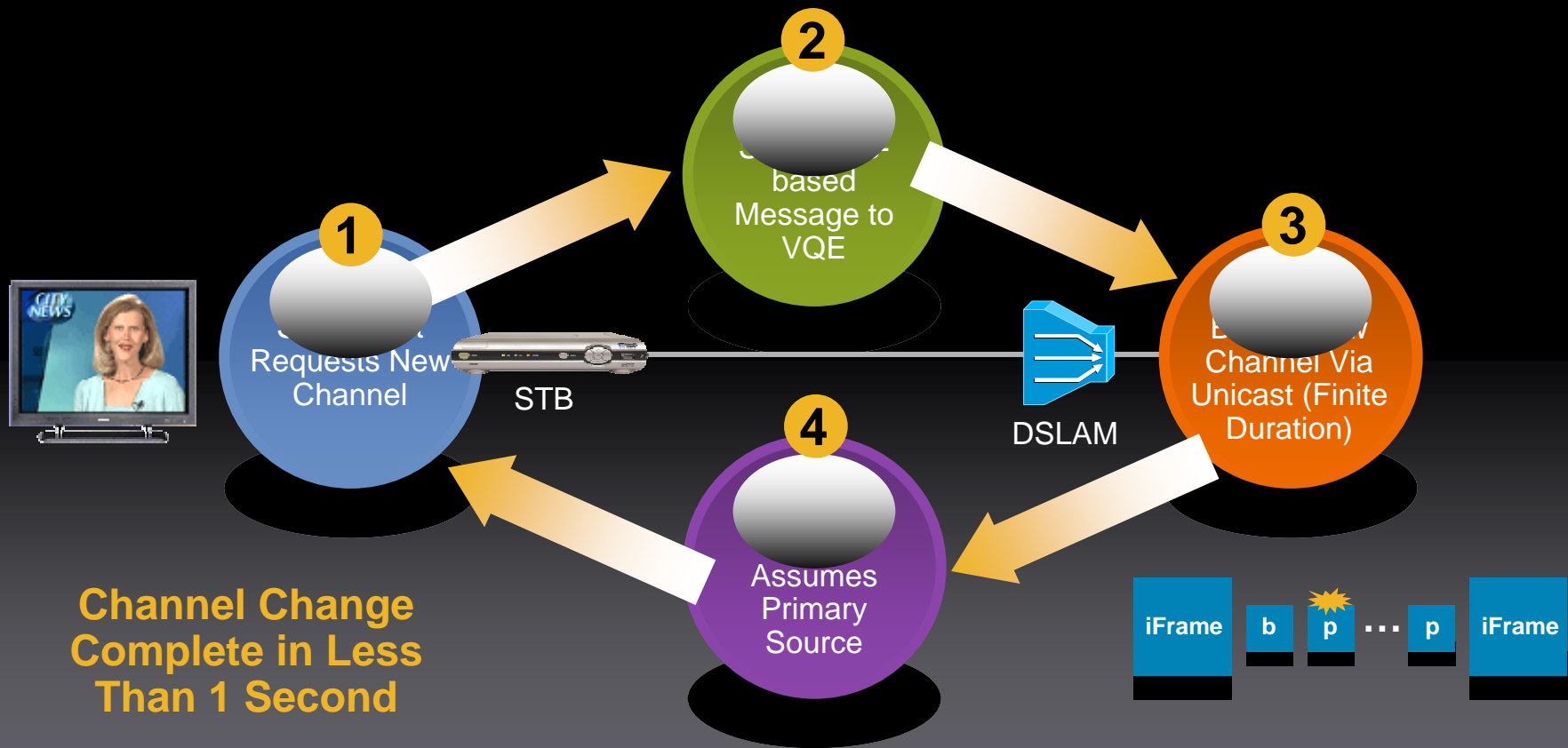
Waiting for the Next I-Frame

MPEG buffering

Channel Change Latency Factor	% total budget
Delay for Mcast Stream to Stop from DSLAM	4%
Multicast Join for New Channel	4%
Dynamic Multicast Set Up Delay	6%
Jitter Buffer Fill	8%
I-Frame Delay *depends on compression	39%
MPEG Buffering *depends on STB	39%

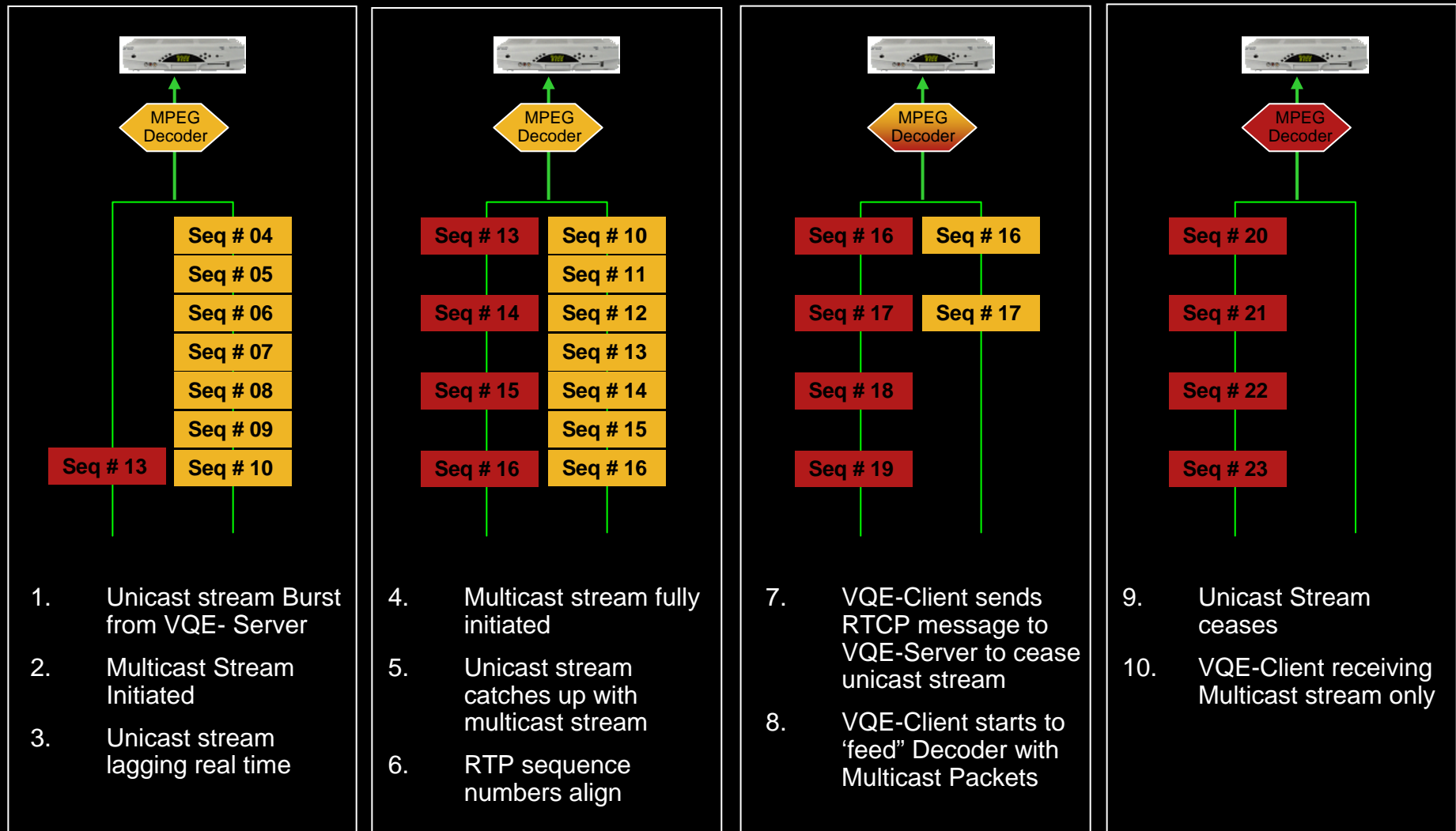


# VQE—Rapid Channel Change



Network Enabled with Standards Based RTCP Messaging  
Maintains Surfer's Visual Quality of Experience (VQE)

# VQE Rapid Channel Change, Behind the Scenes, (VQE-Client)



# QoE Monitoring



# Problem Solving - Quality of Experience Monitoring

- QoE Monitoring offers ability to detect and isolate faults in video network pro-actively

With per subscriber Quality Monitoring, the fault can be narrowed down to Core, Distribution, access link or home network

- Monitoring, when tied with VQE, provides metric of how well Rapid Channel Change and Error Repair is working
- Having video probes in the network is good but does not provide statistic for the edge and home network and neither per user



# VQE – Application Monitoring Tool

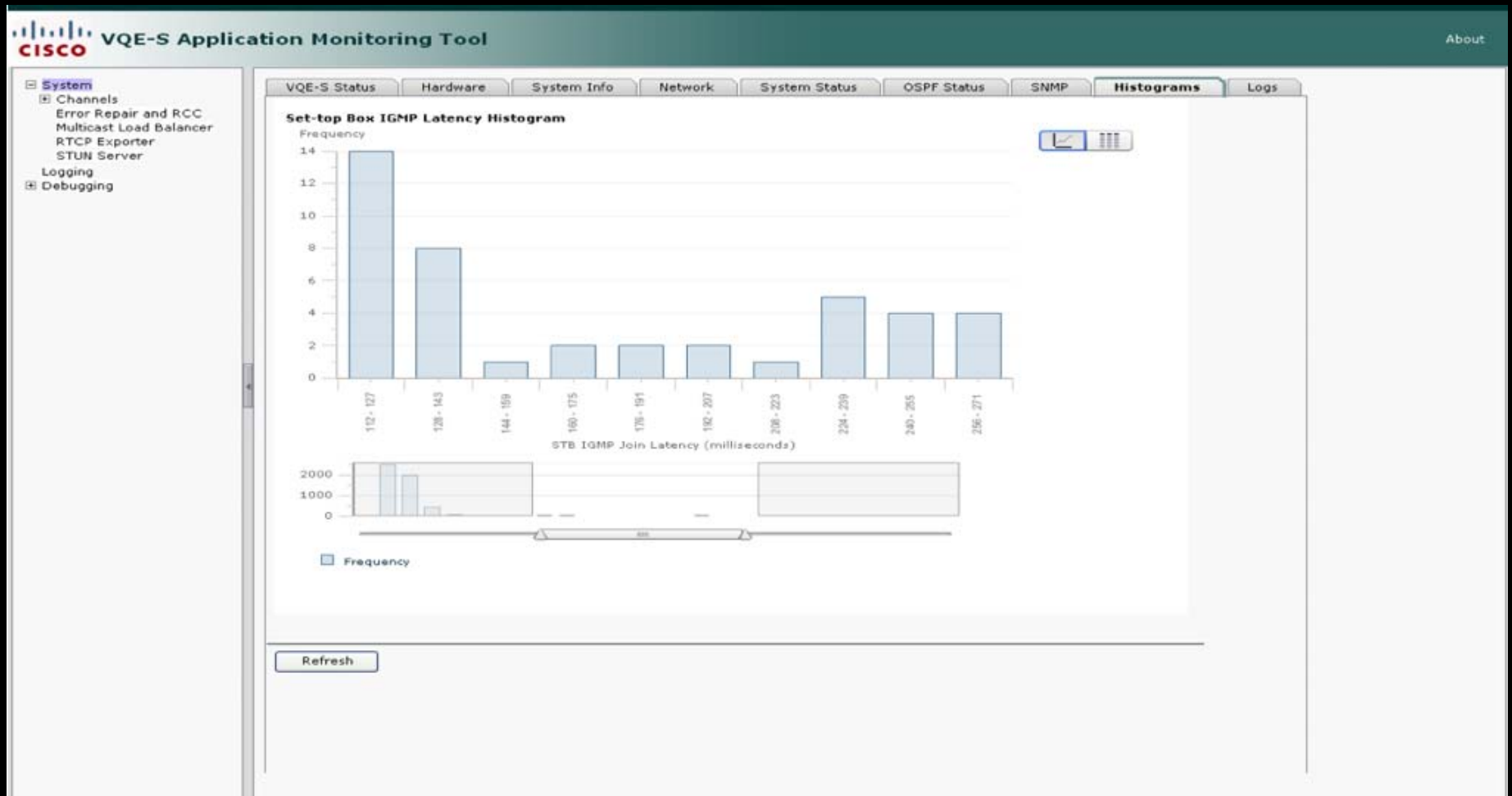
The screenshot displays the VQE-S Application Monitoring Tool interface. On the left is a navigation tree with categories like System, Channels, and Debugging. The main area shows the 'Status/Statistics' tab for a selected channel. The data is organized into several sections:

- Channel Input Stream:** Status: active; Average Stream Rate (Mbps): 4.1; Received Packets: 194224447; Received Bytes: 4116516796; Lost RTP Packets: 0.
- Error Repair Statistics - Generic NACK Messages Received:** Total Messages: 0; Invalid Messages: 0.
- Repair Packets:** Requested: 0; Not Sent: 0; Sent: 0.
- Error Repair Average Rate (packets per second):** 5 Second: 0.000; 1 Minute: 0.000; 5 Minute: 0.000; 15 Minute: 0.000.
- RCC Statistics - Rapid Channel Changes:** Requested: 0; Refused: 0; Accepted: 0; Failed: 0.
- RTCP Packets:** Received: 0; Sent Upstream: 33972; Sent Downstream: 0.

At the bottom, there are buttons for 'Advanced...', 'Refresh', and a timestamp: 'Last refresh: Thu Oct 30 11:18:54 2008'.

- **Aggregate ER and RCC Statistics and associated with a given channel (or all channels)**

# VQE - IGMP Join Latency Histogram



- Occurrence frequency of channel change time at IGMP level

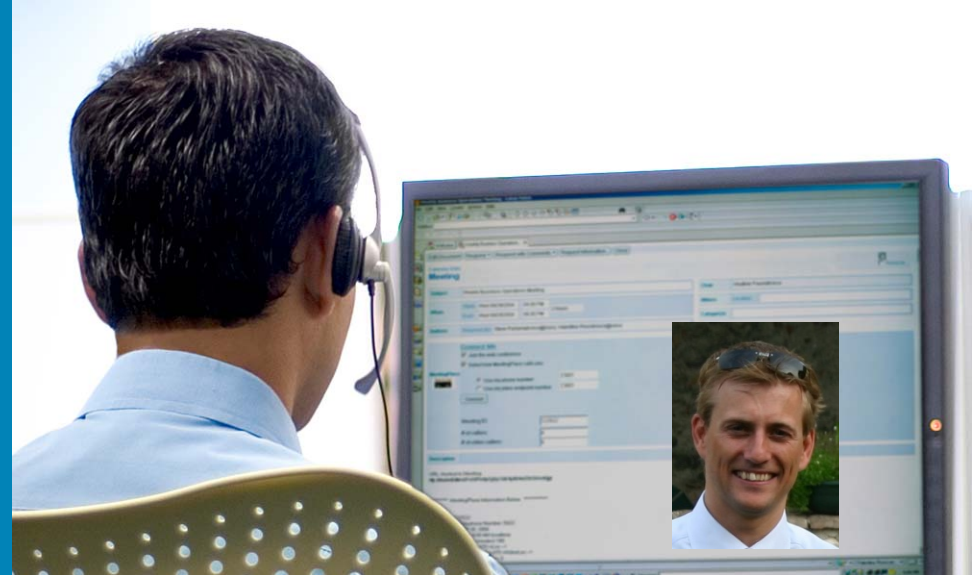
# Why Cisco VQE

- VQE is based on standards protocols and signaling.
- Rapid Channel Change, Error repair and monitoring in one easy managed solution
- The technology is network aware. It relies on direct coupling with QoS, Multicast etc.
- VQE leverages a standalone NEBS compliant
- Cisco's VQE client is available via an Open-Source program. The client is extensible and may be run on a variety of consumer devices



Cisco Expo  
2009

# Cisco Content Delivery System for Personalized Video Networks



# Cisco Content Delivery System Vision

Enables any content, any device, any location from a single, open delivery platform.



Cisco  
(Cable TV & IPTV)

Cisco  
(Internet Video)



TV  
Mobile  
PC

Linear

On Demand      Time Shifted

Personalized

Cisco  
CDS



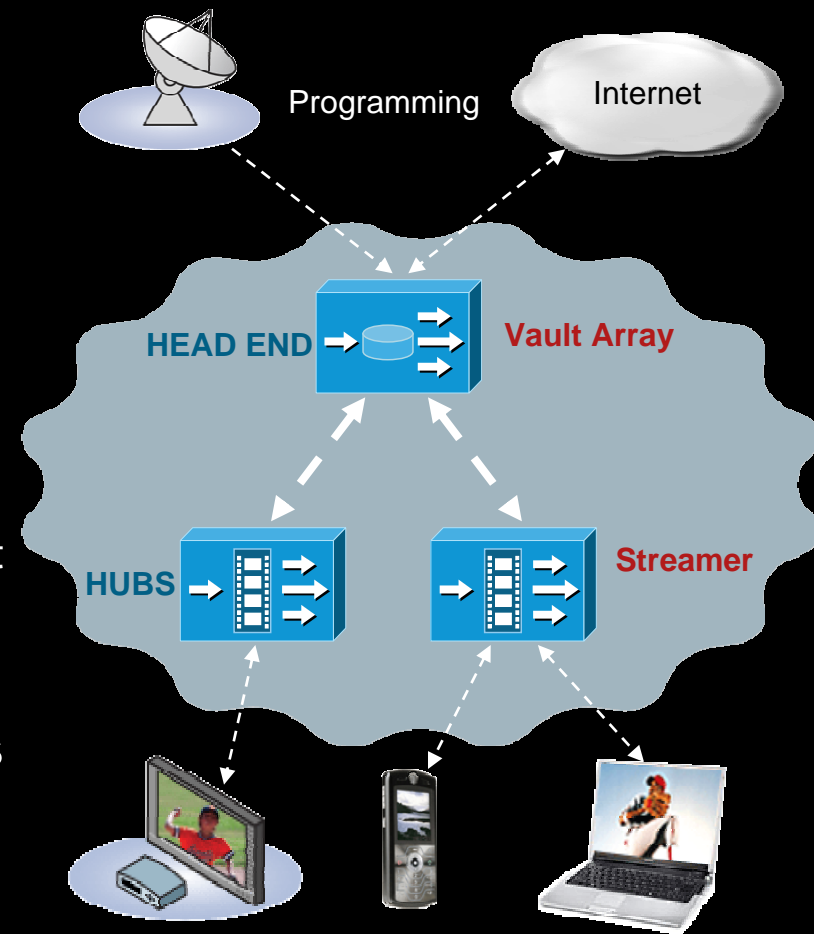
# CDS main functions

- **VoD** - Using industry-standard protocols, the Cisco CDS lets carriers deploy VoD services quickly and economically in either a centralized or decentralized network topology.
- **nPVR** - Deliver program time-shifting to STBs so the user can record, rewind, and pause live TV, directly over the network.
- **Targeted ad insertion** - Carriers can offer advertisers the capability to deliver high-value localized - and even personalized - advertising to subscribers.
- **Broadcast services** - The Cisco CDS can be used to broadcast banner channels that stream looping promotional content or informational services, such as a TV channel guide. Carriers also can schedule and deliver a linear program lineup for public, educational, and government access (PEG) channels.
- **Near VoD (nVoD)** - With the Cisco CDS, carriers can deploy nVoD services through multicast streaming of non-time-shifted content (such as pay-per-view movies).
- **Device shifting**, pause movie on STB, play on PC or mobile device.

# Cisco Content Delivery System

## The Network is the Platform

- Network-centric architecture
  - Intelligent distributed architecture
  - Networked Content Delivery Engines work as one virtual system
    - Centralized, shared ingest and reliable content storage (Vaults)
    - Personalization and streaming at the network edge (Streamers)
- Technology base
  - Unique caching protocol eliminates need to predict viewer behavior or pre-position content – only 300ms from ingest to play out
  - Resilient design with autofailover
  - Multi-format, multi-device
- Optimized for real-time media services
  - Enables converged live and on demand applications
    - Switched video & time-shift TV
    - Personalized content & advertising



# Extreme Scalability

- **Vault arrays**

Content and ingest capacity scale linearly with number of Vaults

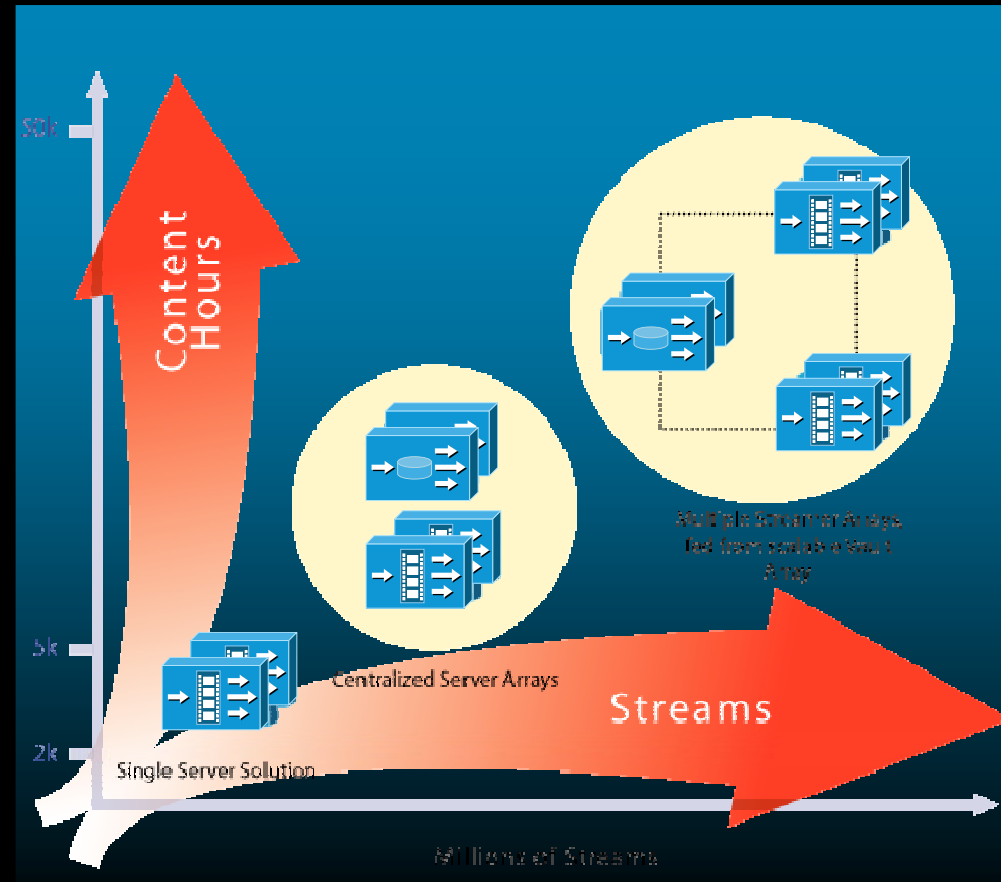
Content added to a Vault is immediately available to all subscribers

- **TV Streamer arrays**

Stream count and cache size scales by adding streamers to an array and adding new arrays to the network

- **Adding CDEs is non-disruptive**

Add capacity, locations, applications without taking service off-line



# Content Distribution Efficiency and the “Long Tail”

- **Different types of storage deployed across the network**

Minimizes total cost – storage, bandwidth, content management

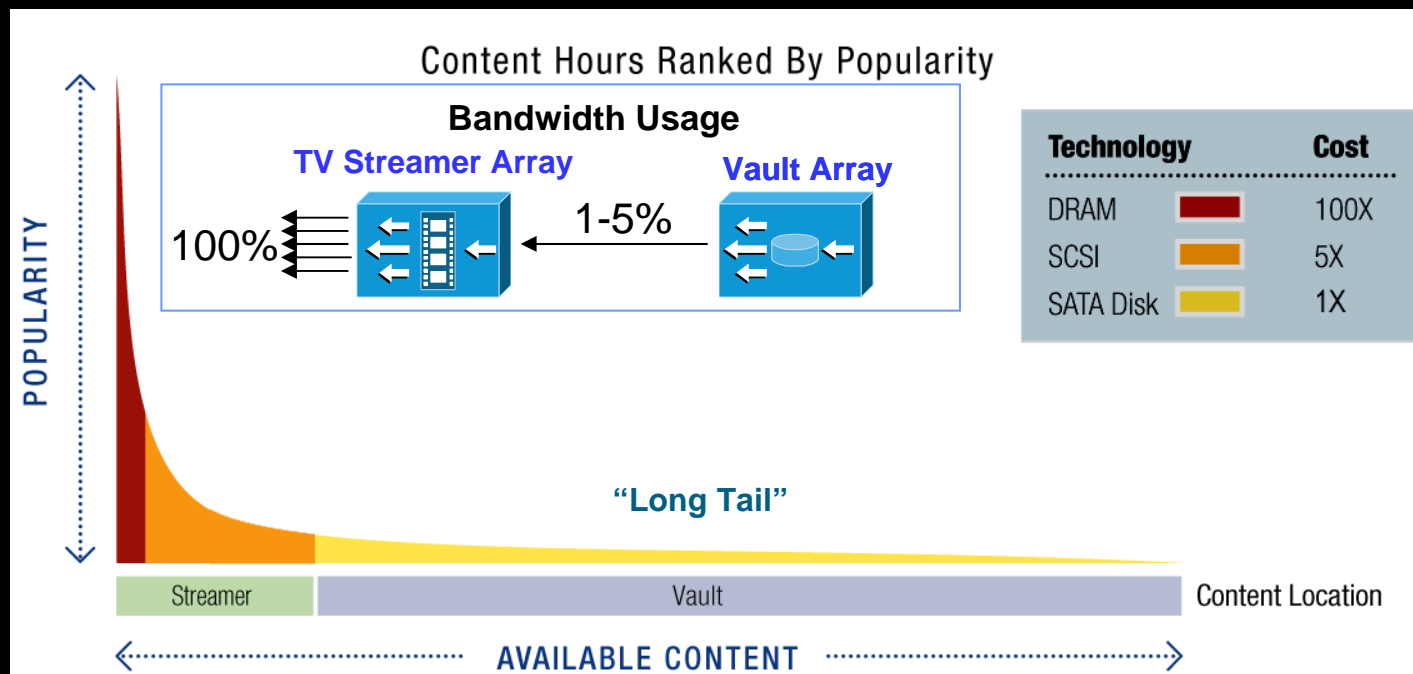
Maximizes performance – unique *content caching protocol*

- **Content from any Vault is instantly accessible to any TV Streamer**

Streamers cache content based on actual viewer demand to reduce backbone traffic

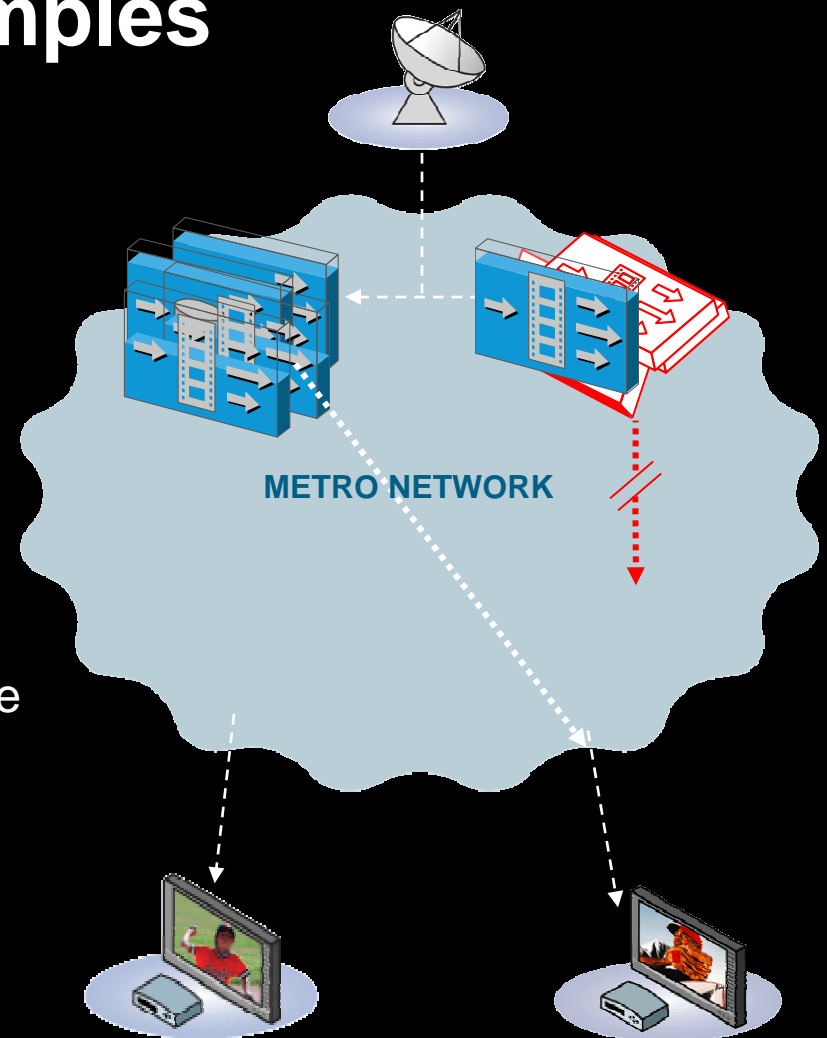
Automatic content distribution – no replication or pre-positioning of content

No other architecture economically scales for long tail, nPVR & user-generated content



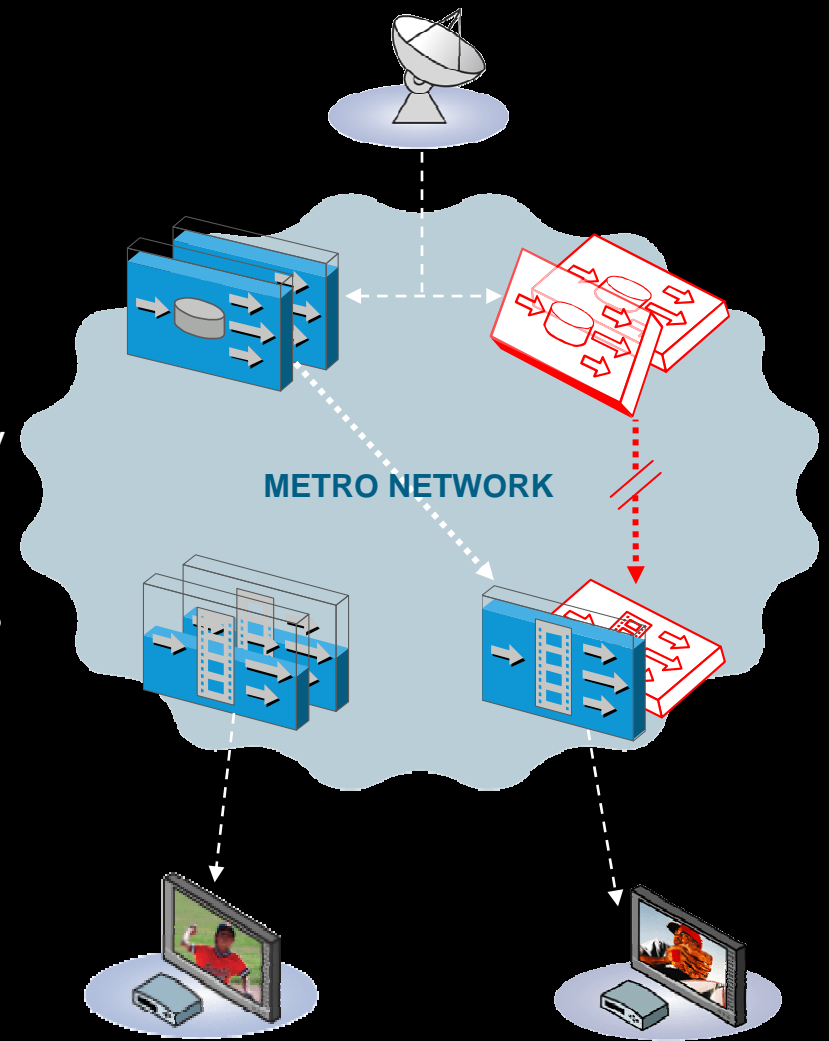
# CDS Deployment Examples

- Centralized,  
Arrays and Streamers at central location
- Decentralized  
Arrays at central location, streamers distributed out in the network
- Hybrid  
Arrays and Streamers at central location, streamers distributed out in the network
- Advantage with decentralized and Hybrid includes scaling, saves bandwidth at central site and in core network.



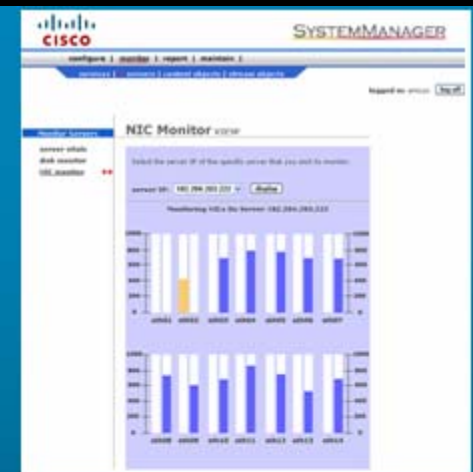
# Non-Stop Availability

- Resource pooling and load leveling
  - Storage and streaming resources allocated dynamically across available hardware based on real-time demand
  - Any server within an array can instantly assume the identity and state of another
- Auto failover prevents service outages
  - Hardware outages do not impact service – no more emergencies
  - No interruption of subscriber sessions
- Non-disruptive maintenance
  - Replace hardware, upgrade software, add capacity or add applications without taking down service
- Applies to any application



# CDS Manager

- Unified browser-based administrative console for all CDEs network-wide
  - Configuration
  - Status monitoring
  - Troubleshooting & maintenance
  - Reporting
- Assign Vault and TV Streamers to arrays
  - Major parameters configured once and automatically propagated across the network
- Extensive reporting capabilities
  - Stream history
  - Bandwidth usage
  - Content activity & popularity
  - Audit logs



# Summary

- QoE er brugerens oplevelse af løsningen
- Cisco's VQE løsning sikrer optimal oplevelse, både med hensyn til billedkvalitet og stabile hurtige zappe tider
- Cisco's CDS løsning tilbyder skalerbart On-demand services med muligheder for stop-start-pause.
- Mere in-depth info: Spørg Per Jensen og Søren Andreasen ved Cisco standen i pauserne.
- Alternativt så tag fat i jeres Cisco Account manager og aftal et møde så kommer vi gerne og fortæller mere.

