Uplink Power Control in 802.16m

IEEE 802.16 Presentation Submission Template (Rev. 9)

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Venue:
IEEE 802.16m-08/024, “Call for Contributions on Project 802.16m System Description Document (SDD)”, on topic of ‘Power Control'
Base Contribution:
None
Purpose:
To be discussed and adopted by TGm for the 802.16m SDD

Outline

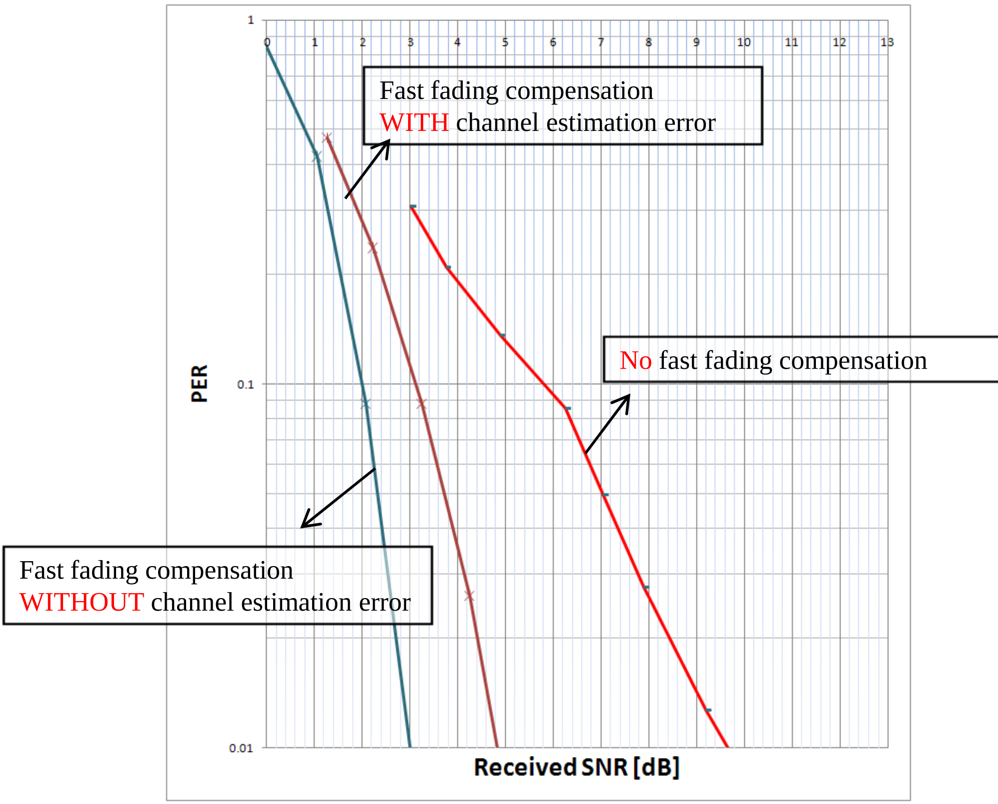
- Power Control in Legacy System
  - Uplink Power Control Algorithm in 802.16e
  - Gain of Power Control
    - LLS verification
    - SLS verification
    - Cell Edge Performance
    - Tx Power Consumption
- Function of Power Control
  - IoT Control in Interference Limit Environments
  - Effect of IoT variance
- Power Control in 802.16m System
  - Requirement of 802.16m Power Control
- Proposed Text

Power Control in Legacy System

- Uplink Power Control (PC) Algorithm in 802.16e
  - Closed Loop Power Control
    - BS calculates the required Tx tone power of every MS
      - based on the latest received packet and the packet which will be assigned to MS
    - BS lets every MS know the amount of tone power correction
      - via message or MAP IE
  - Open Loop Power Control
    - Every MS determines its own Tx power
      - based on uplink noise and interference (NI) level that BS broadcasts
      - based on path-loss each MS estimates

Power Control in Legacy System

- Gain of Power Control ; LLS Verification



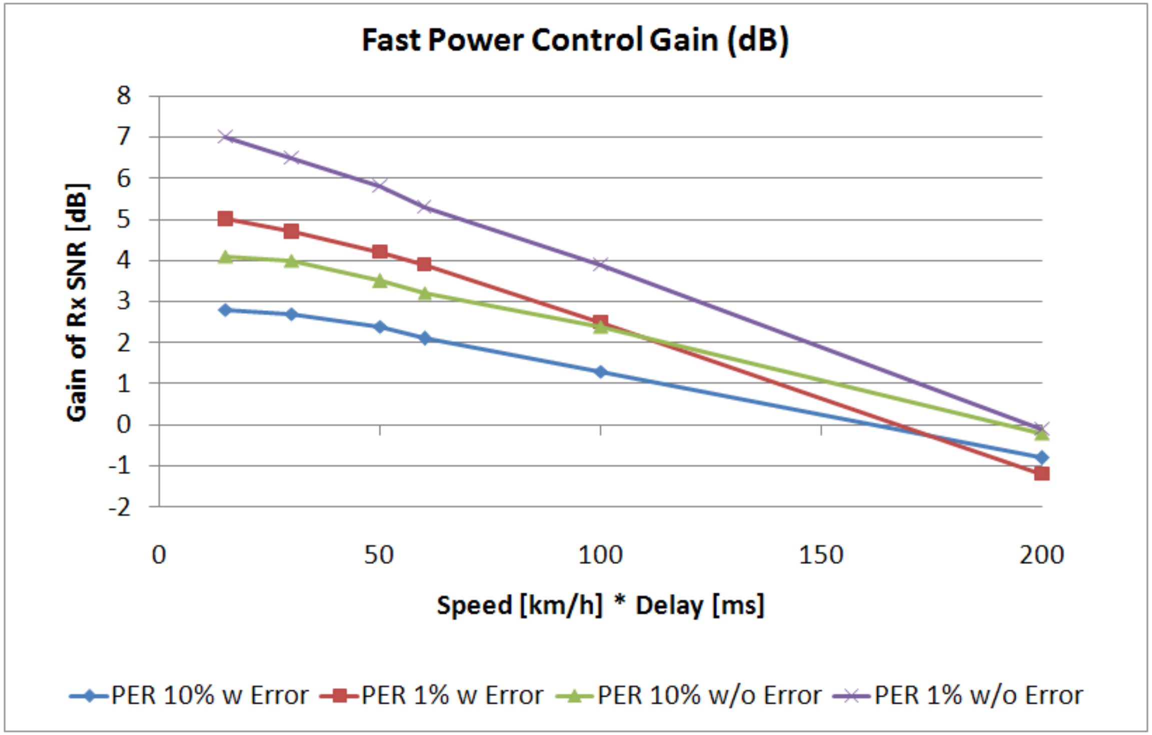
– Condition
  – Nep : 480
  – Code rate : 1/2 Repetition : no
  – Number of Rx Antenna : 2, MRC
  – Center freq. : 2.3GHz
  – Sampling rate : 10MHz
  – Num. of UL symbol for data : 15
  – Subchannelization : PUSC SR on
  – Delay btw estimation & Tx: 10ms*
  – Estimation error model : Normal(0,1.3)**
  – MS speed : 3km/h
  – Channel : Ped A

→ Even with realistic channel estimation error, link performance can benefit from power control (2.7dB @ PER10%, 4.8dB @ PER 1%)

* Refer to Appendix A for definition of delay between estimation & Tx
** Refer to Appendix B for estimation error modeling

Power Control in Legacy System

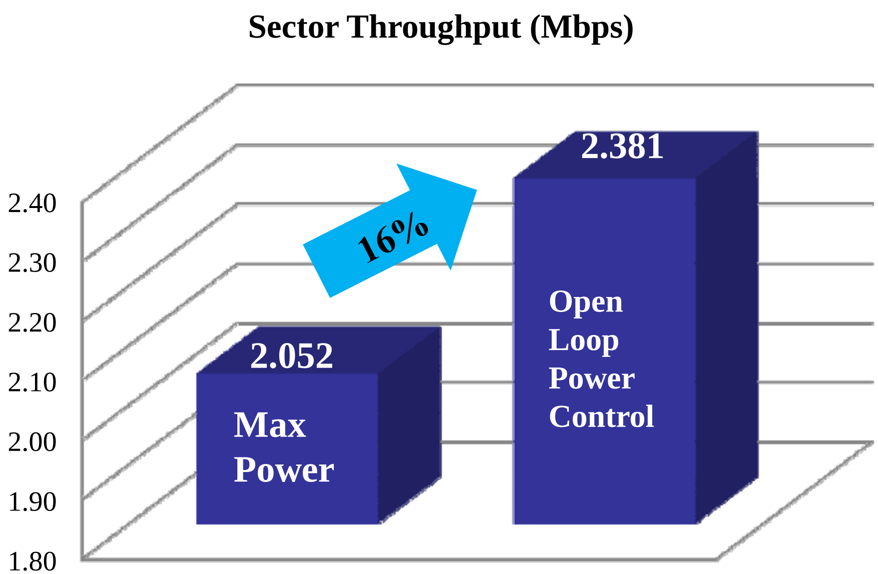
- Gain of Power Control ; LLS Verification (cont'd)

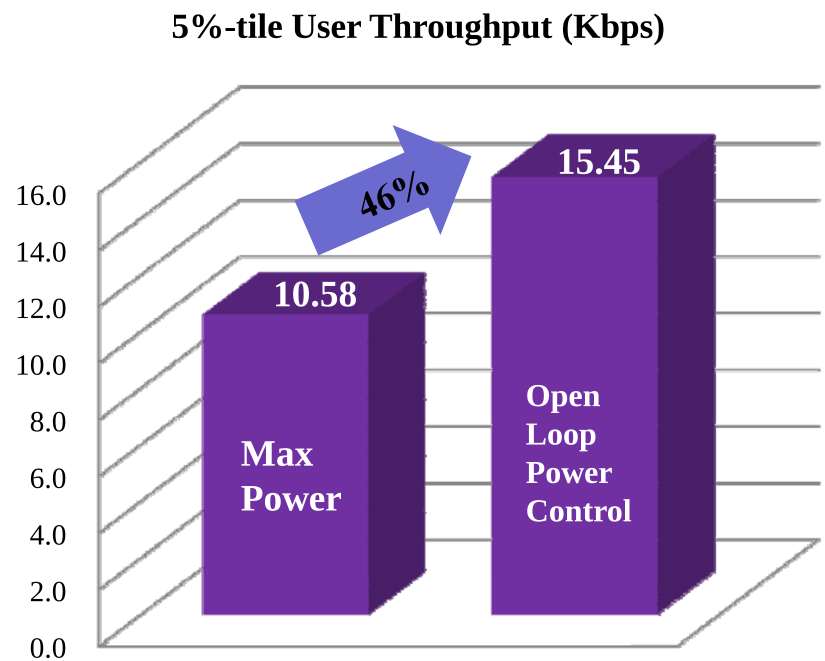


→ As generally known, low speed and short delay between estimation and UL transmission can bring large gain of power control

Power Control in Legacy System

- Gain of Power Control ; SLS Verification*
  - OLPC (open loop PC) vs Max power transmission in 802.16e system



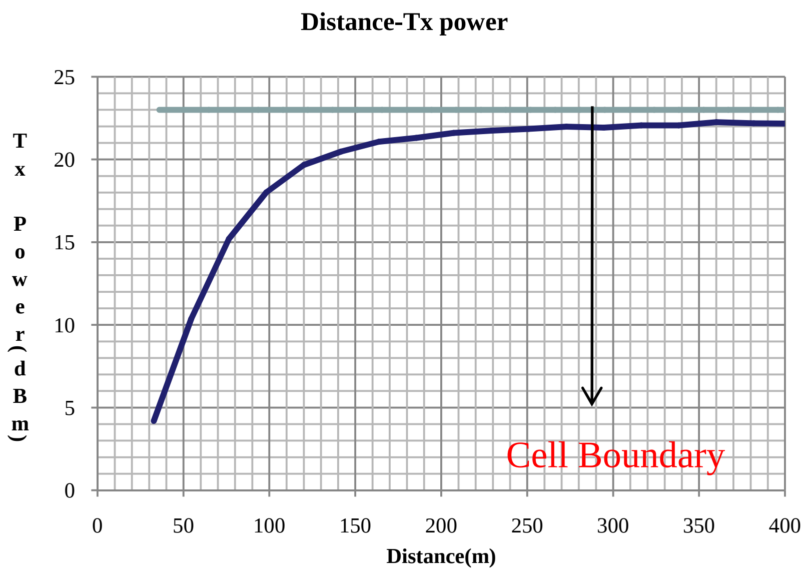


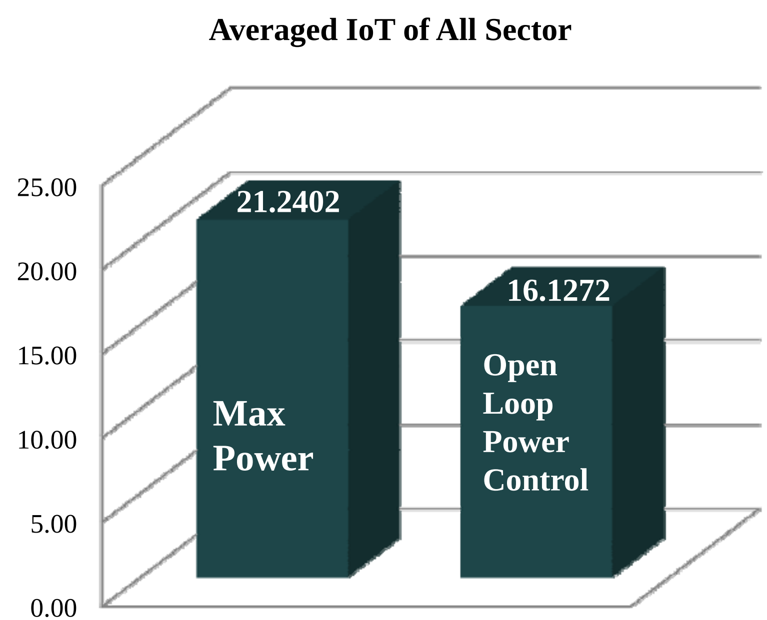
  - Noticeable enhancement can be achieved by PC
    - For both of sector throughput and cell edge

* Refer to Appendix C for SLS conditions

Power Control in Legacy System

- Gain of Power Control ; SLS Verification* (cont'd)
  - OLPC (open loop PC) vs Max power transmission in 802.16e system
    - OLPC can have "Tx Power Consumption Reduction"
    - This is thanks to low mean value of IoT level.





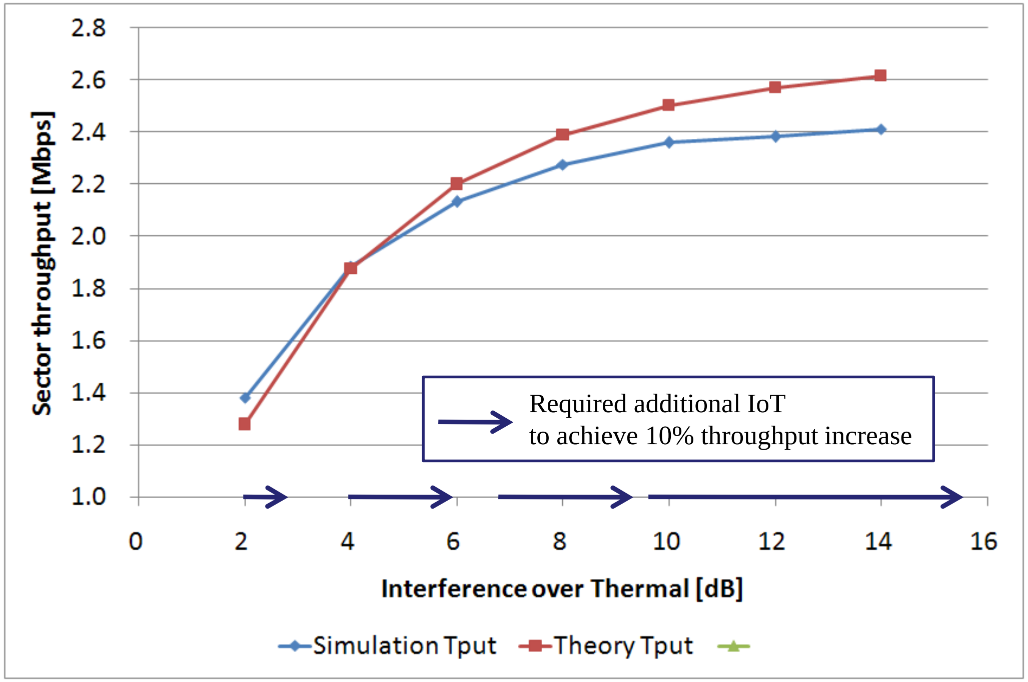
  - MS also can benefit from power control in terms of power consumption

Function of Power Control

- IoT Control in Interference Limited Environments
  - What value of IoT is most efficient in system viewpoint?
  - Theoretical throughput

$$C = BW \log_2\left(1 + \frac{S}{I+N}\right)$$
$$= BW \log_2\left(1 + \gamma\left(1 - IoT^{-1}\right)\right)$$

- BW = effective bandwidth
  (10MHz*15/47*2/3)
- γ = avg. S/I
  (fudge factor, 1.4 in this case)

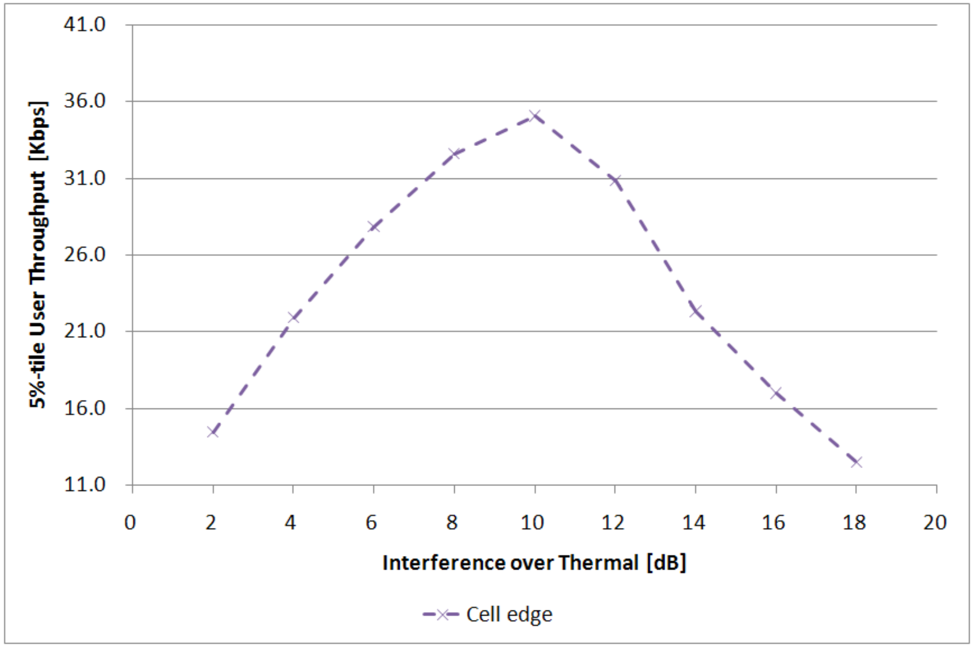


  - Simulation throughput
    - Power control with IoT control

→ When IoT becomes too high (over 9dB in this case), throughput increase is very inefficient.

Function of Power Control

- IoT Control in Interference Limited Environments
  - Relationship between IoT and cell edge performance



  - There is the optimum IoT value to maximize cell edge performance

→ *Ability to control IoT level is desirable in interference limit situation*

Function of Power Control

- Effect of IoT Variance
  - Definition of IoT Var
    - Mean {Sector Var} where Sector Var is the variance of IoT along time

	IoT Var	Sector Tput	5%-tile User Tput
Case 1	1.2657	2.382	30.81
Case 2	1.8877	2.413	22.29
Case 3	1.9859	2.330	16.95
Case 4	3.4892	2.209	12.45
Case 5	6.1636	2.138	11.61

  - As IoT Var increases, system/edge performance is degraded

Power Control in 802.16m System

- Requirement of 16m Power Control
  - Estimation delay should be minimized
    - Reference signal used to estimate uplink channel should be prepared to support effective power control
  - Ability to control IoT is desirable
    - BS should be able to operate network adaptively on its purpose
    - It is desirable to keep IoT variance low as much as possible

Proposed Text

- ***Insert the following text into SDD Section 11 in IEEE 802.16m-08/003r3***

11.X Power Control

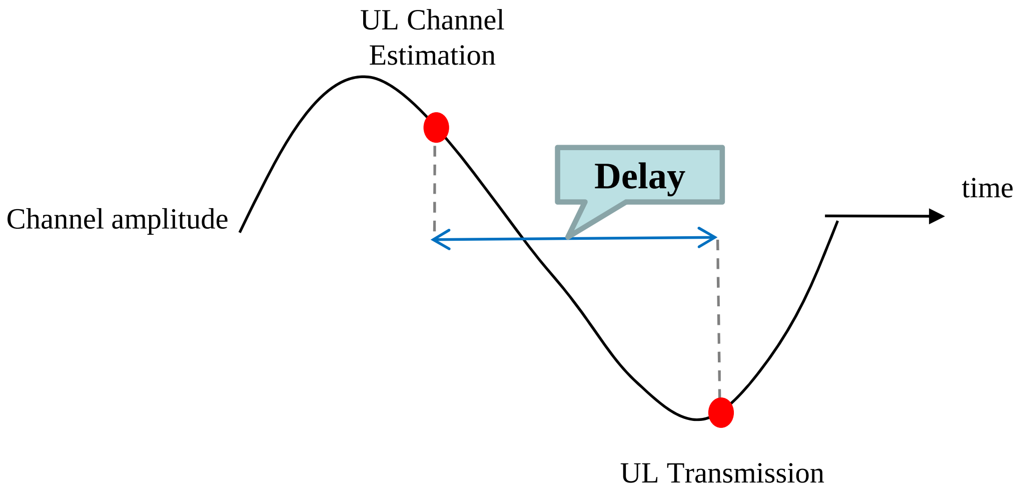
Uplink power control should be supported to compensate the pathloss, shadowing and fast fading.
Uplink power control can be used to control inter-cell interference level.
BS shall transmit signaling channel or message to MS required to support uplink power control.
MS shall transmit signaling channel or message to BS required to support uplink power control.
BS can transmit signaling message to BS required to support uplink power control through backbone network.

11.X.1 Closed Loop Power Control

11.X.2 Open Loop Power Control

Appendix A

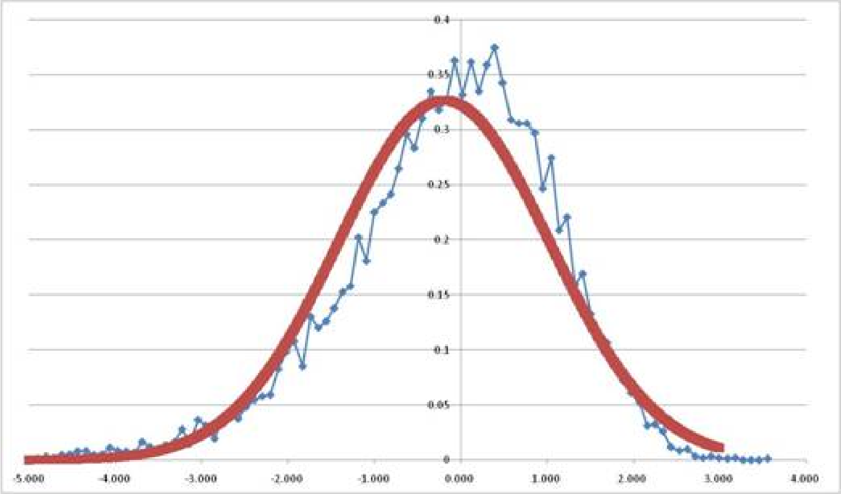
- Delay between Estimation and UL Transmission



  - In addition to MS speed, delay between estimation and UL Tx impacts on the gain of power control
  - In FDD systems, UL channel estimation can be based on UL reference signal such as CQICH, control header and so on
  - In TDD systems, UL channel estimation can be based on DL reference signal such as preamble, common pilot and so on. (thanks to DL/UL reciprocity)

Appendix B

- Channel Estimation Error Model
  - Reference signal for uplink channel estimation : 802.16e CQICH's pilots
  - Assumption of CQICH operating SNR : 0dB



  - Channel power estimation error can be modeled as Gaussian (0,1.3) in dB scale

Appendix C

- SLS Simulation Conditions

Basic Conditions	802.16m EMD
Scenario	NGMN Configuration TDD and FDD in EMD
Channel Mix	ITU (mandatory scenario in EMD)
Error Vector Magnitude	N/A
Channel Estimation	Ideal
Link to system	RBIR
Power control	Open Loop
UL CINR Estimation	Last Packet or BRTH
BRTH report period	3 frames
NI averaging	in Linear scale
NI time domain windowing	Yes (10 frames)

Traffic type	Best Effort
Queue size	Infinite
Scheduling	Round Robin
Number of users per sector	20
Number of scheduled users	5
Bandwidth assignment	Equal bandwidth
Power margin	0
Power outage handling	assign lowest MCS level
Outer Loop Rate Control	No
NI broadcasting period	1 frame