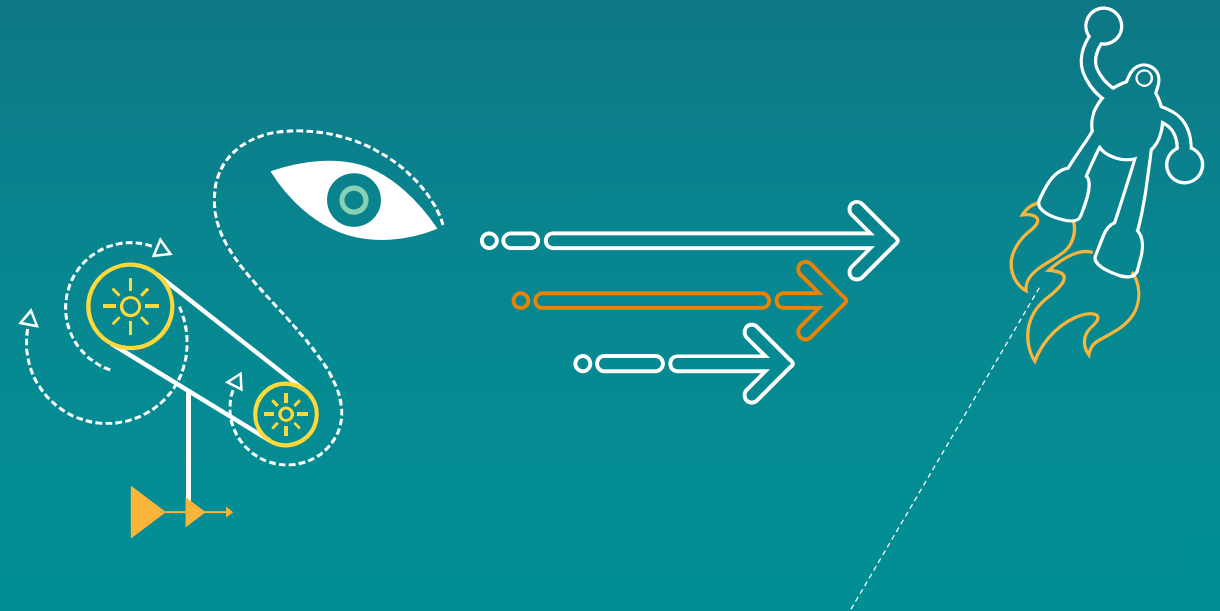


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# Motivation for SI proposal on Further Enhancements to LTE Device to Device

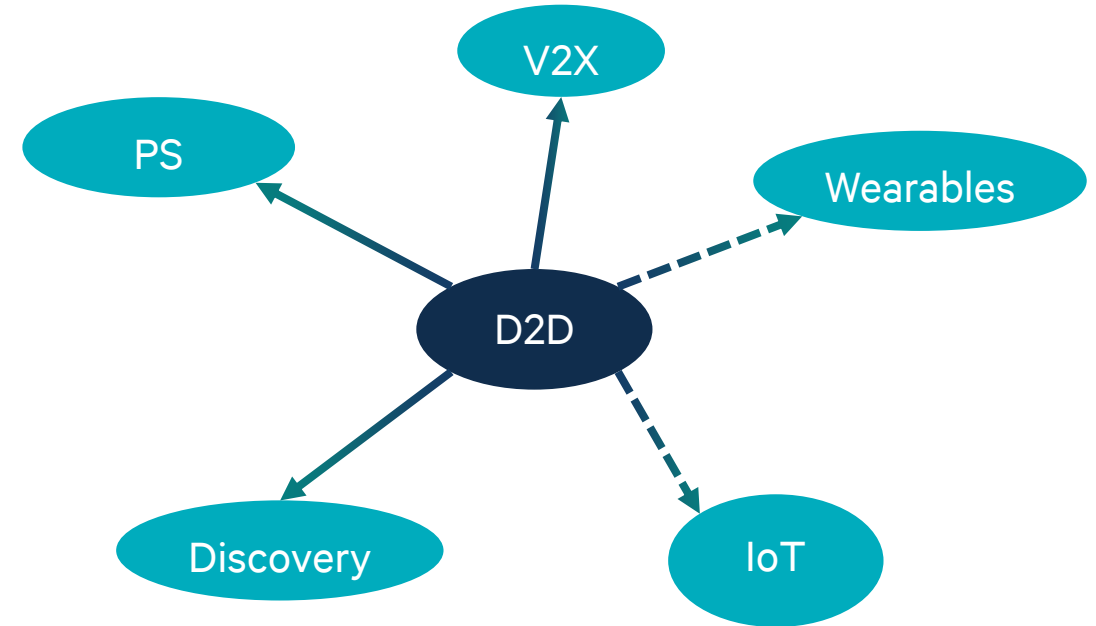
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# Background: D2D successfully standardized in R-12 & R-13

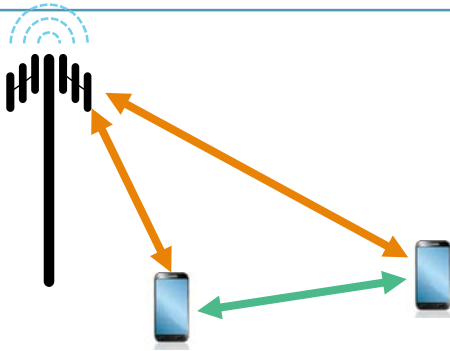
## R-13 eD2D core completed this quarter

- D2D first introduced in Release 12
  - D2D discovery for commercial & Public Safety use cases
  - D2D groupcast communication for Public Safety
- Enhancements to D2D continued in Release 13
  - D2D discovery enhancements to inter-frequency
  - D2D based UE to Network relays
- D2D based V2X being explored in Release 14
- D2D also has applications to IoT and wearables that need to be explored

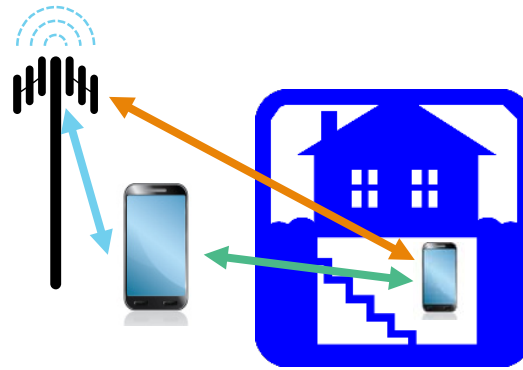


# Use Cases

## IoT



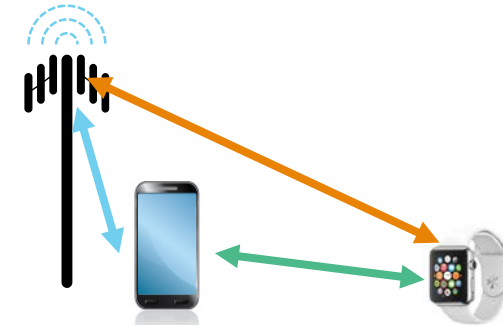
- Single modem solution for proximal and cellular communication
- Operator controlled proximal communication



- Deep coverage operation (MCL 165dB)
- Large amount of bundling needed – power impact
- Relaying can reduce the power consumption

- Cost
- Power consumption

## Wearables



- Wearables getting increasingly complex
- Moving towards independent operation with full LTE modem
- D2D advantages: range, security, power, throughput, & device cost
- Example: lower end device with lower max transmit power and throughput capability

- Cost
- Power consumption
- Throughput

Key  
considerations

---

# Several Enhancements Needed to Current D2D Design

Enhancements needed to enable power efficiency, low device cost, and throughput

- Assumption: All LTE devices have WAN connectivity & D2D occurs on the licensed spectrum
  - Devices with no 3GPP RAT may not have direct WAN connectivity
- Short comings of current D2D design
  - Incompatible with NB-IoT waveforms
  - Low cost D2D solution
  - No feedback channel at phy/mac layer
  - No power optimizations
  - No service continuity for current relay solutions
  - Currently only considers 3GPP RAT

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# Proposal: Low Cost D2D Devices

## Allow NB-IoT & MTC devices to engage in D2D

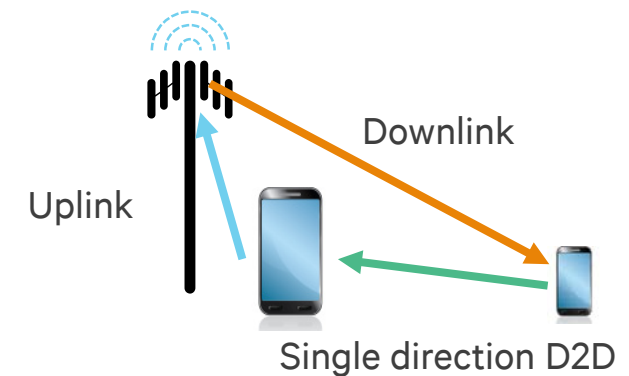
- NB-IoT: D2D transmission using NB-IoT uplink waveform
  - Changes needed for multi-tone transmissions are likely small
  - Single tone transmission requires more changes
  - Some signaling & procedure changes maybe needed
- MTC: No major changes needed
  - No waveform incompatibility between D2D and MTC
  - Some signaling & procedure changes maybe needed
- Category 0 and above devices to communicate with NB-IoT and eMTC devices using D2D
- Cost reduction via re-using downlink receive chain for D2D comm. reception

# Proposed D2D Enhancements: Uni & bi-directional relays

Unidirectional relays enable “zero RF cost” solution & scalable relaying

- Multiple relay configurations

Remote UE cost	FDD	TDD
D2D & WAN co-channel, i.e., same carrier	D2D-Tx: Free D2D-Rx: Adds cost	D2D-Tx: Free D2D-Rx: Free
D2D & WAN not co-channel, i.e. different carrier	D2D-Tx: Adds cost D2D-Rx: Adds cost	D2D-Tx: Adds cost D2D-Rx: Adds cost



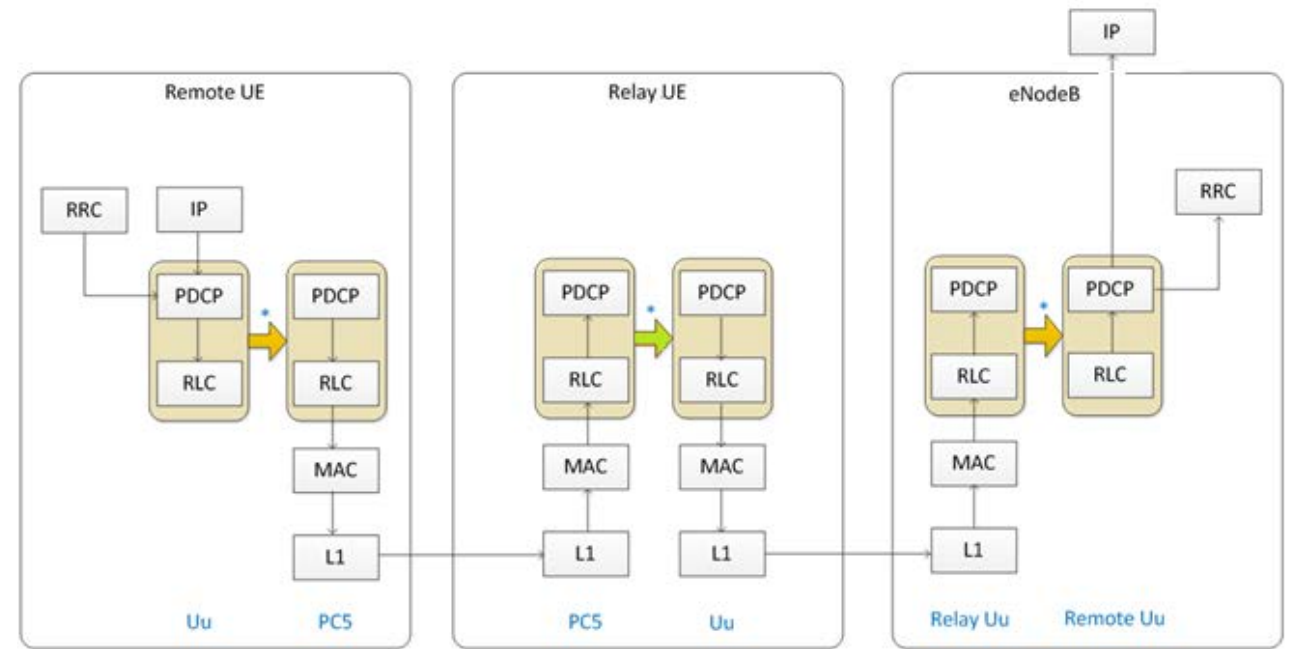
Uni-directional relaying

- Focus on co-channel relaying -- D2D tx comes for free
- Unidirectional relaying does not add any RF cost
- Unidirectional relays do not suffer from half duplex issue on D2D
  - Enables a single relay to relay larger number of remote UEs
  - Each household is expected to have a large number of MTC devices

# Proposal: Enhanced Relays

## L3 based relays no longer sufficient

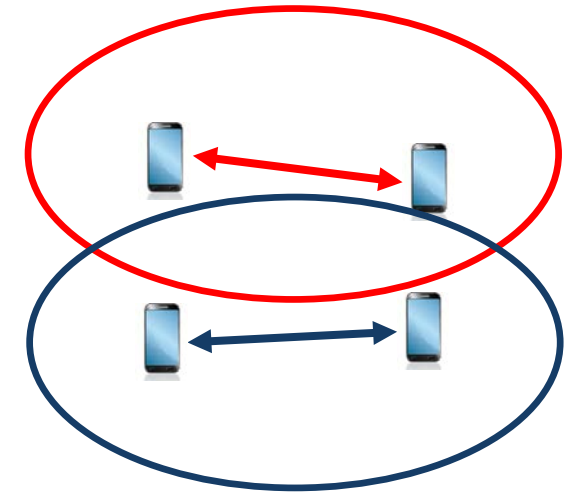
- L2 based relays enables eNodeB to know control and user plane packets of the remote UE – better resource allocation
- Relay D2D link can be WiFi, BT
  - BT, WiFi devices become visible to eNB
  - End to end security
- Relaying of control plane packets improves efficiency
  - Example: connection setup, attach signaling
- Service continuity needs to be enabled
  - Especially applicable to wearables



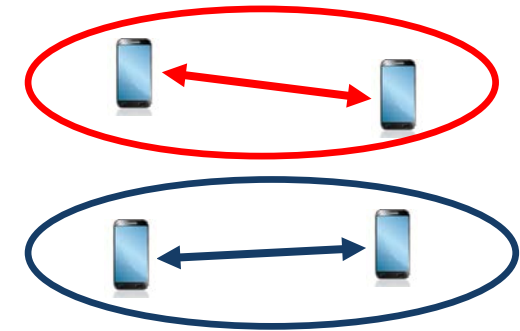
# Proposal: D2D Link Enhancements

Introduce feedback for D2D at least at L2 level

- Adaptive power control to increase spatial reuse
- Adaptive rate control to support higher data rates
- New measurements may need to be defined
- Introduce L2 level feedback, e.g., RLC AM mode for D2D
  - Improves link reliability
- Power optimizations, e.g., using D2D DRX



Interference due to no power control



Increase reuse with power control



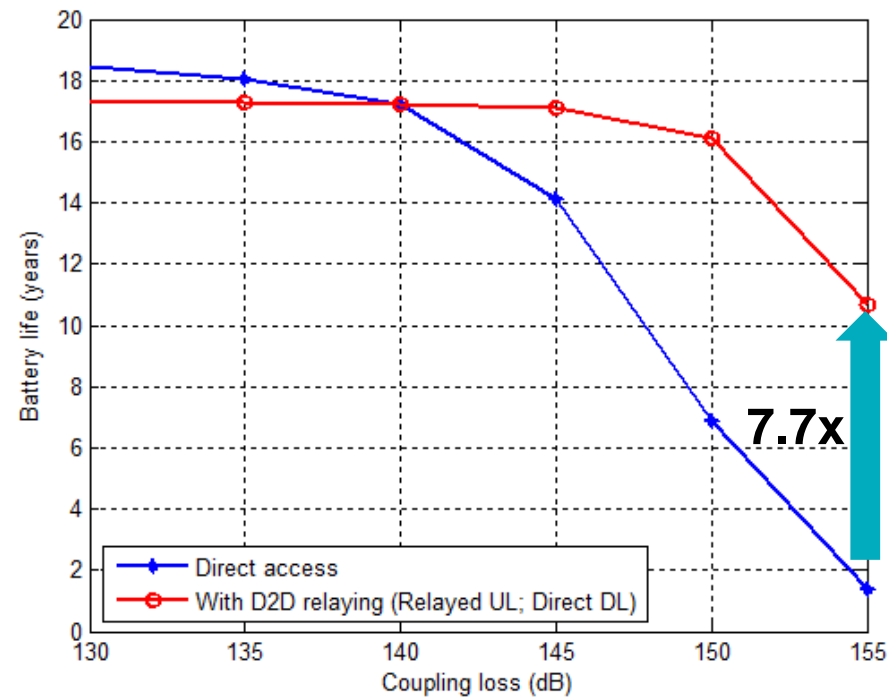
# Initial Results: Battery life advantage

Improved battery life due to reduced tx bundling requirements with unidirectional L2 relays

Arad/Neptune watermeter

Traffic: 2 Tx/day, 4KB/Tx

UE: 1.4MHz NB (Cat-M), 20dBm, 15 Wh battery



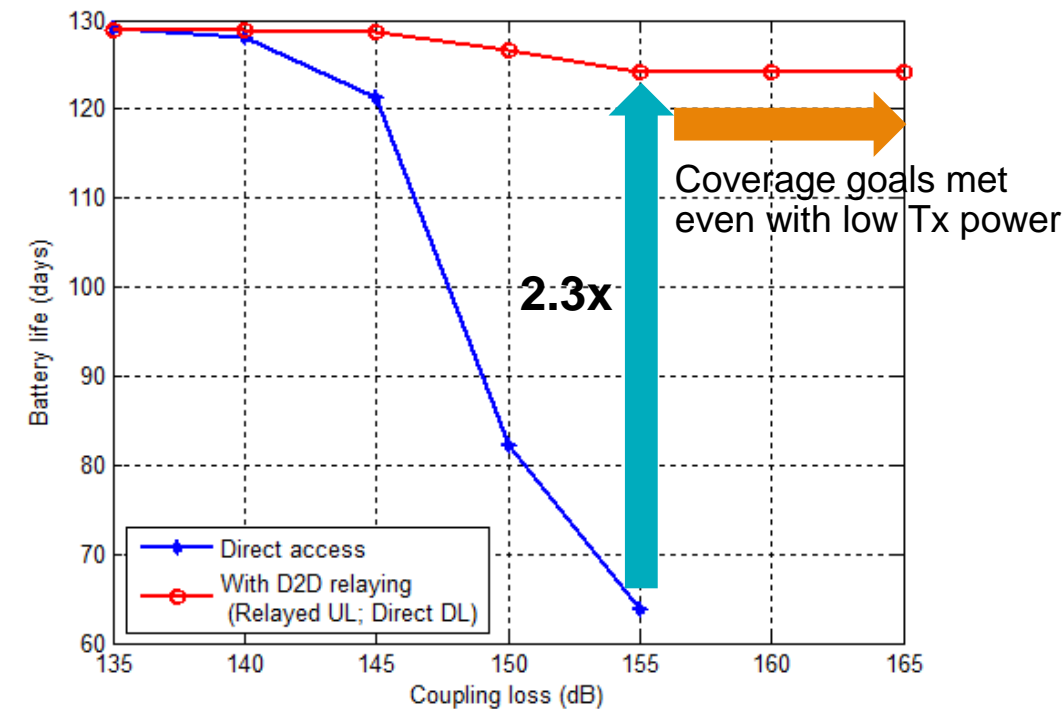
\* eI-DRX with cycle of 10.24x256sec

\* No D2D-link adaptation (max power tx, 4 blind HARQ)

NB-IoT

Traffic: 1 Tx/hr, 100B/Tx

UE: 180kHz NB (NB-IOT), 10dBm, 5 Wh battery



\* eC-DRX with cycle of 10.24sec

\* No D2D-link adaptation (max power tx, 4 blind HARQ)

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# Thank you

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