3GPP TSG RAN Workshop on REL-12 and Onwards
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LTE Rel-12 and Beyond:
Requirements and Technology Components

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Requirements

- Further improvement on spectral efficiency per square km to address data capacity demands
- Further enhancements to hotspot deployment and handling of local traffic
- Improvement on end-user experience
- Support of new use cases and deployment scenarios
  - Traffic offloading
  - Social networking
  - Proximity services
- Further improvement on network efficiency and UE power efficiency to handle diverse types of data applications
- Enhancements to leverage from cloud network architecture

Candidate Technology Components (1/2)

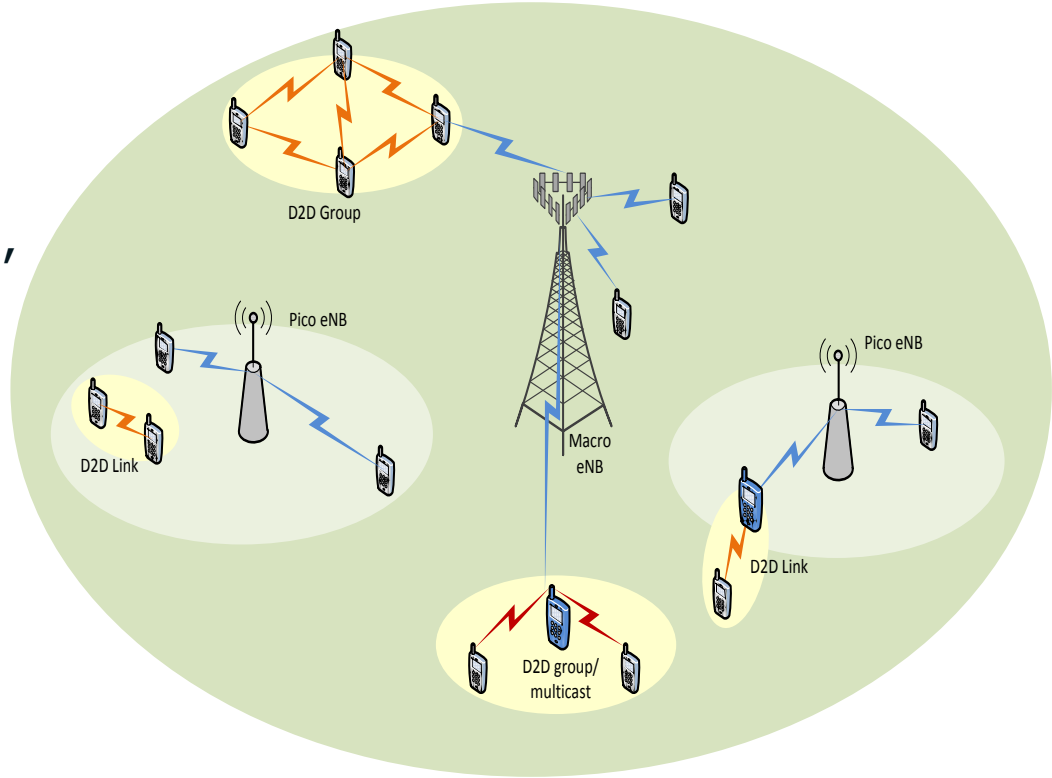
- HetNet enhancements
  - Improve handling of hotspot deployment and local traffic
  - Improve spectral efficiency per square km
  - Improve traffic offloading
- CoMP enhancements
  - Improve spectral efficiency per square km
  - Improve handling of hotspot/local traffic
  - Leverage from cloud network architecture
- Flexible, reconfigurable cell/RRH
  - Improve handling of hotspot/local traffic
  - Leverage from cloud network architecture

Candidate Technology Components (2/2)

- LTE-WLAN interworking enhancements
  - Leverage unlicensed spectrum for traffic offloading
- Opportunistic use of unlicensed spectrum for D2D communication
  - Leverage unlicensed spectrum for traffic offloading and support of new use cases
- Further enhancements for diverse data applications and MTC
  - Improve network efficiency and UE power efficiency
- RAN improvements to handle different QoE requirements
  - Improvement on end-user experience, especially during network congestion
  - Targeted for mobile video which is projected to be the dominant mobile data traffic in the next few years

HetNet Enhancements - Overview

- Use of different cell hierarchies (macro/pico/D2D) to adapt to traffic load, user distribution
- Flexible resource sharing across cell layers, e.g. FDM, TDM or co-channel
- PHY enhancements including new carrier type, use of high frequency spectrum for indoor, different TDD UL-DL configurations for small cells
- Mobility enhancements

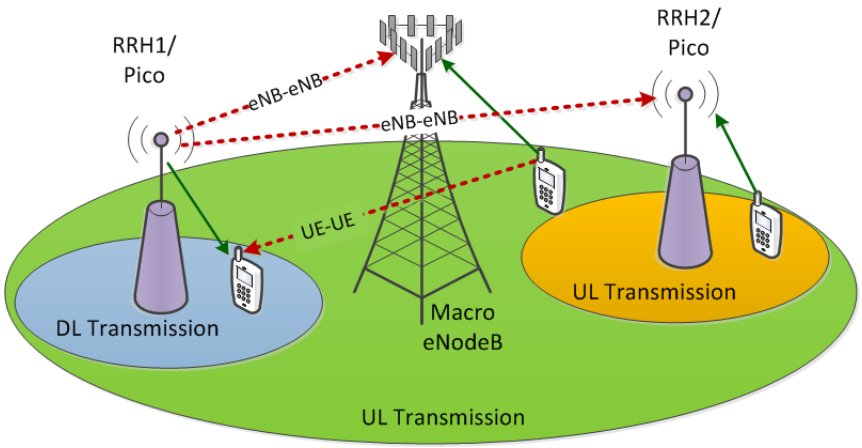


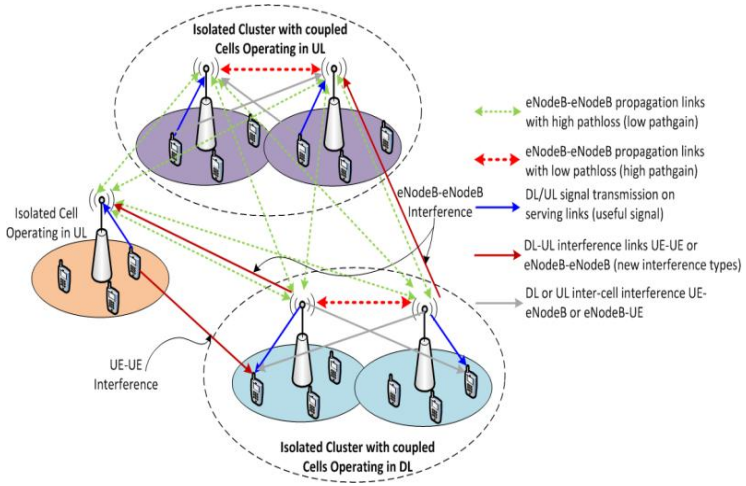
HetNet Enhancements – New Carrier Type

- Stand-alone new carrier type
  - Enable flexible deployment (also applicable for non HetNet scenario)
  - Backward compatible to Rel-11 NCT is preferred
  - Areas of enhancements
    - ePDCCH enhancement
    - ePHICH enhancement
    - UERS based DL OL MIMO
    - Small packet optimization (e.g. VoLTE, MTC)
- Benefits
  - Enhance spectrum efficiency, energy efficiency
  - Performance improvement for interference management/ICIC

HetNet Enhancements – TDD PHY

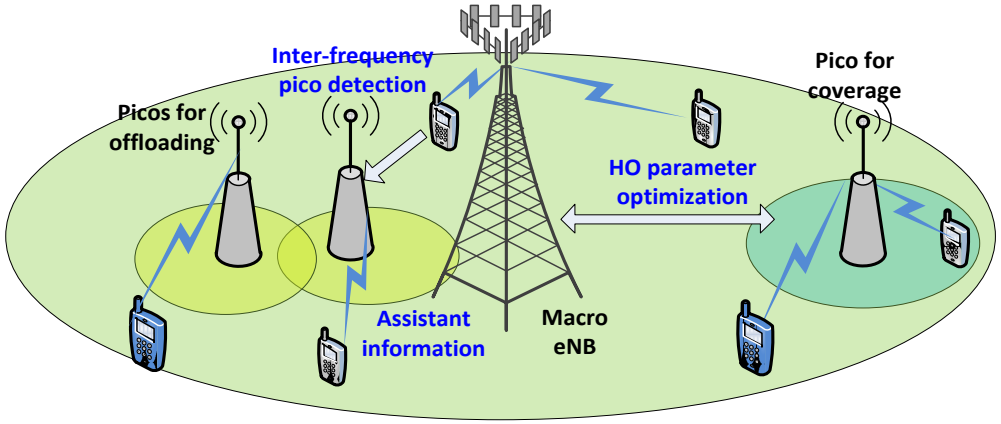
- Flexible traffic adaptation & higher packet throughput to improve user experience
- Small cells may have different UL-DL configuration from Macro- or other small cells in TDD
- Preserve compatibility and commonality with Rel-11 design
- Interference mitigation for new types of eNodeB-eNodeB & UE-UE interference





HetNet Enhancements - Mobility

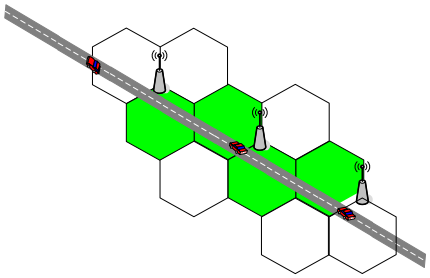
- Rel-11 HetNet mobility SI:
  - Small cell detection/identification in intra/inter-frequency cell deployment
  - Mobility functionality to take different cell-size into account
- Potential aspects for Rel-12 HetNet mobility WI:
  - HO parameter optimization e.g. RSRP based, MSE based
  - Differentiation on the usage of small cells, e.g. offloading vs. coverage
  - Indoor optimization e.g. UE assistant information
  - Improvement of cell detection and mobility for cluster of a large number of small cells
  - HO optimization leveraging features defined for CoMP operation e.g. UE-specific RS and channel configuration



CoMP Enhancements

- CSI feedback enhancements for JT
  - Depending on progress of Rel-11 CoMP WI
  - Aggregated PMI/CQI enhancements
  - Inter-node CSI feedback
  - **Note**: MIMO enhancements need to explicitly take into account JT-CoMP operation
- Identification of appropriate CoMP schemes and backhaul requirements which provide favorable tradeoff between performance and complexity in the case imperfect backhaul between nodes
- Performance investigation for realistic traffic models, e.g., video transmission and web browsing instead or in addition to FTP traffic model

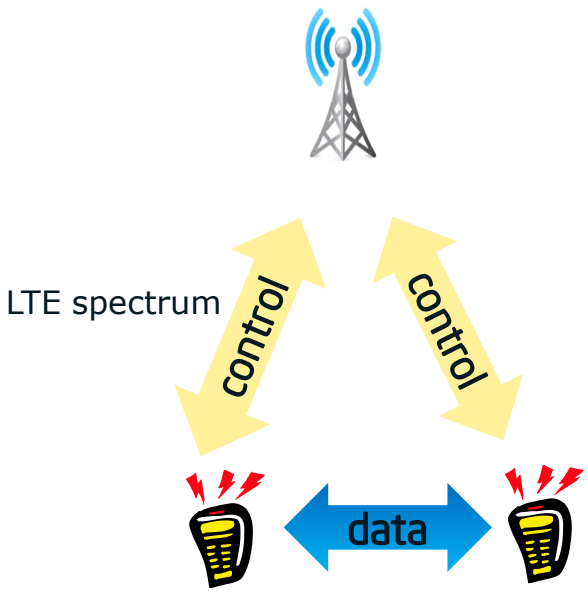
Flexible/Reconfigurable Cells



- Re-configurable cells (e.g. RRH) enables LTE network self-optimization to optimize capacity, coverage, energy efficiency and user experience.
- Mobility management: rush hour vs. off peak requires different configuration for performance and mobility management
- Energy efficiency: cellular traffic varies dramatically based on locations (e.g. home/work) and times (e.g. day/night). Cells can be selectively reconfigured and turn on/off.
- Adaptive cell reconfiguration can be enabled/enhanced by cloud network architecture.
- RAN1/RAN2 impact:
  - UE measurement in support of reconfiguration
  - Signaling support for transition between re-configurations

Opportunistic Use of Unlicensed Spectrum for D2D Local Traffic

D2D on LTE licensed spectrum
(possible use cases: public safety, offloading, social networking)

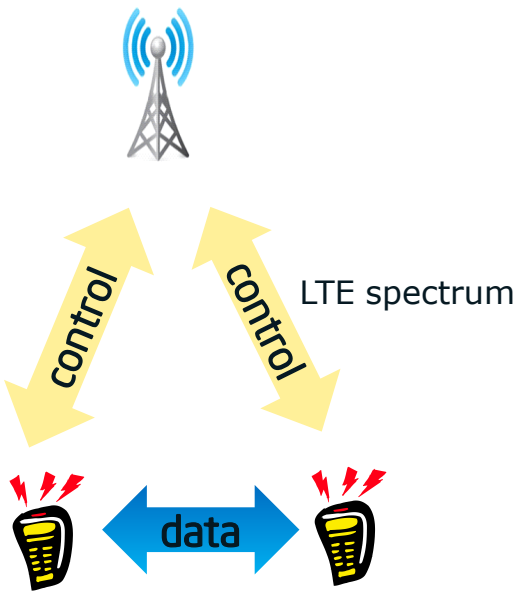


LTE spectrum
FDM, TDM or co-exist with traditional link

EPC functions:
- Initial configuration
- Session management
- Security

RAN functions:
- Proximity discovery

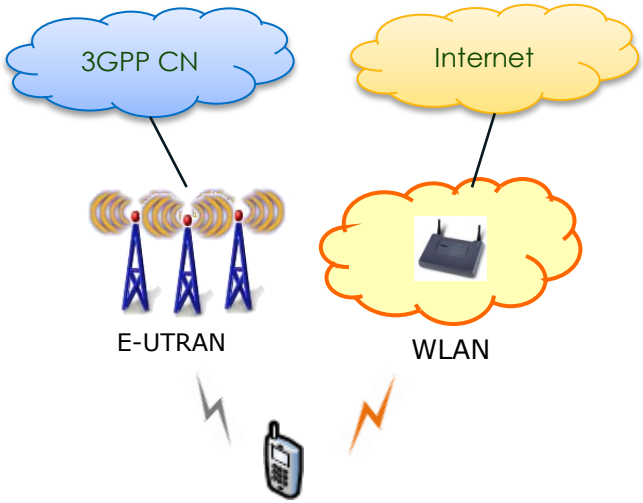
D2D on unlicensed spectrum
(possible use cases: offloading, social networking)

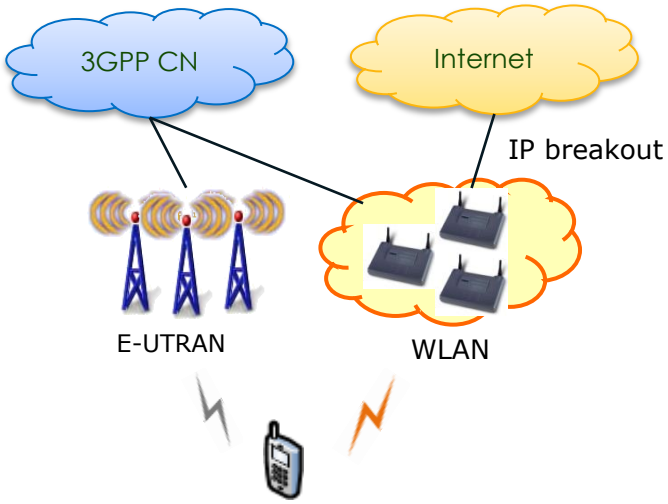


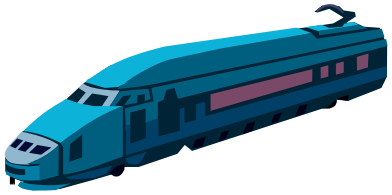
Unlicensed spectrum
WiFi Direct

Use of unlicensed spectrum for D2D communication offloads traffic from licensed spectrum and avoid interference between eNB-UE link and D2D link

LTE-WLAN Interworking – Possible Deployment Scenarios







Hotspot WLAN deployment with little integration and non-seamless offload

- Most of deployments today. Non-seamless offload. User experience is not always satisfactory
- In future – WLAN offload to multiple WLAN networks, roaming agreements with multiple WLAN service providers

WLAN deployment as extension of LTE network to meet increasing data demands, seamless offload

- Similar level of user experience is expected from WLAN and LTE
- Session continuity is maintained. Data interruption during HO should be minimized
- Some level of network control as for intra-3GPP mobility is desirable

High speed trains, bus or other moving transport:

- LTE backhaul, WLAN access

LTE-WLAN Interworking - RAN Enhancements

- RAN level enhancements for non-seamless WLAN offload
  - Goal: Improved UE battery life, WLAN connection time and success rate, and WLAN network utilization
  - RAN provides assistance information (e.g. timely loading information, surrounding APs) to the UE to facilitate UE's detection of WLAN network and to improve offloading efficiency.
  - Possible ANR between 3GPP and WLAN to reduce OAM effort and OPEX
- Seamless WLAN offload at the core network layer provides service continuity, but loss of packets during HO can still occur
  - Enhancements described above for non-seamless offload still apply
  - Optimization to minimize data loss due to lost of WLAN or LTE coverage
- Network initiated HO to WLAN for better operator's control
  - Also addresses high speed train scenario when a UE moves in/out of the train

Further Enhancements to Support MTC

- New Rel-12 work item on Machine Type and Smartphone Communications Enhancements (MTSC) was approved in SA2#90.
- 4 new work items which are the building blocks for MTSC parent feature were approved
  - Small Data and Triggering Enhancements (SDDTE) – RAN impact
  - UE Power Consumptions Optimizations (UEPCOP) – RAN impact
  - Group based features (GROUP) – RAN impact
  - Monitoring Enhancements (MONTE)
- In addition to the above potential RAN impacting features, additional RAN specific enhancements can be considered:
  - Optimization for stationary/low mobility
  - Support of multi-personality (both MTC and non-MTC) device
  - Support of MTC traffic with different QoS constraint

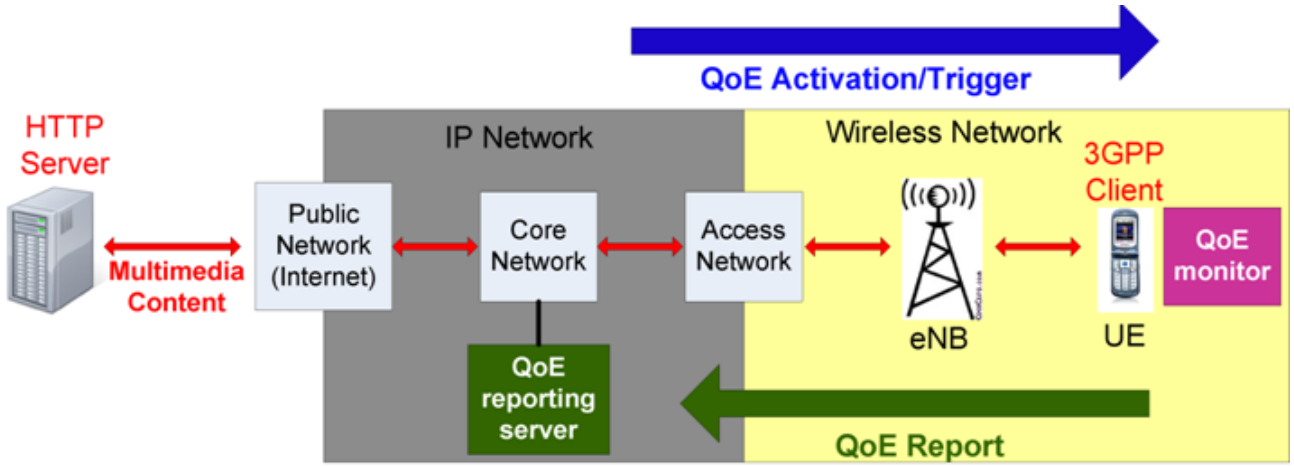
Further Enhancements to Support Diverse Data Applications

Un-attended Mode

Attended Mode

- Rel-11 eDDA WI focuses on RAN enhancements for the following to reduce (a) power consumption and (b) signaling overhead:
  - Un-attended mode background traffic (e.g., updates on Skype, Facebook, Stock, Weather, etc) and
  - Attended mode IM traffic (e.g., QQ, Yahoo messenger, etc.)
- Rel-12 eDDA extensions may consider RAN enhancements for the following to reduce (a) power consumption and (b) signaling overhead:
  - Attended mode active traffic (e.g., YouTube, Pandora, Skype, FaceTime, QQ, WhatsApp, Interactive Gaming (Chess, Halo, etc), etc.)

RAN Enhancements for Video Streaming QoE



- Growing importance of video streaming optimizations with increasing consumer demand for mobile video services. HTTP-based Video Streaming solutions expected to be adopted broadly.
- 3GPP SA4 developed the Dynamic Adaptive Streaming over HTTP (DASH) standard for HTTP-based video streaming.
- QoE optimization at RAN level is essential for HTTP streaming. It targets directly end-user experience and is not the same as QoS optimization. Capacity gain observed is shown in the Appendix.
- RAN impact:
  - Develop QoE-based capacity evaluation methodologies for HTTP-based video streaming
  - QoE-aware RAN optimizations, including QoE-aware radio resource management, scheduling, service differentiation, etc.

RAN Enhancements for Internet Video Call

- **<u>Problem</u>: Currently, all OTT applications are treated the same. Unacceptable long delay for real-Time traffic during congestion**
  - Available bandwidth for users in mobile network changing due to interference, fading, and other users' traffic. Internet video call application, e.g. Skype, adapts its audio/video rate in a range from <0.1Mbps to several Mbps, e.g. HD
- **<u>Possible solution</u>: Intra-Flow (Sub-QCI) Prioritization**
  - Audio consumes significantly less bandwidth than video, especially when the total rate is high (>1 Mbps). Prioritize audio over video of the flow in response to temporal bandwidth drop to ensure good audio quality and prevent call drop.
- **<u>Standard Impact</u>: Intra-Flow (Sub-QCI) Classification**
  - Apps provide intra-flow (sub-QCI) classification info (note: non-IMS apps may not follow standardized (RTP) header format and therefore intra-flow classification must be provided by the app explicitly)

Approach #1: Network-Initiated Intra-Flow Classification

Approach #2: UE-assisted Intra-Flow Classification

Appendix: RAN Enhancements for Video Streaming QoE

Video Streaming QoE Enhancements (1/2)
Capacity Evaluation

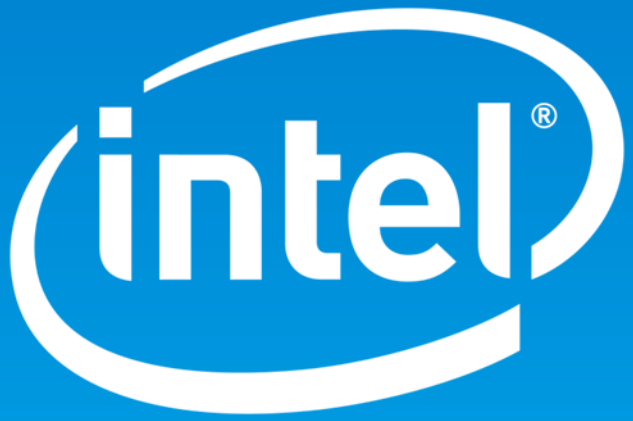
- Based on QoS (delay):
  - Consider the 95th percentile of the 95th percentile delay (across all MAC PDUs) across all users
  - Delay includes PHY (HARQ re-tx) delay and MAC (scheduling) delay, but not TCP re-tx delays
  - **Threshold for QoS criterion = 280 ms**
- Based on QoS (throughput):
  - Consider the 5th percentile long-term average throughput across all users
    - "long-term average" = throughput averaged over all MAC PDUs during the entire video session
  - Data unit size: MAC PDU
  - **Threshold for QoS criterion = Video source rate = 225.15kbps**
- Based on QoE:
  - 95% of the users should experience **re-buffering for less than or equal to 5% of the time**

# of users	MAC PDU thpt (kbps) [5th percentile]	MAC delay (ms) [95th percentile]	% Rebuffering [95th percentile]
18	258.25	99.84	0
19	234.20	191.97	0
25	197.86	564.68	4.55
26	177.69	650.63	6.07

User capacity values observed considering QoE vs. QoS metrics differ by more than 31%!

Video Streaming QoE Enhancements (2/2)
Potential QoE-aware RAN Optimizations

- Appropriate QoE-related metrics (e.g., rebuffering percentage, # of frames in the client playback queue, frame loss percentage, etc.) may be utilized to enable QoE-aware RAN optimizations for video streaming
- To enable an efficient tradeoff between user satisfaction and system performance, QoE metrics may be used in the RAN to further optimize
  - scheduling at the eNodeB
  - admission control
  - service differentiation
- Initial evaluations indicate capacity gains of about 20~25% for buffered as well as live video streaming with QoE-aware RAN and adaptive streaming when compared to the use of adaptive streaming alone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