Performance Evaluation for IEEE 802.16m Downlink Control Structure

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Re: IEEE 802.16m-08/024 – Call for Comments on Project 802.16m System Description Document (SDD), on the topic of "Downlink Control"

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Introduction

- This contribution evaluates different schemes for DL control structure
  - Multiplexing schemes: TDM vs. FDM
    - Criteria
      - Coverage (95% user's MCS)
      - Capacity (# of users supportable)
  - Coding schemes: separate coding vs. joint coding vs. hybrid coding
    - Criteria
      - Capacity (# of users supportable)
- Evaluation methodology is based on contribution *DL-Ctrl-Comp-Criteria-v3.doc*

Evaluation of Multiplexing Schemes: TDM versus FDM

Link Level Simulation Assumptions

Table 1.1: Link Level Simulation Parameters

Parameters	Values
Bandwidth	10 MHz
FFT size	1024
Carrier Frequency	2.5 GHz
Channel Model	Pedestrian B 3 km/hr, ITU-Vehicular A 120 km/hr,
DL Tx scheme	2 Tx antenna, STBC
DL Rx scheme	2 Rx antenna
Permutation and symbol structure	16e PUSC (baseline permutation in EMD)
Channel Coding	16e CTC
MCS	QPSK ½ with repetition 0, 2, 4 and 6.
Channel Estimation	MMSE based on all pilots in 2 symbols for TDM and 6 symbols for FDM

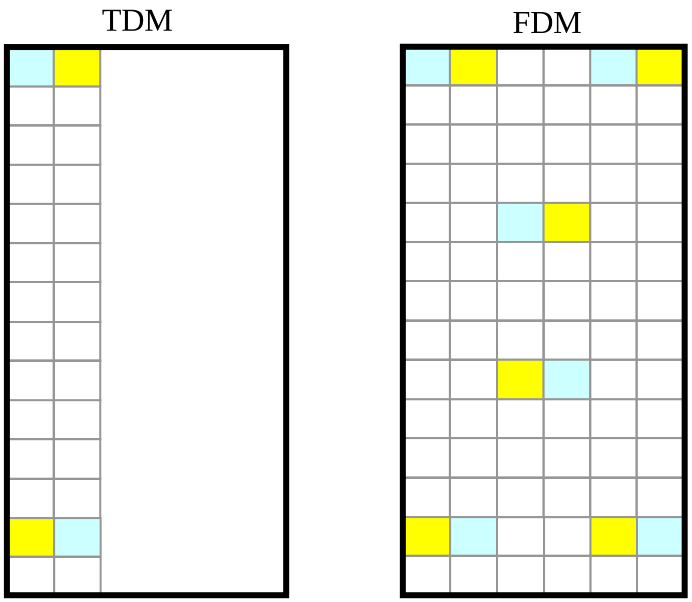
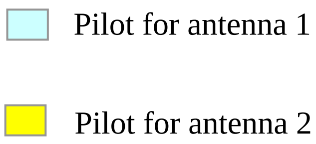
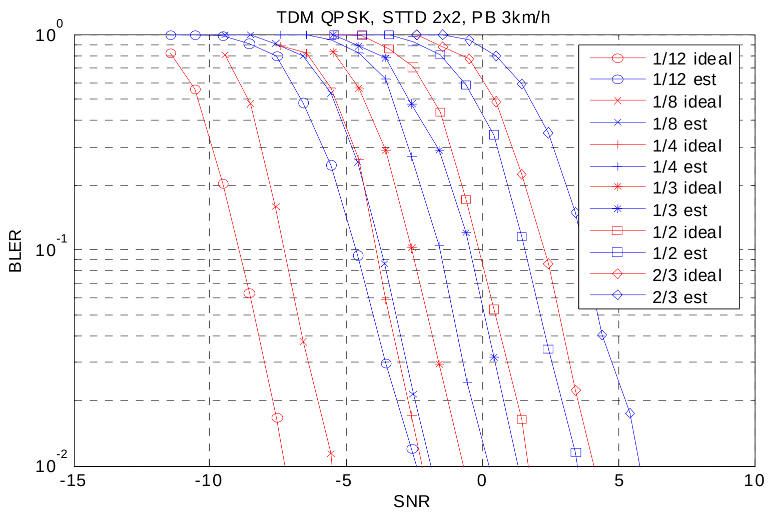
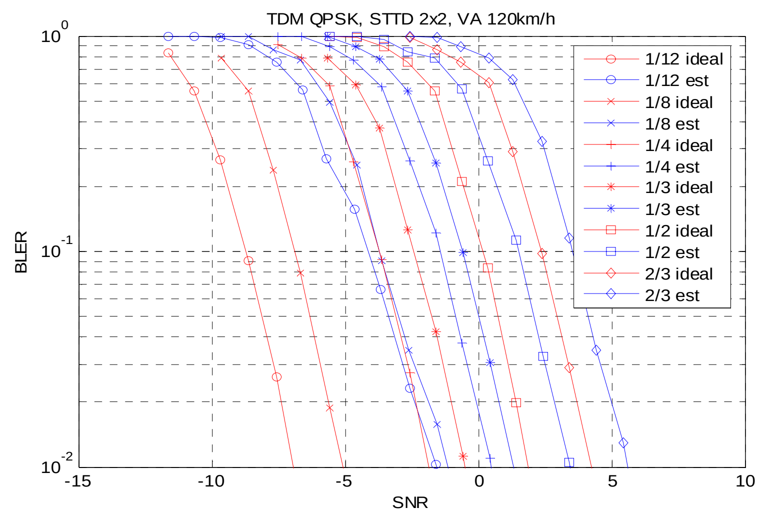


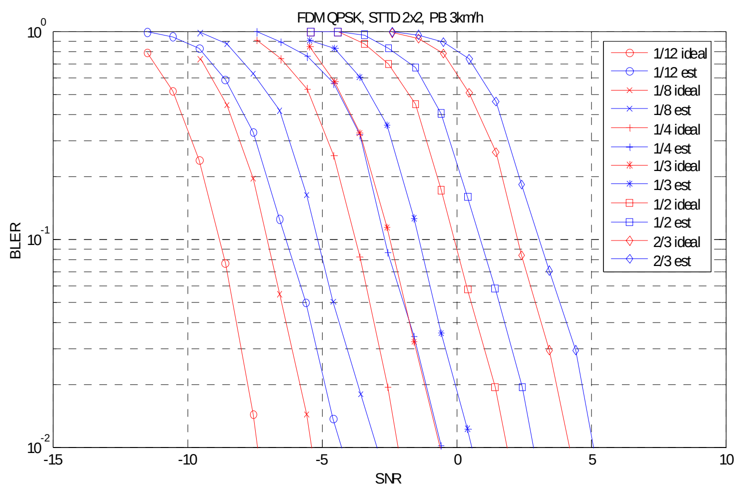
Figure 1: Pilot Design

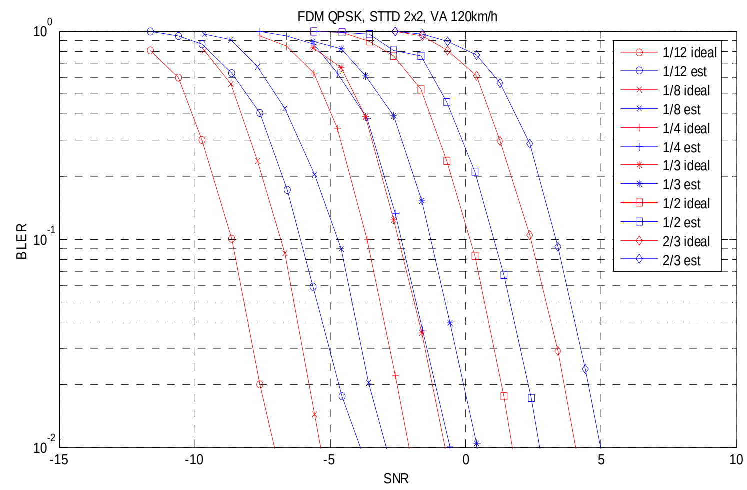


Link Level Performance Results (1/2)









Link Level Performance Results (2/2)

Table 2: MCS SNR at 1% BLER

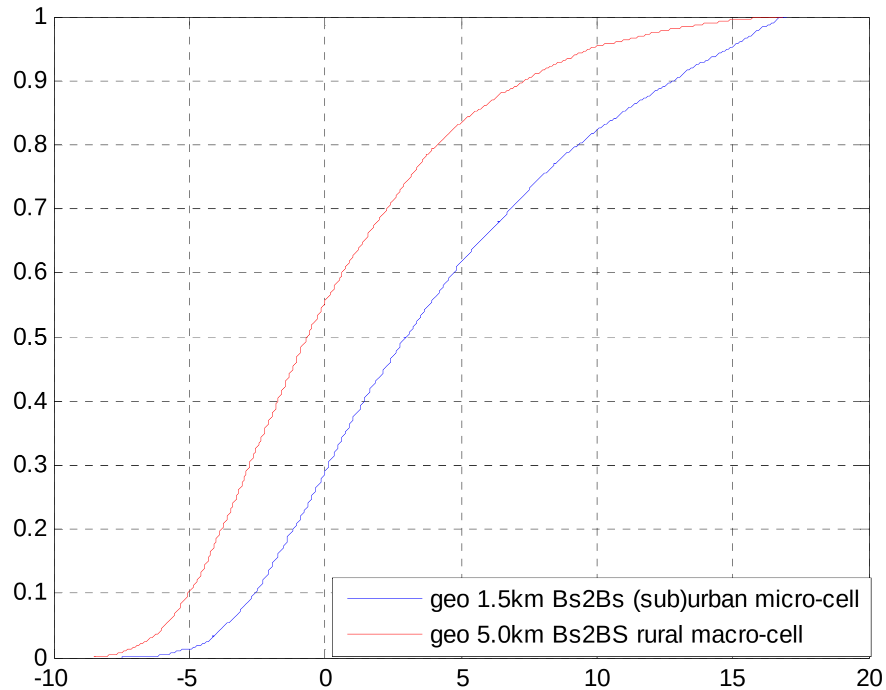
Code Rate	TDM PB3km/h	TDM VA120km/h	FDM PB3km/h	FDM VA120km/h
QPSK ½ rep 6	-2.3188 (dB)	-1.5222 (dB)	-4.1482 (dB)	-3.794 (dB)
QPSK ½ rep 4	-1.7772 (dB)	-0.9984 (dB)	-2.8395 (dB)	-2.8067 (dB)
QPSK ½ rep 2	0.3323 (dB)	0.5476 (dB)	-0.5509 (dB)	-0.5688 (dB)
QPSK ½	3.5882 (dB)	3.4901 (dB)	3.0496 (dB)	2.9522 (dB)

System Level Simulation Assumptions for Coverage Evaluation

Table 1.2: System Level Simulation Parameters

Parameters	Values
BS-to-BS distance	1.5km urban 5.0km open rural microcell NLOS
Frequency reuse	Reuse-1
Transmission power/sector	46 dBm
BS height	32 m
Tx antenna pattern	70^o (-3dB) with 20 dB front-to-back ratio
Tx antenna gain	17 dBi
MS height	1.5 m
Rx antenna pattern	Omni directional
Rx antenna gain	0 dBi
MS Noise Figure	7 dB
Penetration loss	10 dB
Hardware losses (Cable, implementation, etc.)	2 dB
Lognormal shadowing	μ=0 dB, σ_{SF} =8 dB
Shadowing correlation	100% inter-sector, 50% inter-BS

Coverage Performance



1.5km urban: 95% SNR = -3.70dB

5.0km rural: 95% SNR = -5.88dB

Table 3: MCS for 95% cell-edge users

	TDM	FDM w/o power boost	FDM with 3dB power boost
1.5km PB3	Not Supportable	QPSK ½ rep 6	QPSK ½ rep 4
1.5km VA120	Not Supportable	QPSK ½ rep 6	QPSK ½ rep 4
5.0km PB3	Not Supportable	Not Supportable	QPSK ½ rep 6
5.0km VA120	Not Supportable	Not Supportable	QPSK ½ rep 6

System Level Simulation Assumptions for Capacity Evaluation

Table 4: Simulation Assumptions

Parameters	Values
Resource budget	30 slots
TDM USCCH region	30 subchannels by 2 symbols
FDM USCCH region	10 subchannels by 6 symbols
Other hybrid schemes	Total data subcarriers in the region should be the same as the above TDM or FDM scheme.
Mininum resource unit	Per MAP IE size
Power budget	46 dBm for TDM 41.2 dBm for unboosted FDM (10 out of 30 subchannels are used so power budget should be 46-10log10(3)=41.2) 44.2 dBm for 3 dB boosted FDM
Possible MCS	QPSK ½, QPSK ½ repetition 2, QPSK ½ repetition 4, QPSK ½ repetition 6
Code scheme	Separate encoding
CID size	0 bit (masked by CRC)
Start RB index	6 bits (or proposal specific value)
Allocated RB	5 bits (or proposal specific value)
Other L1/L2 information (data MCS etc.)	x (5, 21,37)
CRC	16 bits
Total MAP IE sizes	32, 48, 64 bits (including CID, RB allocation and other L1/L2 information, and CRC)
Power Sharing	Yes for TDM and FDM
BS-to-BS distance	1.5km

Capacity Results

Table 5: Number of Supportable Users
PB 3km/h channel, 30 slots resources , at BLER = 1% realistic channel estimation

MAP IE size	1.5km TDM	1.5km FDM (gain)	1.5km FDM Power Boost 3dB (gain)
32	24	27 (13%)	41 (70%)
48	14	19 (35%)	28 (100%)
64	11	14 (27%)	20 (81%)
sum	49	60 (22%)	89 (81%)

Table 6: Number of Supportable Users
VA 120km/h channel, 30 slots resources , at BLER = 1% realistic channel estimation

MAP IE size	1.5km TDM	1.5km FDM (gain)	1.5km FDM Power Boost 3dB (gain)
32	20	27 (35%)	41 (105%)
48	14	18 (28%)	28 (100%)
64	10	14 (40%)	20 (100%)
sum	44	59 (34%)	89 (102%)

Summary of Multiplex Schemes

- FDM outperforms TDM
  - From coverage perspective
    - Cell-edge users are supportable by FDM with power boost
    - Cell-edge users are not supportable by TDM
  - From capacity perspective
    - FDM (with power boost) achieves more than 20% (80%) capacity gain over TDM

- Reasons
  - FDM has ~2dB link level gain due to time-direction de-noising.
  - FDM has 3dB power boost gain.

Evaluation of Coding Schemes

Types of Coding Schemes Compared

- Joint coding
- Separate coding
- Hybrid coding (refer to contribution C802.16m-08/176r1)
  - MCCS is jointly coded and multicast to all the scheduled users
    - MCCS includes combination index (CI) + CRC
      - Combination index (CI) has 10 bits
      - CRC has 16bits
  - Traffic is separately coded from the unicast control and is individually power controlled to each user

Simulation Assumptions

Table 7: Simulation Assumptions

Parameters	Values
Resource budget	5 or 10 out of 30 subchannels per symbol for control, i.e., 16% or33% control overhead
Multiplexing scheme	FDM with 3dB power boost
Coding scheme	Separate coding, joint coding, hybrid coding (joint coding for MCCS and separate coding for unicast)
Power Sharing	Separate coding: Yes. Joint coding: No. Hybrid: Yes.
Number of user groups for joint coding	4
Power budget	44.2 dBm for unboosted FDM (10 out of 30 subchannels are used for DL control) 41.2 dBm for unboosted FDM (5 out of 30 subchannels are used for DL control)
Possible MCS	QPSK ½, QPSK ½ repetition 2, QPSK ½ repetition 4, QPSK ½ repetition 6
CID size	16 bits for joint coding, 0 bits for separate coding, 0 bits for hybrid unicast
Start RB index	6 bits for joint or separate coding, 0 bits for hybrid unicast
Allocated RB	5 bits for joint or separate coding, 0 bits for hybrid unicast
L1/L2 information (data MCS etc.)	5 bits
CRC size	16 bits
Other information (e.g. MCCS)	For diversity channelization, MCCS has one set of CI(10bits) plus CRC(16bits) supporting up to 25 resource units. CRC bits can be further reduced.
MAP IE sizes	32 bits (including CID, RB allocation, L1/L2 information) for joint coding 16 bits (including RB allocation, L1/L2 information) for separate coding 5 bits (includingL1/L2 informaton) for hybrid unicast
Joint coding overhead reduction multiplier	0.8
Total MAP IE sizes	Joint coding: MAP IE size (32bits) x Number of Group Users x DiscountFactor + CRC (16bits) Separate coding: MAP IE size (16bits) + CRC(16bits) Hybrid multicast: MCCS size CI (10bits) + CRC(16bits) Hybrid unicast: MAP IE size (5bits) + CRC(16bits)
Mininum resource unit for control	Total MAP IE sizes
Channelization	Diversity
Channel	PB3
BS to BS distance	1.5km

Capacity and Control Overhead Comparison

Table 8: Number of supportable users and corresponding control overhead with fixed 20 subchannels for data and up to 10 subchannels for control

	Joint Coding	Separate Coding	Hybrid coding
Number of supportable users (Number of subchannels required for DL control)	20 (8)	20 (6)	20 (4)
DL control resource saving gain over joint coding	0	25%	50%

Table 9: Number of supportable users using 16% (5 subchannels) resource for control and 84% (25 subchannels) resource for data

	Joint Coding	Separate Coding	Hybrid coding
Number of supportable users	12	18	25
Gain over Joint Coding	0	50%	108%

Conclusions

- Multiplexing scheme
  - FDM is recommended
- Coding scheme
  - Hybrid coding scheme is recommended