

UCP simulation: Approach and Initial Results

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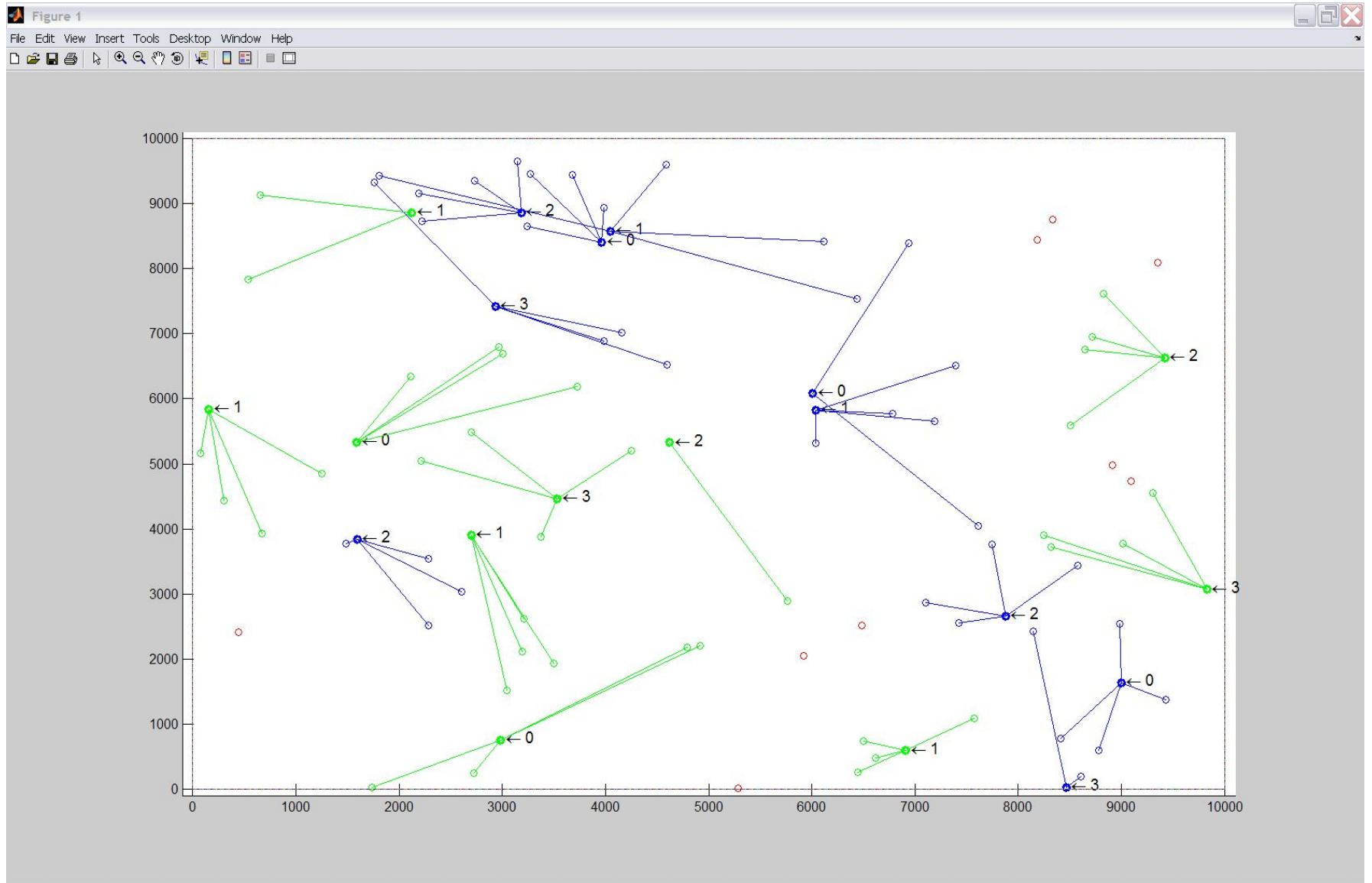
UCP simulation: Approach and Initial Results

Paul Piggin
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Presentation Overview

- Present a simulation environment for proof of concept of UCP (Uncoordinated Coexistence Protocol) – sub clause 6.4.2.4 in P802.16h/D1
- Considering 3.65GHz, looking to demonstrate coexistence with 802.11y and supporting a solution based on UCP
- Simulation overview:
 - Equipment
 - Environment
- LBT and EQP/aEQP features and simulation results
- Further work

Definition of the *Simulation Space*



High-level simulation model

- Current traffic model – full buffer
- 802.16h initial assumptions for equipment are similar to *WiMAX Forum Release 1* certification parameters
- 802.11 model (under development) but based on 802.11a 5GHz OFDM with some modifications defined by 802.11 TGy
- Simulation 1-10secs, with $1\mu\text{s}$ resolution, averaged n times to generate a data point in the results that follow

Simulation assumptions: Equipment I

- 5ms frames
- 47 symbols per frame
 - 26 in the downlink (1 for preamble)
 - 21 in the uplink
- 102 μ s symbol duration
- RTG=60 μ s, SSTTG=SSRTG=50 μ s (WiMAX Forum TWG parameters), TTG >50 μ s

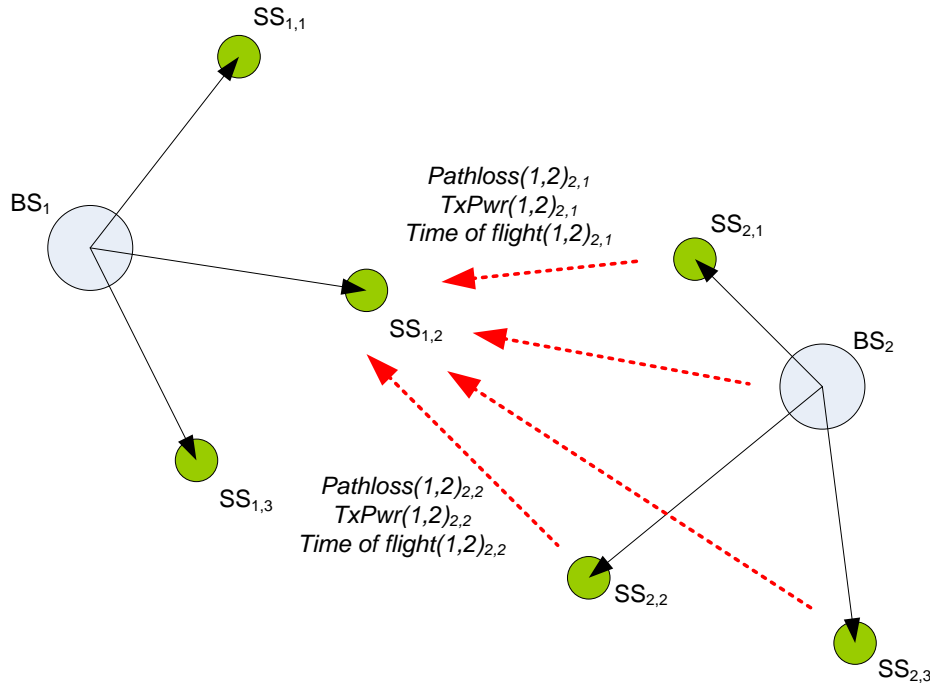
Simulation assumptions: Equipment II

- 0 dBi antenna BS and MS (omni)
- 10MHz channels (5 channels in the simulation)
- 3 modulation schemes supported:
 - CTC QPSK $\frac{3}{4}$ (sensitivity -85.1dBm, Pwr = 20dBm)
 - CTC 16QAM $\frac{1}{2}$ (sensitivity -82.8dBm , Pwr = 17dBm)
 - CTC 16QAM $\frac{3}{4}$ (sensitivity -78.7dBm, , Pwr = 17dBm)
 - (NB AWGN from WiMAX Forum RCT v1.0.0)
- Noise Figure = 6dB (BS & SS)
- Adjacent channel rejection (all modulation schemes):
 - $n \pm 1 = 10\text{dB}$
 - $n \pm 2 = 30\text{dB}$
 - $> n \pm 2 = 40\text{dB}$

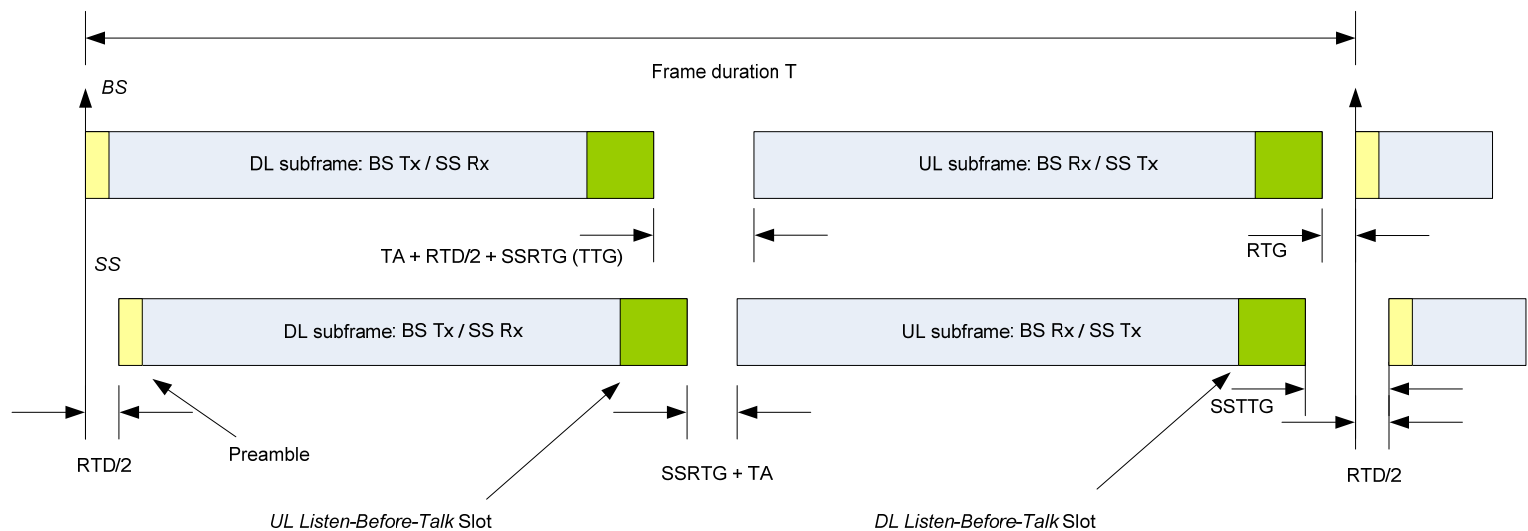
Simulation assumptions: Environment

- 1km square simulation area
- Free space path loss model ($n=2$)
- No height variation in devices
- Specify x 802.16h BS and y 802.11y APs
- Up to z SS/STA associated with each BS/AP, respectively
- UCP:
 - DCS (undertaken once at the beginning of the simulation to distribute frequency allocation)
 - EQP/aEQP
 - LBT

Interference geometry calculation

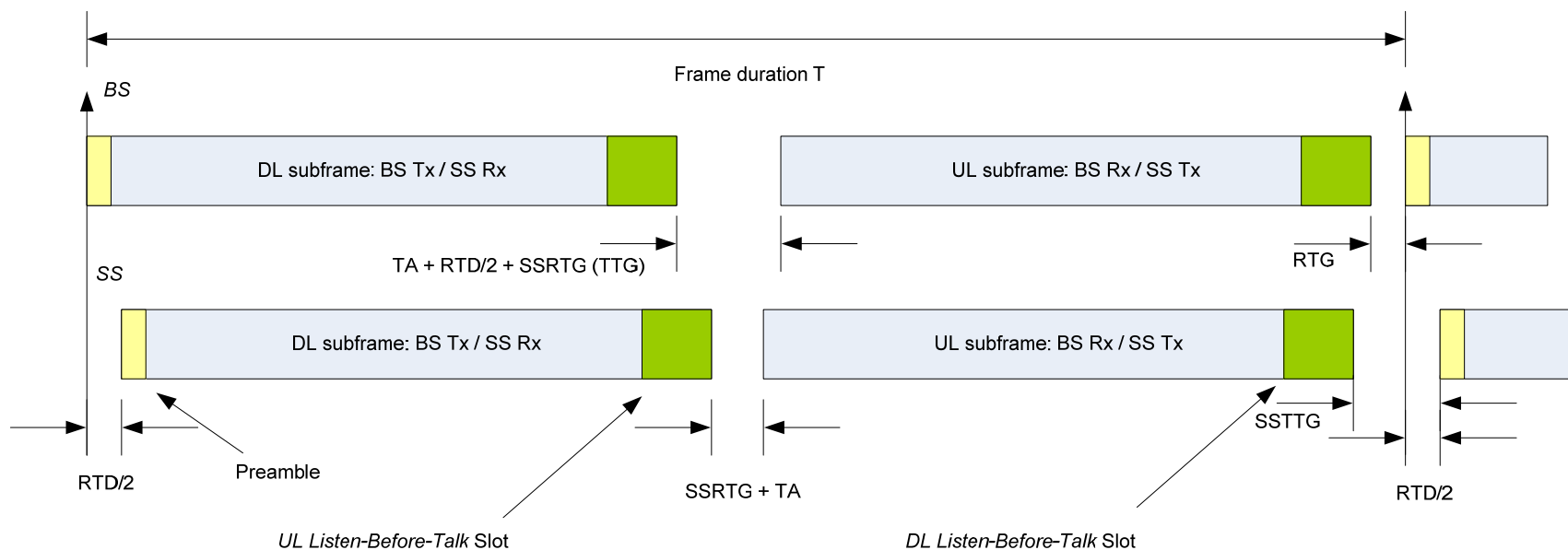


- Evaluation of link budget to calculate interference
- Compensation for *time of flight* given the $1\mu s$ resolution of the simulation
- -> Provides a decision on whether or not a device is transmitting at a given simulation interval

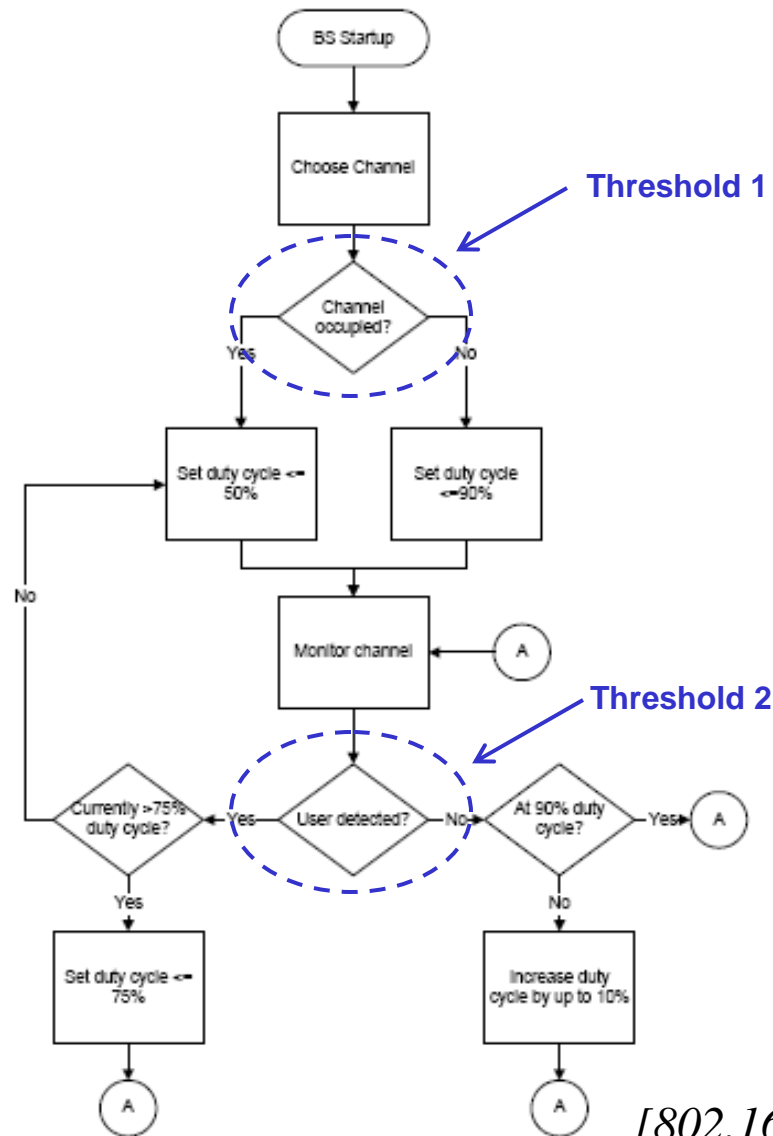


Listen Before Talk (LBT)

- Configuration:
 - DL LBT
 - UL LBT
 - DL&UL LBT
- *First realisation*: measured in a dedicated OFDM slot ($102\mu\text{s}$) just prior to respective DL and UL sub-frame
- Controlled at BS and associated SS - act independently



Adaptive Extended Quiet Period (EQP/aEQP)



- As implemented in 802.16h/D1:
 - Sub clause 6.4.3.3
 - Sub clause 6.4.3.4
- *First realisation:*
 - Threshold 1 = -80dBm
 - Threshold 2 = -75dBm
- Controlled at the BS
- Driven by interference calculations in the entire EQP UL sub-frame
- Measured at 50 μ s intervals

[802.16h/D1 sub clause 6.4.3.4]

Results summary

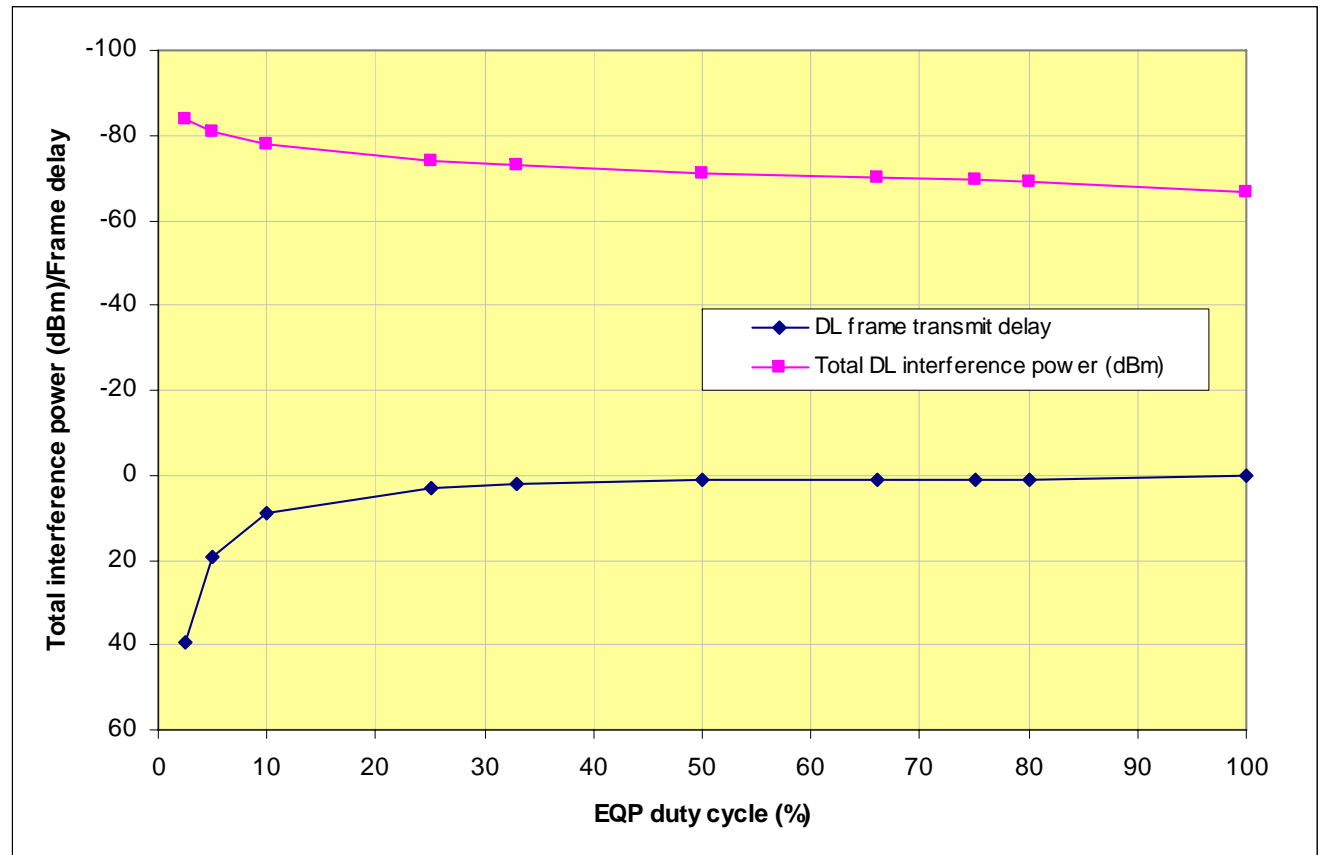
- 16h BS with a maximum of 4 SS per BS
- Specification of the number of channels based on bandwidth
- Frame sync. and/or EQP sync.

- What *system wide* results are produced?
devices_active
general_int_level
- What *user specific* results are produced?
dl_lbt_interference_power_per_lbt_slot
ul_lbt_interference_power_per_lbt_slot
failed_dl_lbt_ratio
failed_ul_lbt_ratio
eqp_ratio
dl_aeqp_interference_assessment
dl_dot16_activity
ul_dot16_activity
dl_dot11_activity
ul_dot11_activity
dl_dot16_transmit_delay
ul_dot16_transmit_delay
dl_dot11_transmit_delay
ul_dot11_transmit_delay

Simulation results I

EQP

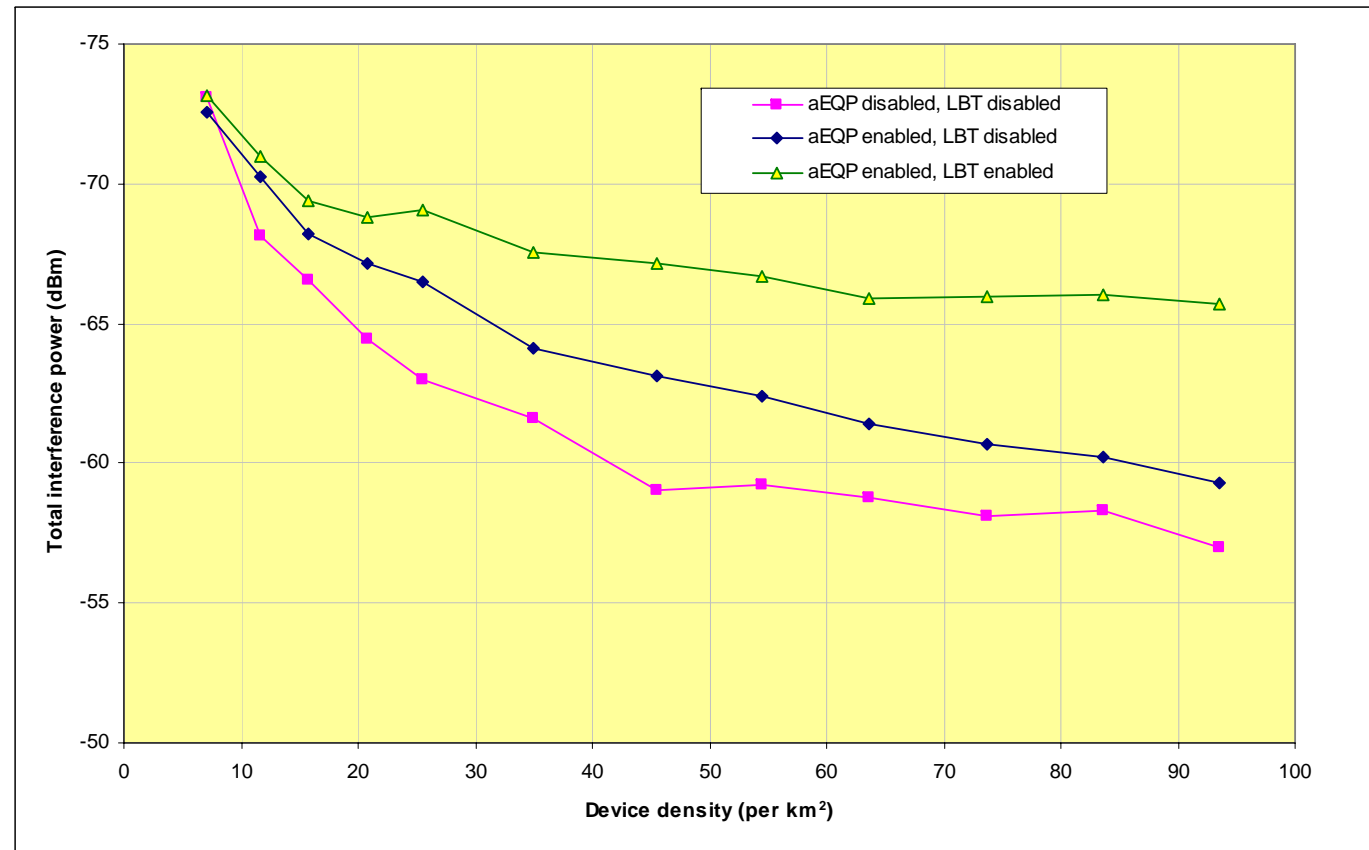
- 5 channels
- No BS sync.
- Results for DL
- EQP behaviour



Simulation results II

aEQP + LBT

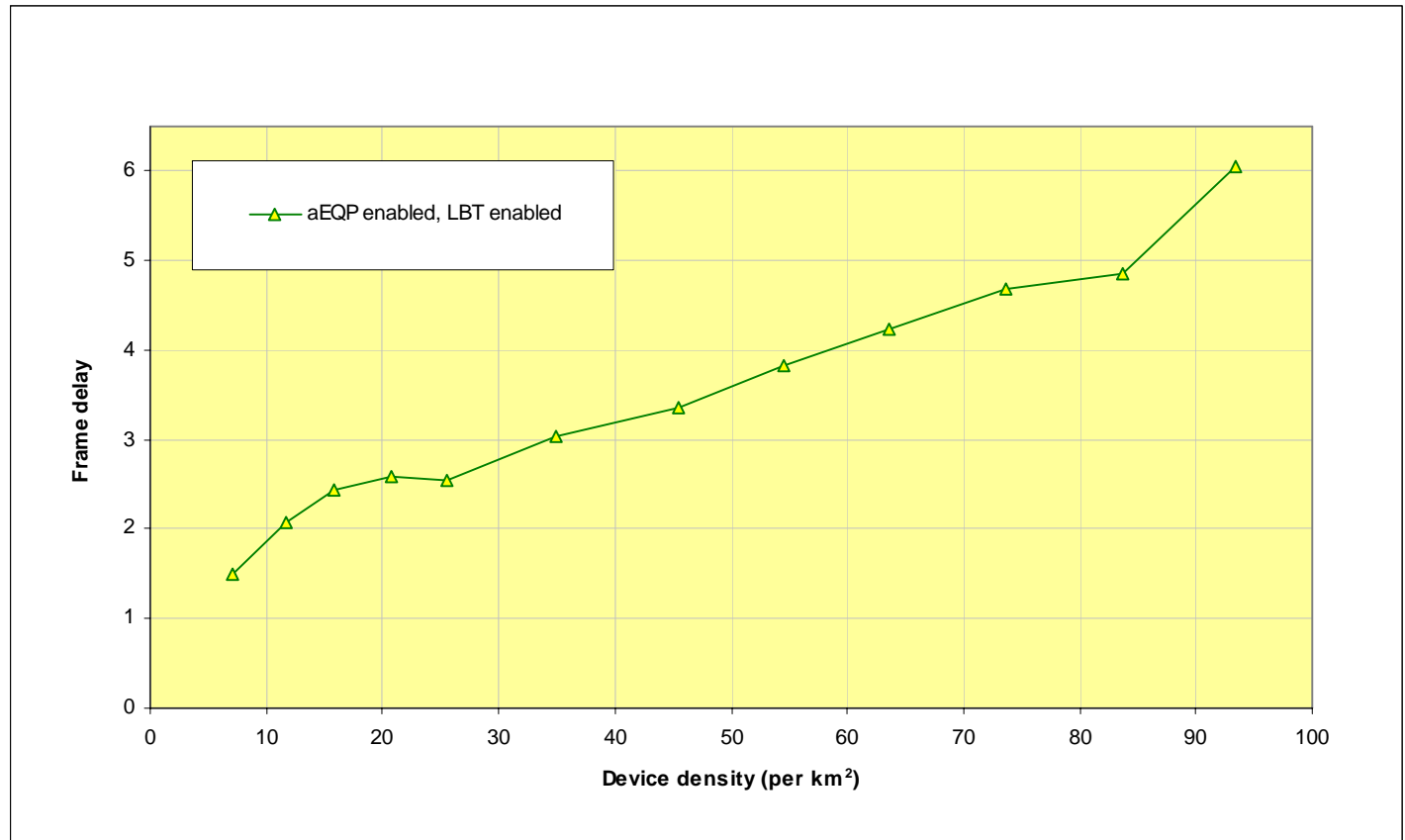
- 1 channel
- No BS sync.
- DL considered
- aEQP and LBT enabled/disabled



Simulation results III

aEQP + LBT

- 1 channel
- No BS sync.
- DL considered
- aEQP and LBT enabled/disabled



Future work

- Fully integrate the 802.11 model
- Improved interference reporting based on the incorporating of an 802.11 model
- Provide a statistical traffic model
- Provide a more realistic method for interference calculation
- Applicability to other bands containing 802.11 devices in other *legacy bands*