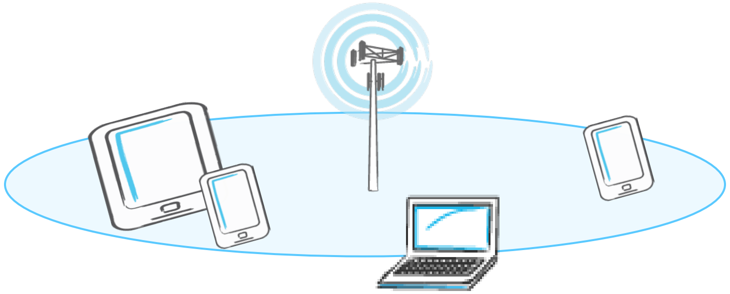
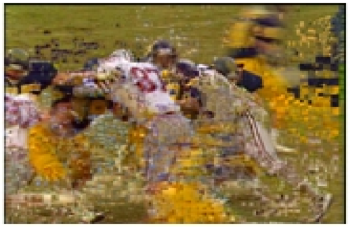
VIDEO DELIVERY OPTIMISATION VIA CROSS-LAYER DESIGN AND VIDEO TRAFFIC DIFFERENTIATION

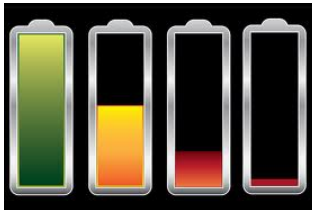
Mobile Video Optimization
Brussels, Belgium, June 12-13, 2012

Challenges in Mobile Video Delivery



- **Finite network capacity:**
  - Increase in mobile traffic lowers QoS:
    - Lower Available Bandwidth
    - Increased Network Delay & Jitter
    - Increased Packet loss
  - This affects Quality of Experience:
    - Rebuffering
    - Dropped video calls
    - Jerky motion
    - Frame freezes
    - Ghosting artifacts





- **Finite power:**
  - Low battery life for streaming and video calling
    - iPhone 4 lasted just 2 hours and 21 minutes-capturing, manipulating, exporting and viewing 25 minutes of HD video and making 34 minutes of FaceTime calls.
    - Anecdotal data: for mobile chat, for every minute, 2% of the battery is used on iPhone

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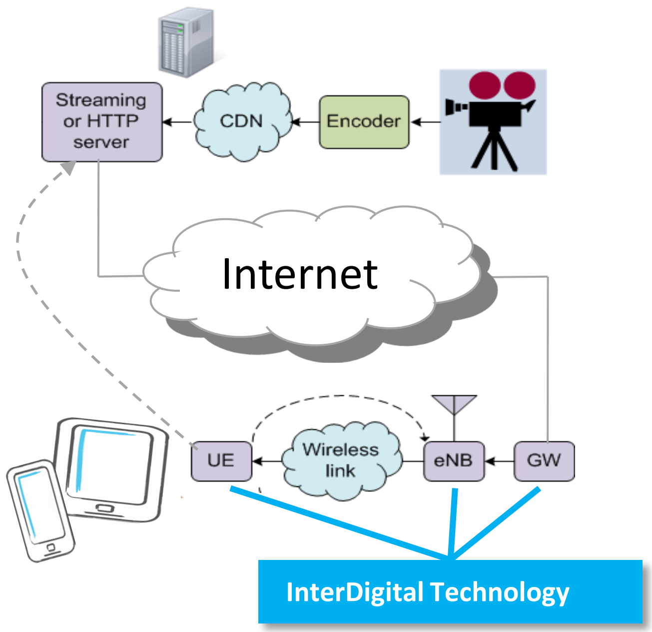
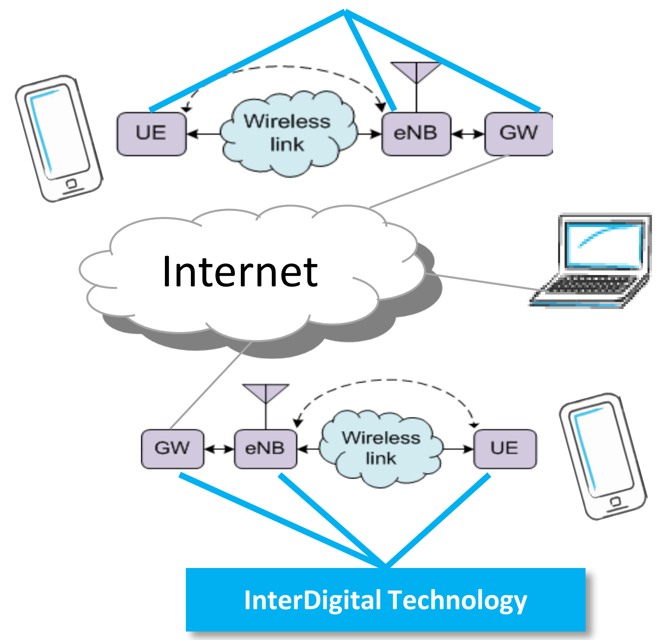
Improving Mobile Video Calling and Streaming

Mobile Video Streaming



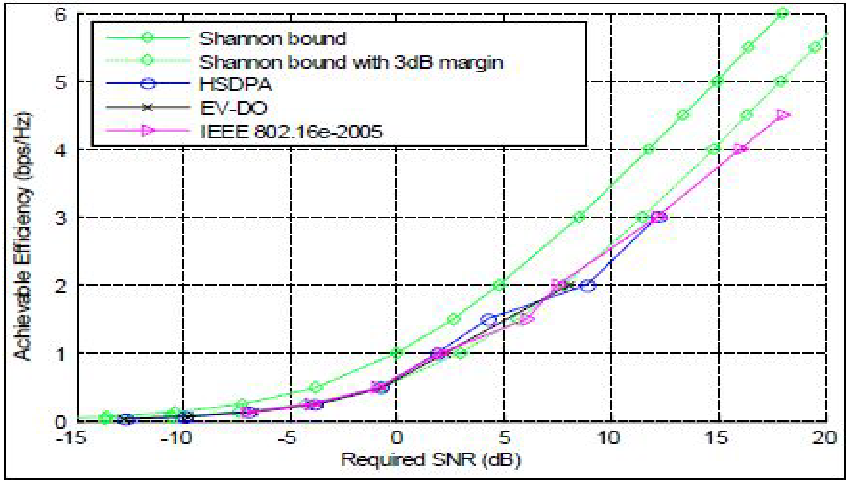
Mobile Video Telephony



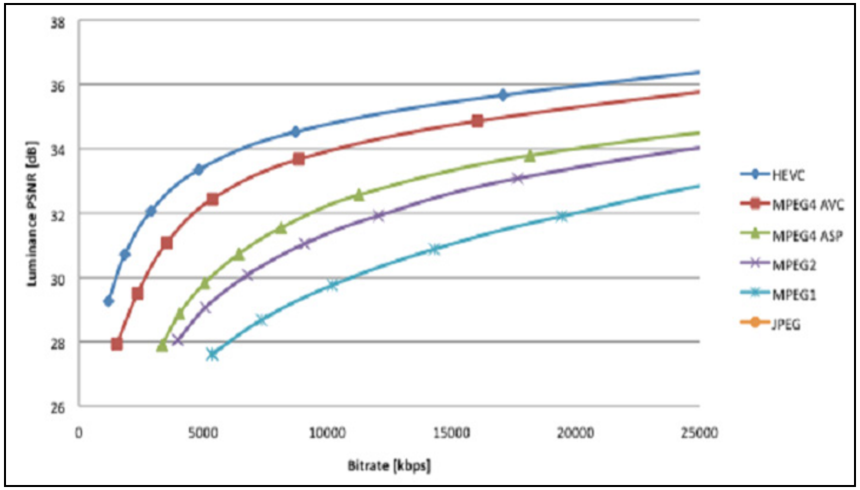
- We develop technologies that improve performance of mobile video calling and streaming applications
- Our technologies are based on principles of cross-layer design

Why Cross-layer?

Current PHYs are operating close to the Shannon limit



Only incremental improvements in video coding are possible with current paradigm



Significant improvements can be achieved by:

- New paradigms (e.g. model-based video coding) – long term

  Or

- Using cross-disciplinary approach, combining knowledge of video coding and expertise in wireless systems design

Combining Video-aware & Wireless-aware Approaches

Addresses Bandwidth Crunch, Improves User Experience and Reduces Terminal Power Consumption

Wireless-aware Video Processing

Video-aware Wireless Design

Gain achieved by

Interaction and feedback between video processing and wireless transmission

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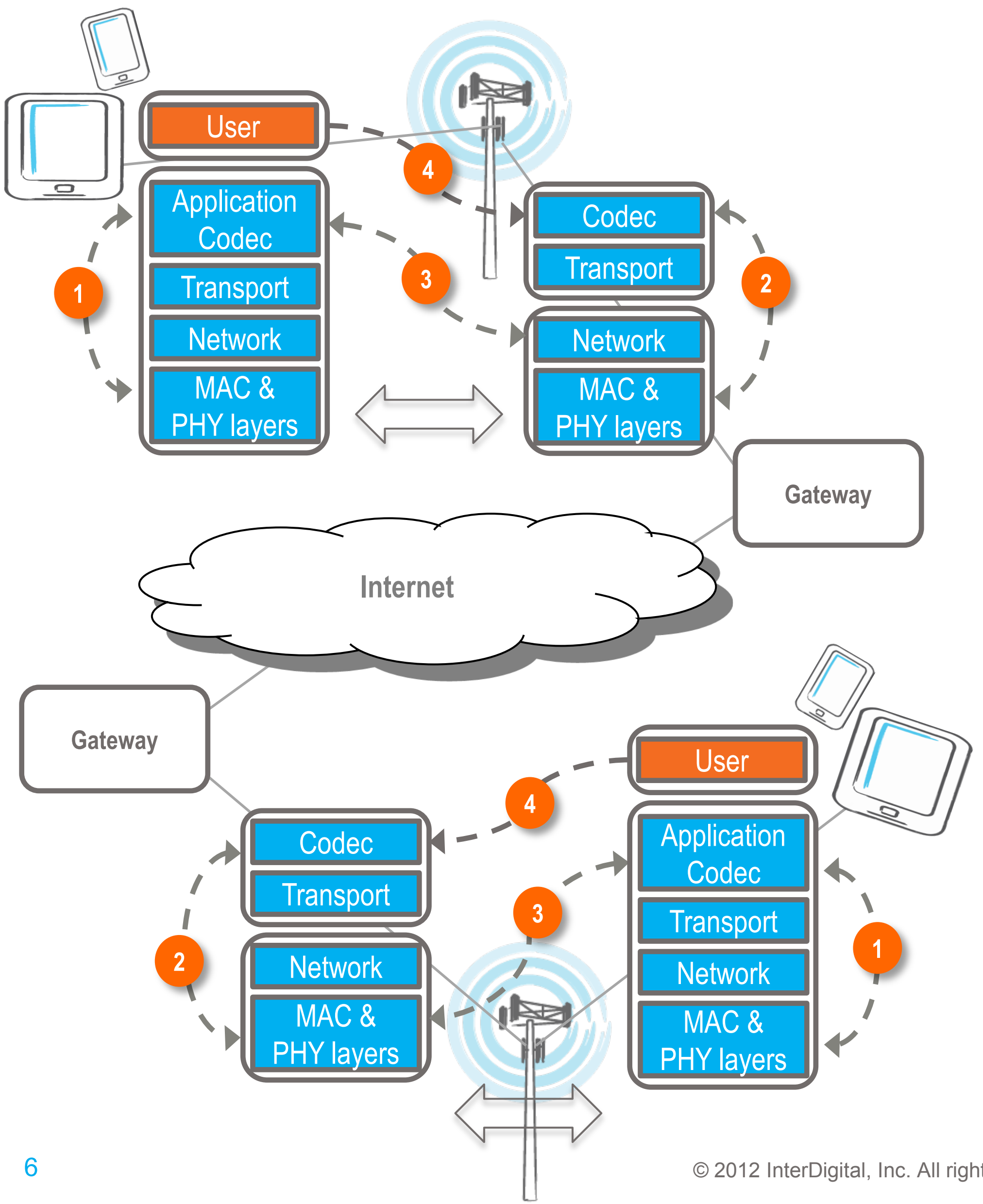
Leveraging the unique characteristics of video

No need to break concrete - - Evolution of LTE and Wi-Fi

Combining cross-layer design with optimizing wireless transmission for video can yield significant gains while improvements in communication theory and DCT-based video coding are hitting a wall

How Cross-Layer Techniques Work?



Interaction and feedback between video processing and wireless transmission

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Leveraging the unique characteristics of video

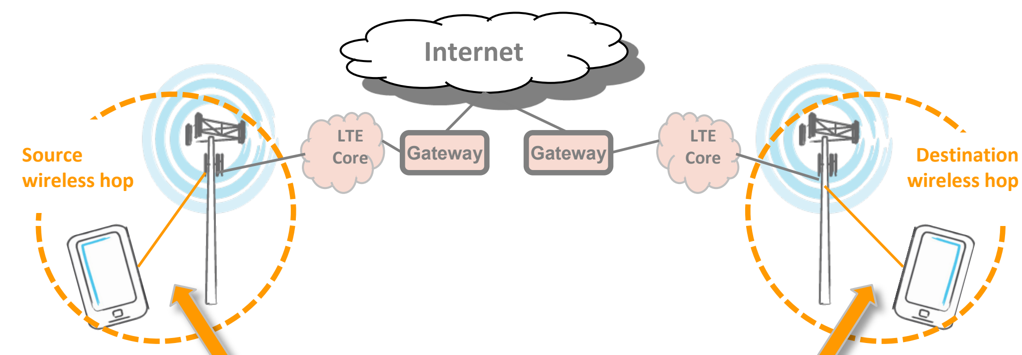
1. Information Exchange between MAC & Application /Codec in the mobile
2. Information Exchange between MAC & Application /Codec in the base-station
3. Information Exchange between MAC in the base-station & Application /Codec in the mobile
4. Delivery optimizations with “user in the loop”

Mobile Video Telephony system shown, similar interactions for Mobile Video Streaming

Video-aware Retransmission Improves Video Quality

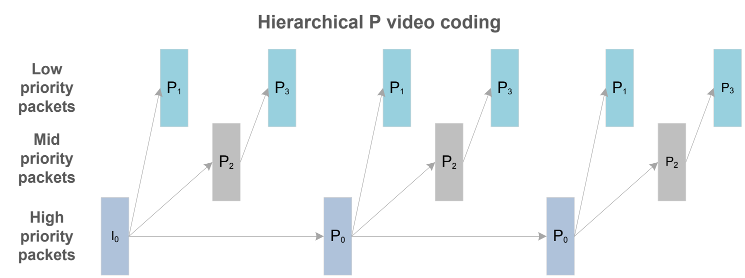
Moderate modifications to encoders & LTE result in significant performance gains

Average Video PSNR gain: ~ 1dB over all users, and up to 4 dB for some users



Max # of Hybrid ARQ transmissions determined by video frame importance

Not all Video Frames are Created Equal



Video frame structure is defined as follows:

I_0 - IDR frame layer 0, high priority
P_0 - Predictive frame layer 0, high priority
P_2 - Predictive frame layer 1, mid priority
P_1, P_3 - Predictive frame layer 2, low priority

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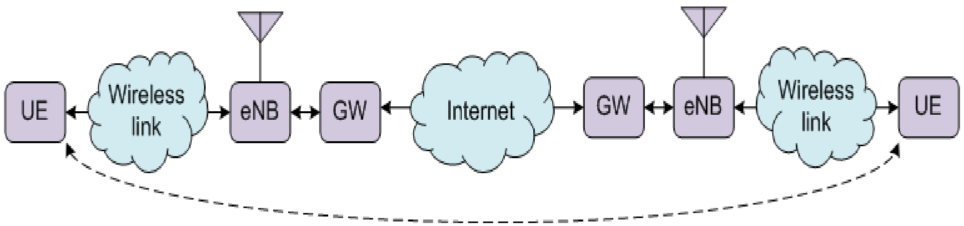
Instant Packet Loss Detection and Concealment Reduces and Mitigates Error Propagation

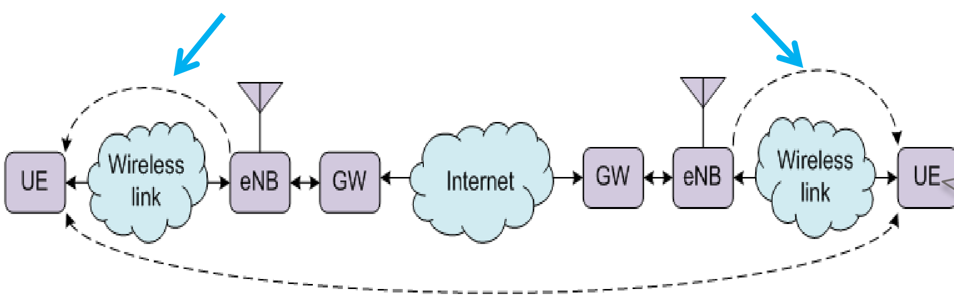
Conventional mobile video telephony system with RTCP feedback



RTCP notifications usually arrive every 1-5s,
not very efficient for stopping loss propagation

Instant feedback

Additional feedback loops are used to instantaneously detect lost packets and avoid loss propagation in encoded video



Examples of error propagation:

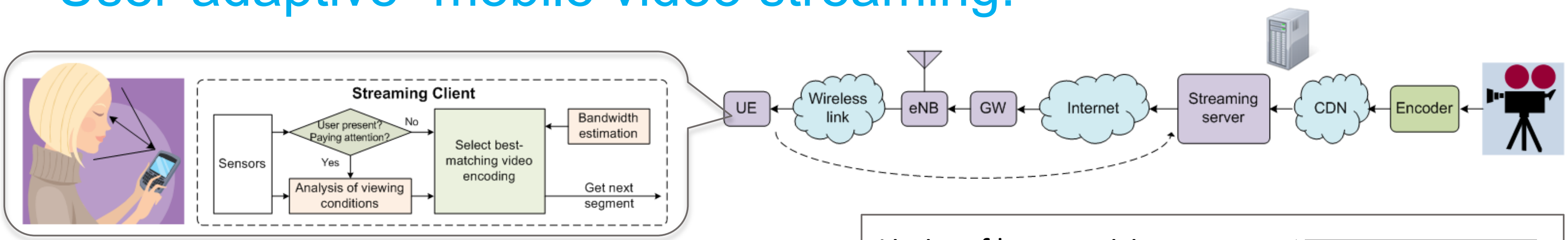
Recovery using instant feedback:

Video encoder dynamically adapts encoding structure based on information about lost video packets

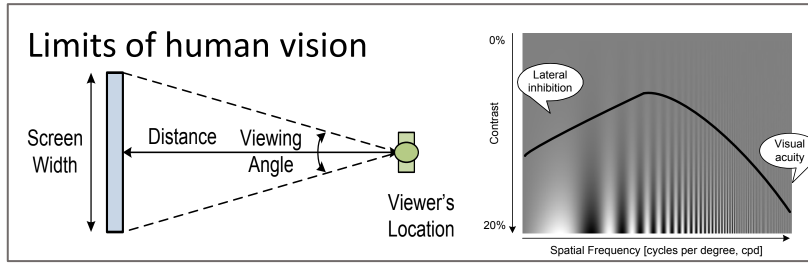
Improves quality by preventing propagation of errors caused by lost packets ("ghosting" artifacts)

Adaptation to User's Behavior and Viewing Conditions Reduces Load on Wireless Networks

"User-adaptive" mobile video streaming:



- Visibility of information on mobile screens is affected by many factors, including:
  - Distance between user and screen
  - Display pixel density
  - Ambient illumination
  - User's attention, etc.
- Detection of user's presence, attention, and analysis of his viewing conditions offers significant potential for reducing amounts of bandwidth used by streaming systems.
- Can be combined with video-aware scheduling and other cross-layer techniques



Density of information on mobile screens may exceed acuity limit:

Device	Size	Pixels	DPI	Viewing distance	Pixels per degree
Notebook	13.3"	1920 x 1080	165.63	16"	46.3
				24"	69.3
Tablet	9.7"	2048 x 1536	263.92	12"	55.3
				16"	73.7
				24"	110.5
Large smartphone	4.3"	1280 x 720	341.54	8"	47.7
				12"	71.5
				16"	95.4
				24"	143.1
Small smartphone	3.5"	960 x 640	329.65	8"	46.0
				12"	69.0
				16"	92.1
				24"	138.1

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Road Ahead

- Many described optimization techniques are reducible to practice now:
  - instant packet loss detection and feedback can be done entirely in UE with modest changes in software stack
  - same applies to user detection and feedback for adaptive streaming

- Some others may benefit from changes in standards, applications, and infrastructure. For example, to take advantage of prioritized delivery:
  - Video encoders should be able to produce “polarized” streams
    - E.g. by using hierarchical B or P – structures, scalable/layered coding, etc.
  - Priorities of such streams should be communicated to the network.
    - E.g. using DSCP fields, transport-level, multiple RTP streams, etc.
  - Networks should be able to recognize such priorities and react accordingly

- Standards work along all these directions is already under way:
  - MPEG: HEVC, S-HEVC, DASH, MMT
  - IETF: RTP payload formats for SVC, HEVC (S-HEVC)
  - 3GPP: evolution of LTE, DASH (hybrid delivery), MTSI
  - ITU-T: extensions of H.241, etc.

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THANK YOU!

Q&A

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