Motivation for SI: Further LTE D2D Enhancements for Wearables and MTC

3GPP TSG RAN Meeting #71
Göteborg, Sweden, March 7-10, 2016

RP-160427

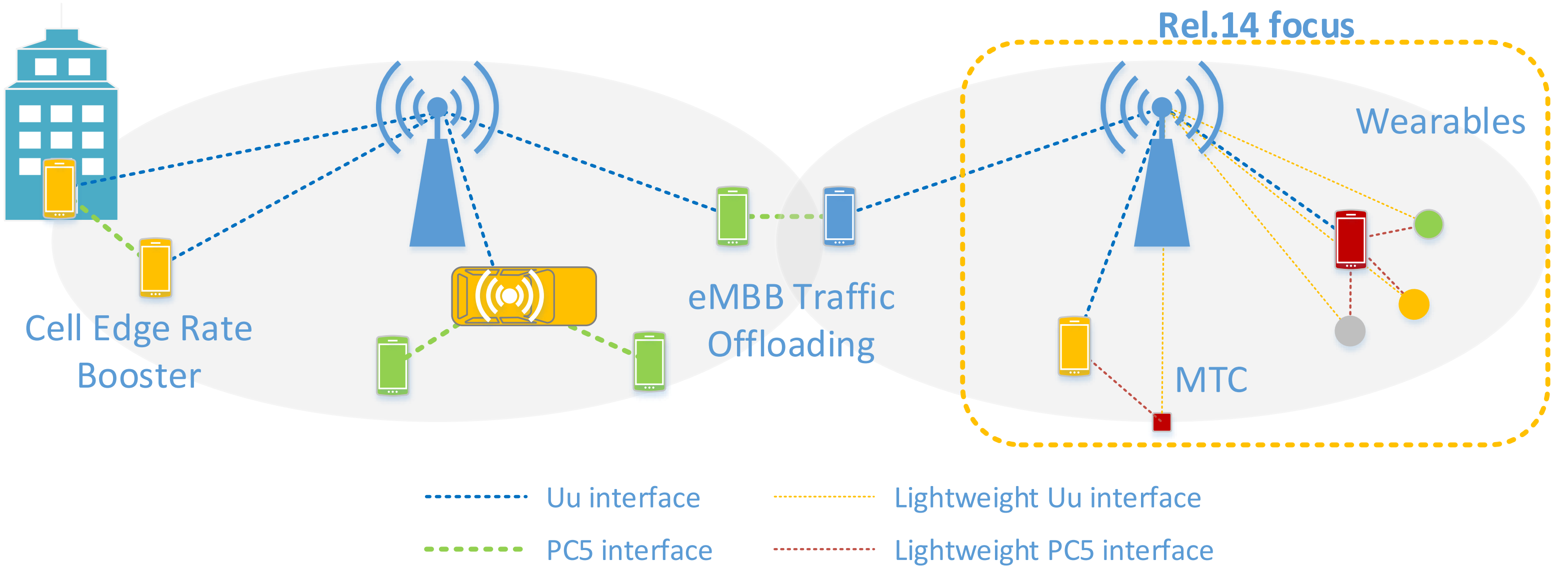
Background

Use cases and work directions from RAN#70

- Wearable & eMBB [1-5], [10-11]
  - Energy & spectral efficient operation of wearables and traffic management through enhanced D2D relaying, including operation in unlicensed spectrum
  - Support of non-3GPP RAT relaying (e.g. Bluetooth and Wi-Fi) [5]
- MTC [6-7]
  - More energy & spectrum efficient transmission in coverage limited scenarios utilizing D2D relaying
- Companion device [8-9]
  - Enhanced connectivity for companion devices to connect to E-UTRAN through another UE considering both 3GPP and non-3GPP air-interfaces

Request from 3GPP RAN chair – converge the scope of Rel.14 work

Identified use cases



Proposed prioritization for LTE Rel.14 work: Wearables ≥ MTC > eMBB

Requirements overview

Wearable sensors (e.g. fitness, health, and wellness sensors)

- Ultra-low-power, low-data-rate, low range, no mobility and low cost

Wearable (e.g. watch, glasses and camera)

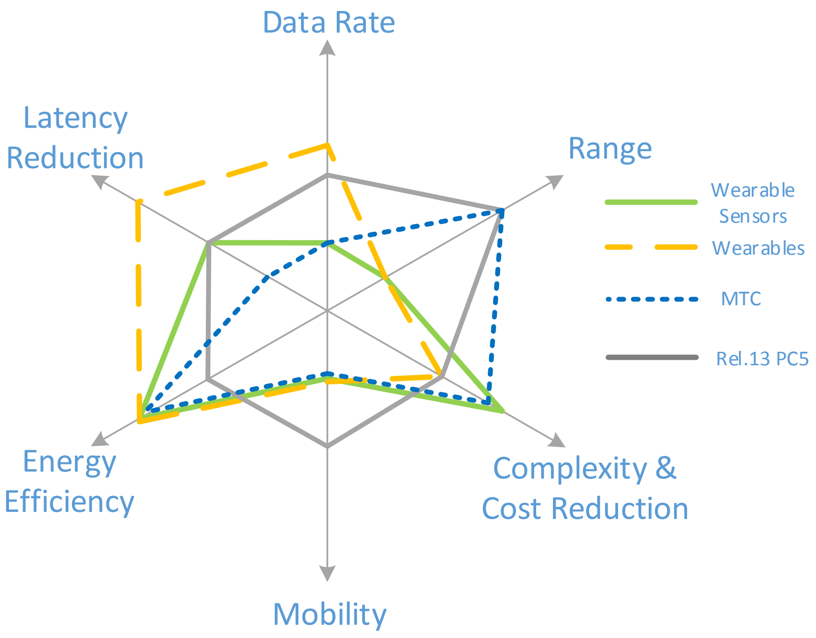
- Ultra-low-power, high-data-rate, low range, no mobility and low latency

MTC (e.g. smart meters)

- Ultra-low-power, low-data-rate, deep coverage, no mobility and low cost

All of the above are IoT use cases

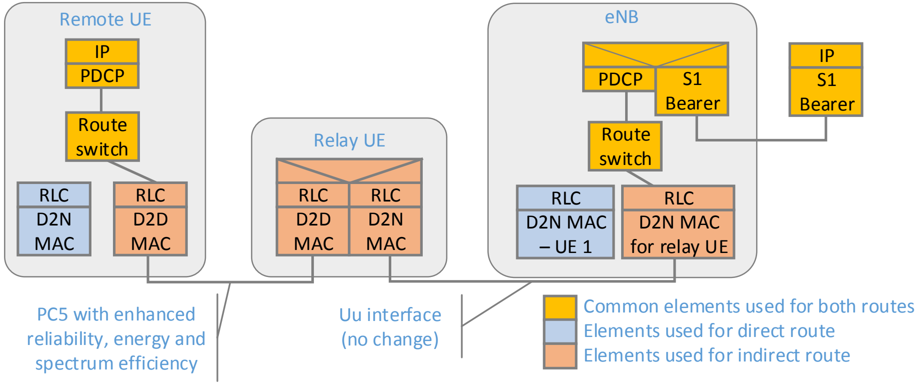
PC5 interface



Rel.14 FeD2D enhancement vectors

Layer 2 relay

- Relay UE assisted connection management
- Radio aware path switching and service continuity
- Integrated security
- Generic architecture to support 3GPP/non-3GPP RAT for D2D



PC5 efficiency enhancements

- Spectrum & energy efficient communication and reduced complexity
- Link adaptation and feedback mechanisms (power, MCS, resources, number of transmissions)

Low power and low complexity / cost PC5

- Narrow bandwidth operation (eMTC and NB-IoT like devices)
- Support of PC5 for eMTC and NB-IoT devices using single TX/RX chain

Limitation of Rel-13 UE-to-NW relay

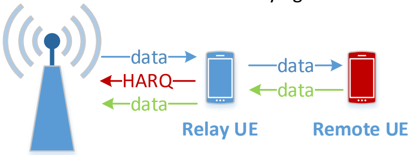
Aspect	L2 relay	L3 relay in Rel-13
Traffic multiplexing from multiple remote UEs	Multiple options possible: 1) Each remote UE maps to a single radio bearer, 2) Multiple remote UEs multiplexed onto a single radio bearer on Uu, with new protocol layer to perform multiplexing	Relay UE multiplexes multiple remote UE packets into one radio bearer. Prioritization at eNB may be challenging
Control plane traffic routing	SRB traffic can be routed	Not supported
IP address assignment	No new methodology at relay UE to assign IP	Relay UE needs to be capable to assign an IP address
Security	Remote UE to eNB security establishment, relay UE cannot decipher data from remote UE	Remote UE to relay UE security establishment is needed; relay UE to eNB will be traditional AS level sec.
While remote UE In-coverage	Remote UE traffic may be mapped to its own EPS bearer at eNB (assuming that the remote UE is in connected mode between switching)	Mapping to its own EPS bearer may not be possible
Service interruption time when switching from direct path to relay path	L2 reconfiguration: bearer reconfiguration (release Uu and send over D2D radio bearer; depends on option for relay to eNB bearer configuration)	With multi-connectivity (direct path and relay path), application takes care of service continuity (make-before-break and break-before-make possible)

PC5 limitations for UE-to-NW relay

L2 and L3 relaying w/o L1 enhancements may have the following limitations:

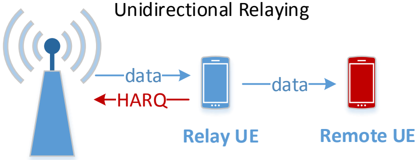
- Complexity and energy efficiency
  - Support/processing of multiple resource pools
  - Excessive blind decoding and uncoordinated parallel TX/RX processes
  - Non-aligned transmission/reception timelines across eNB / Relay UE / Remote UEs
  - Excessive transmission power over PC5
- Peak and average data rate
  - Concurrency between SL TX, SL RX, UL TX negatively affects data rate
  - Control overhead of RLC or TCP retransmissions and associated inefficiency
  - Channel quality unaware MCS setting, resource assignment/selection

Bidirectional Relaying



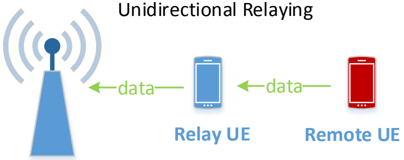
TX (Cellular HARQ) & TX (SL)
TX (SL) & RX (SL)
TX (Cellular) & RX (SL)
- conflicts at Relay and Remote nodes

DL
Unidirectional Relaying



TX (Cellular HARQ) & TX (SL)
- conflict at the Relay node

UL
Unidirectional Relaying

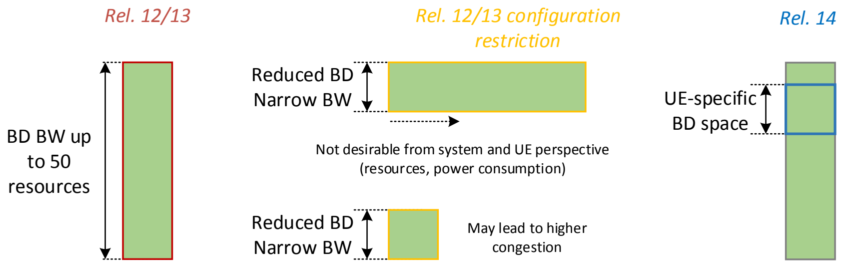


HD constraint:
TX (Cellular) & RX (SL)
- conflict at the Relay node

Enhanced PC5: Low rate / low complexity

More energy efficient, reduced complexity / cost than Rel.12 D2D

- Support of narrowband 1.4 MHz and/or 200 kHz UEs (eMTC and NB-IoT)
- Support of single RX chain remote UE with reduced RF and BB complexity
- Complexity reduction at Relay UE
- Intelligent transmit power settings taking into account PC5 link quality
- Power saving communication modes (smarter duty cycles e.g. DRX)
- Low complexity link adaptation (MCS, power, resource) and feedback mechanisms



References

[1] RP-151754, “Motivation for SI: Further LTE D2D enhancement for eMBB and wearables”, Intel Corp., December 2015

[2] RP-151753, “New SI proposal: Study on further LTE D2D enhancement for eMBB and wearables”, Intel Corp., December 2015

[3] RP-152221, “New SI proposal: Study on further LTE D2D enhancement for eMBB and wearables”, Intel Corp., December 2015

[4] RP-151934, “Wearable Devices based on LTE technologies”, Huawei, HiSilicon, December 2015

[5] RP-151971, “Discussion on D2D enhancements for LTE in Rel-14”, Huawei, HiSilicon, December 2015

[6] RP-151946, “Motivation for WI on D2D based MTC” Qualcomm Incorporated, December 2015

[7] RP-151948, “New WI proposal on D2D based MTC” Qualcomm Incorporated, December 2015

[8] RP-151947, “Motivation for new SI on enhanced connectivity for companion device”, LG Electronics, December 2015

[9] RP-151949, “New SI proposal: Study in enhanced connectivity for companion device”, LG Electronics, December 2015

[10] RP-152007, “D2D Communication for commercial use cases”, ZTE Corporation, December 2015

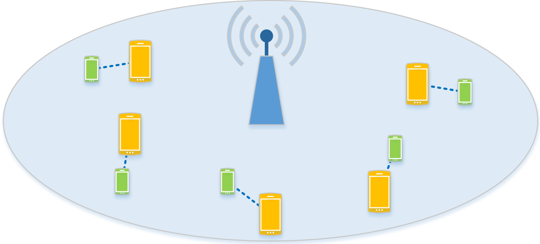
[11] RP-152009, “D2D Communication for commercial use cases”, ZTE Corporation, December 2015

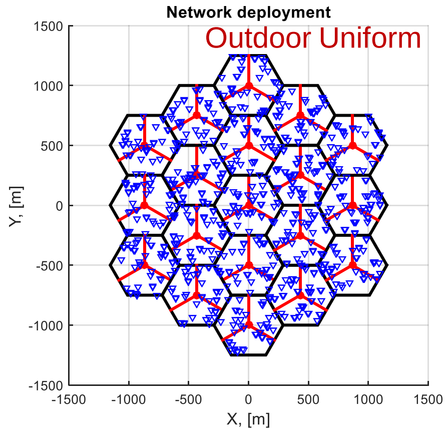
[12] RP-160267, “New SI proposal: Further LTE D2D enhancement, UE to Network relays, for IoT and wearables”, Qualcomm Incorporated, Intel, Huawei, HiSilicon, March 2016

Backup:
LTE Wearable
Initial Performance Analysis

Evaluation assumptions

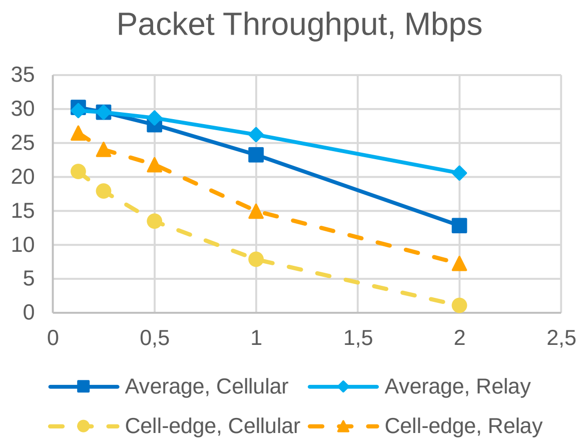
Parameter	Value/Reference/Comment
Deployment Scenarios	Homogeneous macro scenario, ISD = 500m, all UEs outdoor UE drop: 5 UE pairs per sector. Each pair is composed from a relay UE and a wearable UE. The wearable UE is dropped in [1:5]m random uniform range from the relay UE.
Spectrum	10MHz@2GHz, FDD
Traffic model	FTP Model 3, 0.5 Mb file size
Channel model	3GPP TR 36.843
Power control	eNB max power 46 dBm, UE max power 23 dBm. UL: P_0 is set to satisfy 20 dB UL SNR, α = 0.8. D2D: P_0 is set to satisfy 20 dB D2D SNR, α = 1.
Resource allocation	50 PRBs on all layers
Performance metric	Packet throughput: $PT = \frac{Packet\_size}{Packet\_TX\_time}$, Normalized Energy Efficiency: $EE_N = \frac{EE}{PT}$
Relay selection	Pre-assigned based on UE drop
Antenna configurations	Relay UE: 2 RX MTC/Wearable UE: 1 RX

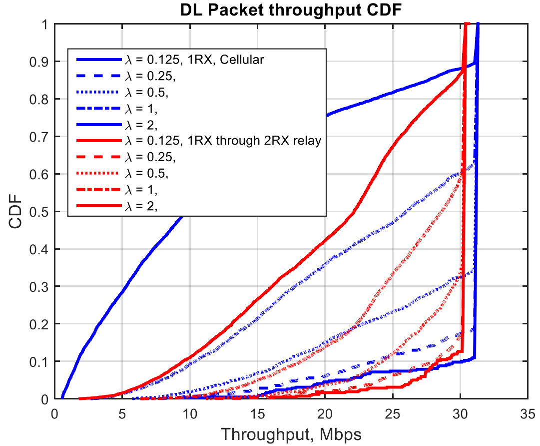




DL offloading throughput gain

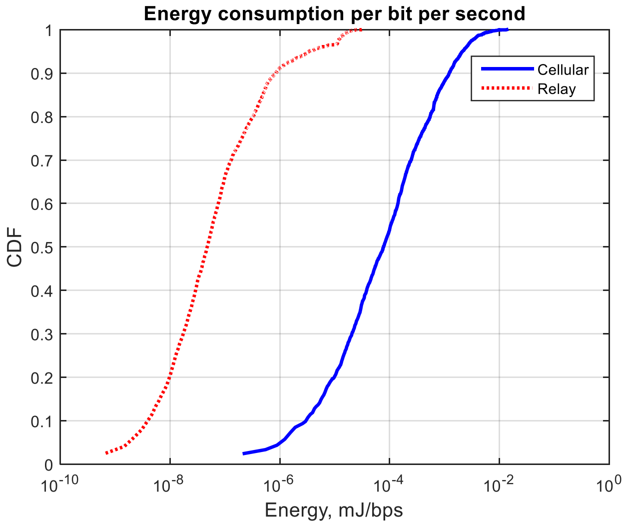
- <u>Cellular case</u>
  - wearable UEs download traffic using 1 RX antenna
- <u>Relaying case</u>
  - relay UE downloads packets with 2 RX (rank adaptation) and forwards it in SL using rank-1 towards wearable UE
- <u>Performance gains</u>
  - improved DL resource utilization in case of Rank 2 transmission and reduced overall interference load in DL (so called turbo effect)
- Note:
  - Relay and cellular scenarios have slightly different upper bounds in packet throughput due to a bit higher latency of 2-hop relay operation





UL offloading and energy efficiency

Radiated energy efficiency



- Significant savings in radiated energy for wearable UEs
- Significant saving in radiated energy normalized per packet throughput (file transfer time)

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