TDD Performance Evaluation Report II

Jim Tomcik
jtomcik@qualcomm.com

Project	**IEEE 802.20 Working Group on Mobile Broadband Wireless Access** <http://ieee802.org/20/>	
Title	**QTDD Performance Report 2 Presentation**	
Date Submitted	**2005-11-15**	
Source(s)	Jim Tomcik Qualcomm, Incorporated 5775 Morehouse Drive San Diego, CA, 92121 Voice: 858-658-3231 Fax: 858-658-2113 E-Mail: jtomcik@qualcomm.com	
Re:	MBWA Call for Proposals	
Abstract	This contribution (part of the QTDD proposal package for 802.20), contains the QTDD Performance Report 2 Presentation slide set.	
Purpose	For consideration of 802.20 in its efforts to adopt an TDD proposal for MBWA.	
Notice	This document has been prepared to assist the IEEE 802.20 Working Group. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.	
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.20.	
Patent Policy	The contributor is familiar with IEEE patent policy, as outlined in Section 6.3 of the IEEE-SA Standards Board Operations Manual <http://standards.ieee.org/guides/opman/sect6.html#6.3> and in *Understanding Patent Issues During IEEE Standards Development* <http://standards.ieee.org/board/pat/guide.html>.	

Outline

- Report II Requirements:
  - Traffic mix simulations.
    - Overhead channel modeling.
    - QoS arbitration.
    - Performance of each individual QoS class.
  - Mobility and handoff
- Performance of Salient Features:
  - Antenna techniques.
    - MIMO Multiple Code Word with Successive Interference Cancellation.
    - Pseudo-eigen Beamforming.
  - System enhancements.
    - Quasi-Orthogonal Reverse Link (QORL).
    - Fractional Frequency Reuse (FFR).
    - Spatial Division Multiple Access (SDMA).
    - Beamforming.

Overhead Channel Dimensioning

- SSCH: 18 total assignments, power control bits for 200 users, and ACK/NACK for 30 RL channels ➔ 18% FL overhead.
- Resource utilization is shown not to be affected by 12 FLAB constraints.

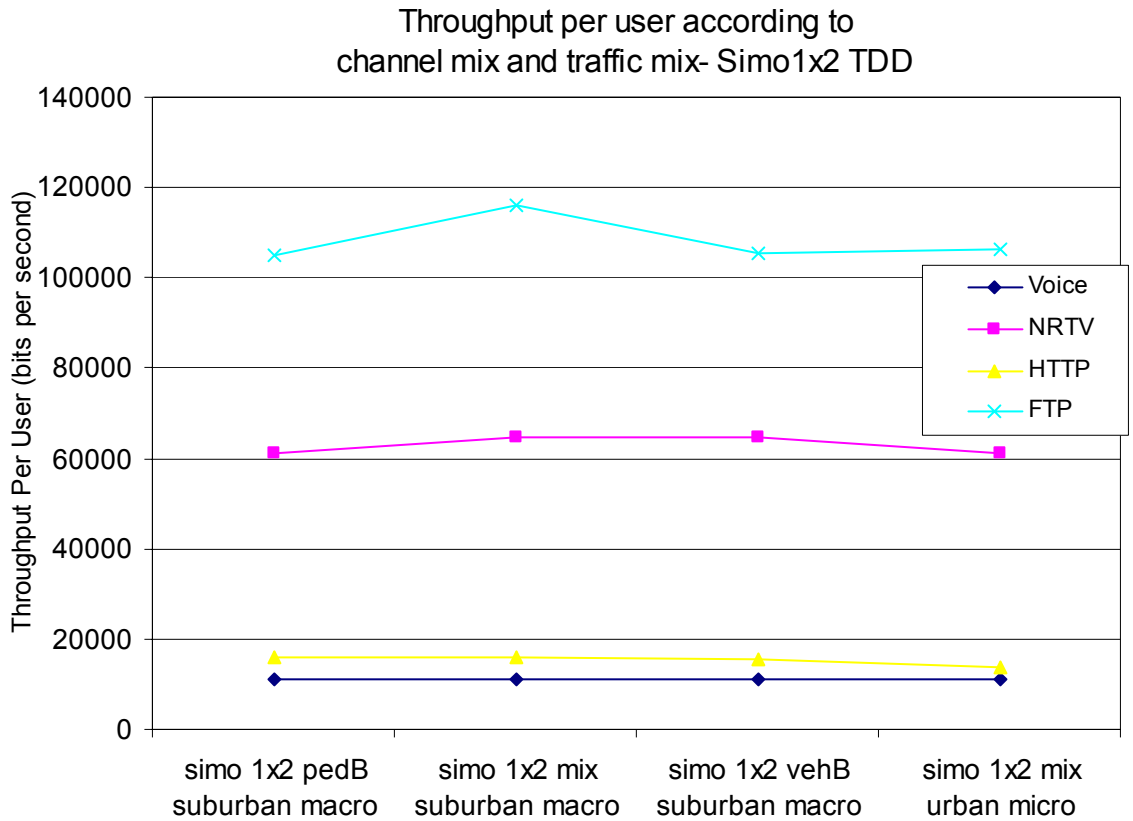
Resource Utilization	Number of Users		
	100	160	220
No Assignment Limitation	97.3%	99.9%	100%
Maximum 12 FLABs	97.3%	98.4%	99.4%
Maximum 8 FLABs	95.7%	94.7%	96.9%
Maximum 4 FLABs	78.4%	86.3%	89.6%

Traffic Mix Assumptions

	FL Evaluation	RL Evaluation
QoS Admission Control	30-30-30-10% Per-sector FTP-HTTP-NRTV-VOIP	VOIP
TCP Packet Size	1500 bytes	N/A
Maximum RLP Transmissions	1(VOIP), 2(Others)	1
Simulation Time	5:00 minutes	5:00 minutes

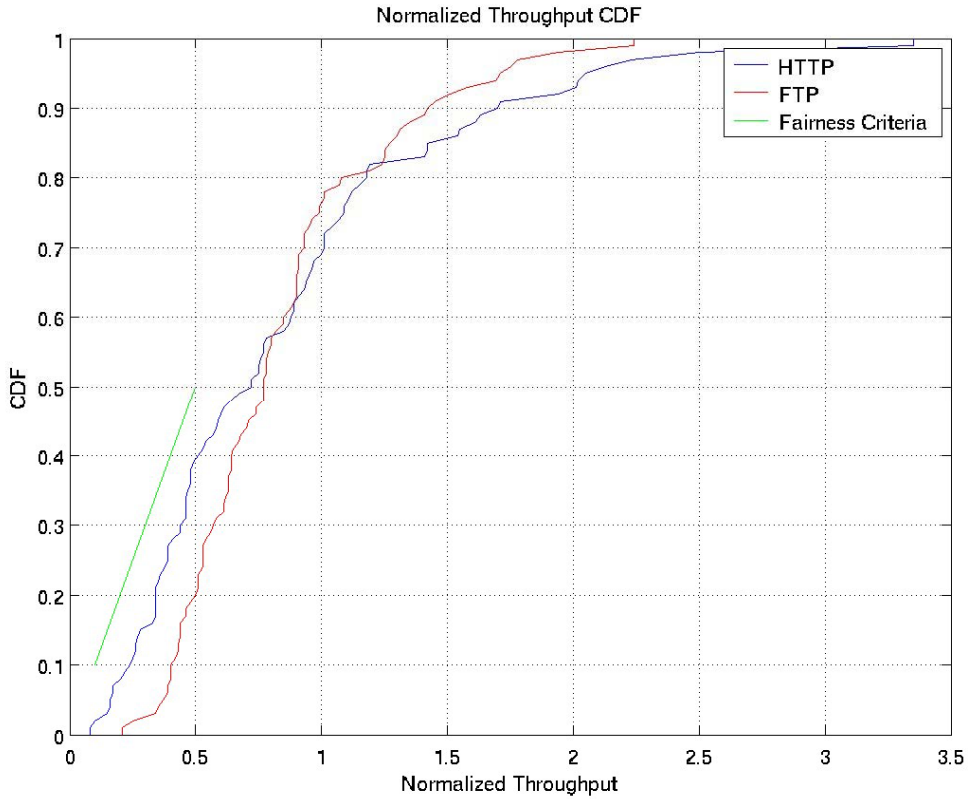
Channel Mix Test

- Channel models:
  - Suburban macro pedB 3 Km/h
  - Suburban macro vehB 120 Km/h
  - Suburban macro mix.
  - Urban micro mix.
- 19 cell wrap-around layout.
- Traffic mix:
  - 30-30-30-10
  - 10 users per sector.
- Conclusions:
  - Served data rate matches the offered data rate.
  - Different channel models have similar performances.



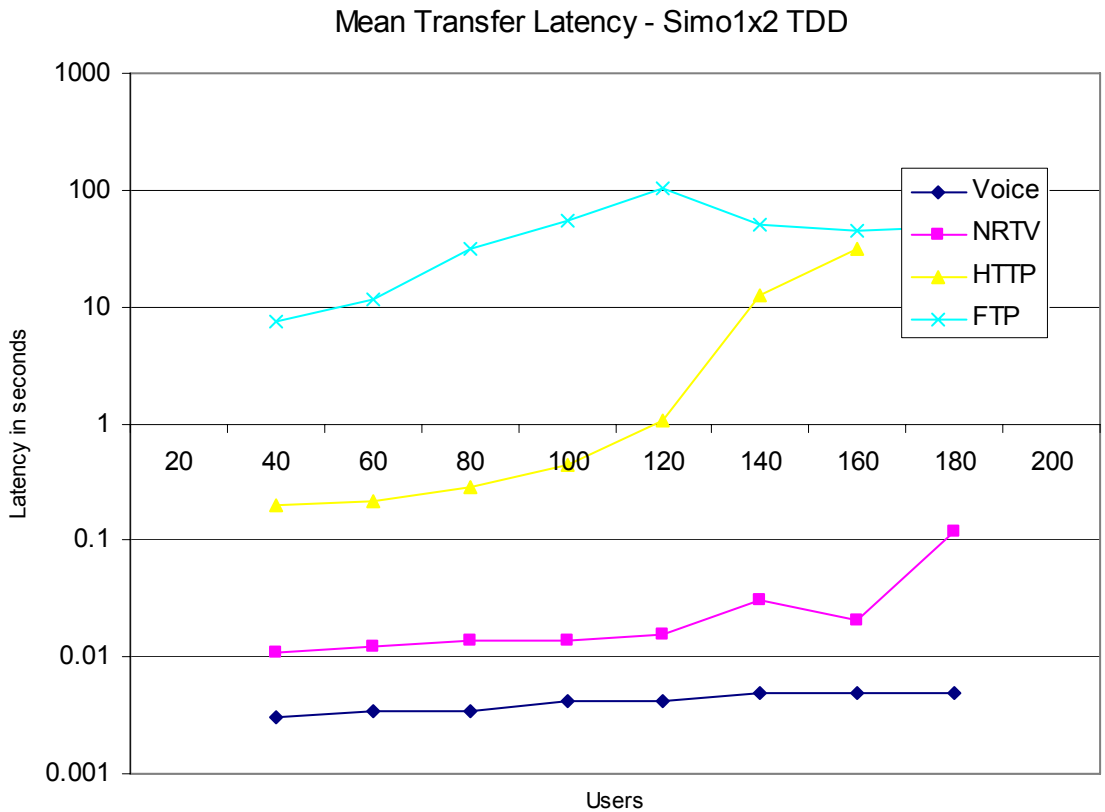
Fairness Among BE Flows

- Simulation setup:
  - Suburban macro mix.
  - Loading level: 80 users/sector
  - EF and AF flows is scheduled with higher priority than the BE flows.
  - Proportional fairness is enforced among BE flows.
- Conclusion:
  - BE flows meet the 802.20 fairness.



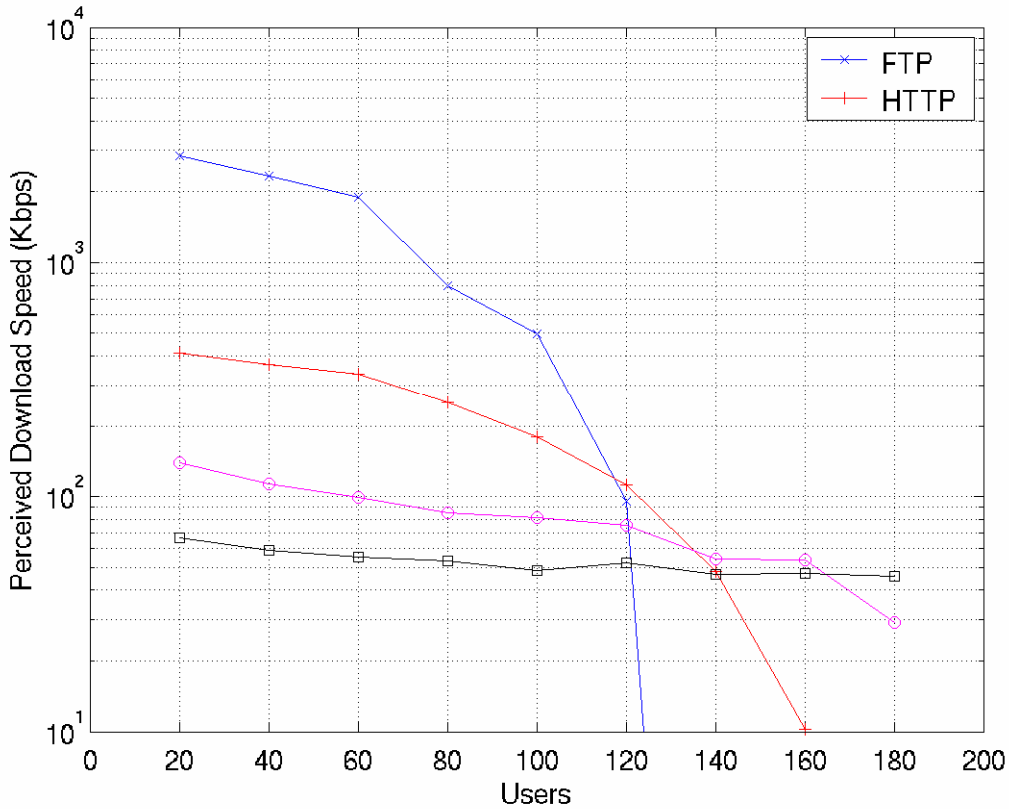
Latency vs. Load

- Flows with QoS reservation:
  - Mean latency of VOIP and NRTV satisfy QoS for all loading level.
- Best effort flows:
  - HTTP and FTP latency increases as load increases.



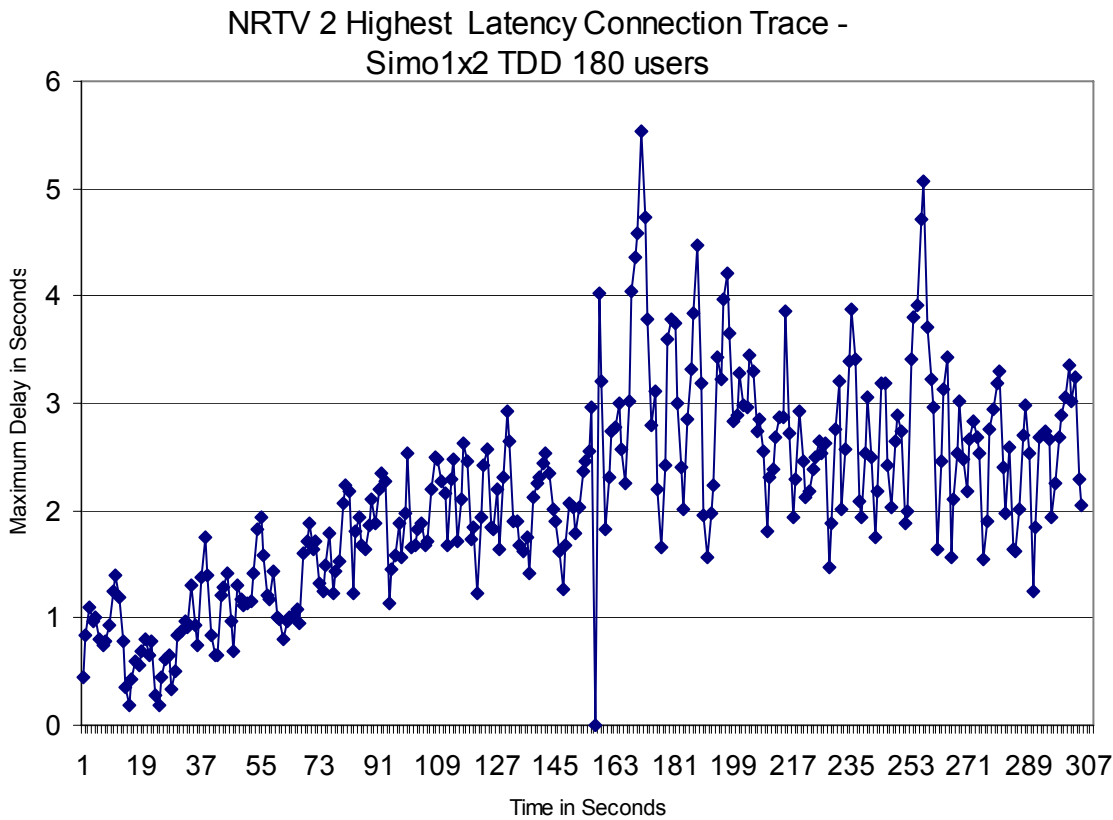
Download Speed vs. Load

- Simulation setup:
  - SIMO 1x2
- Light loading
  - FTP: 3 Mbps.
  - HTTP: 500 Kbps.
- Heavy loading
  - FTP and HTTP rate goes to 0 when NRTV starts to suffer.
  - NRTV and VOIP QoS priority is enforced properly.



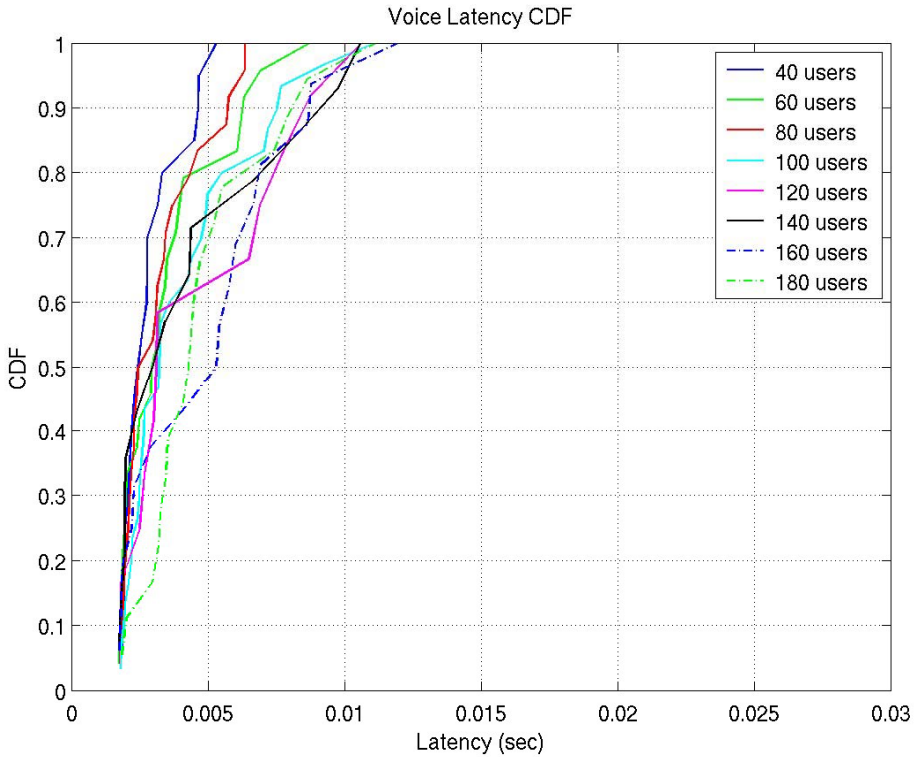
NRTV Outage Trace

- Latency trace of the worst user at high system loading.
- One connection briefly reaches the 5 seconds buffer underflow condition.



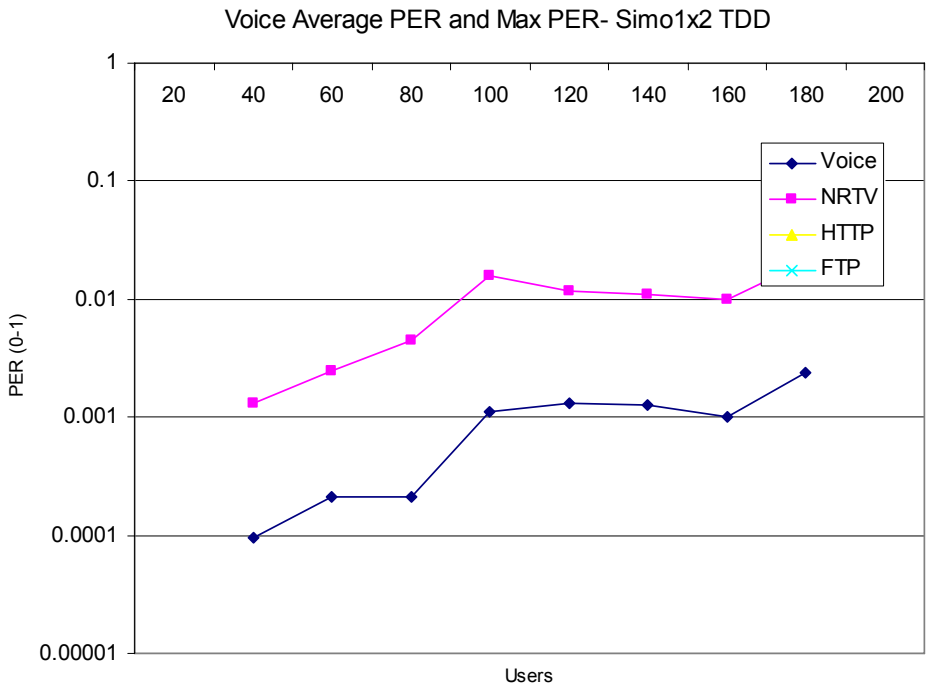
Voice Latency vs. Load

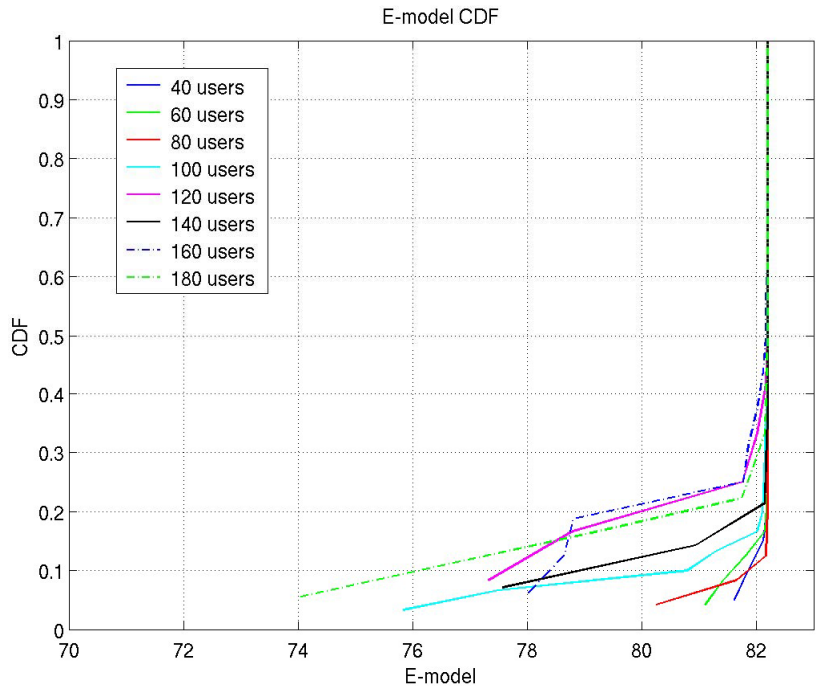
- Maximum mean user latency is less than 12 ms @ 180 users/sector.



Voice E-Model Score

- Mean user voice packet error rate is low for all load.
- Worst user experiences close to 2% packet error rate.
- E-Model score reflects the packet errors experienced by users in poor channel condition.





Outline

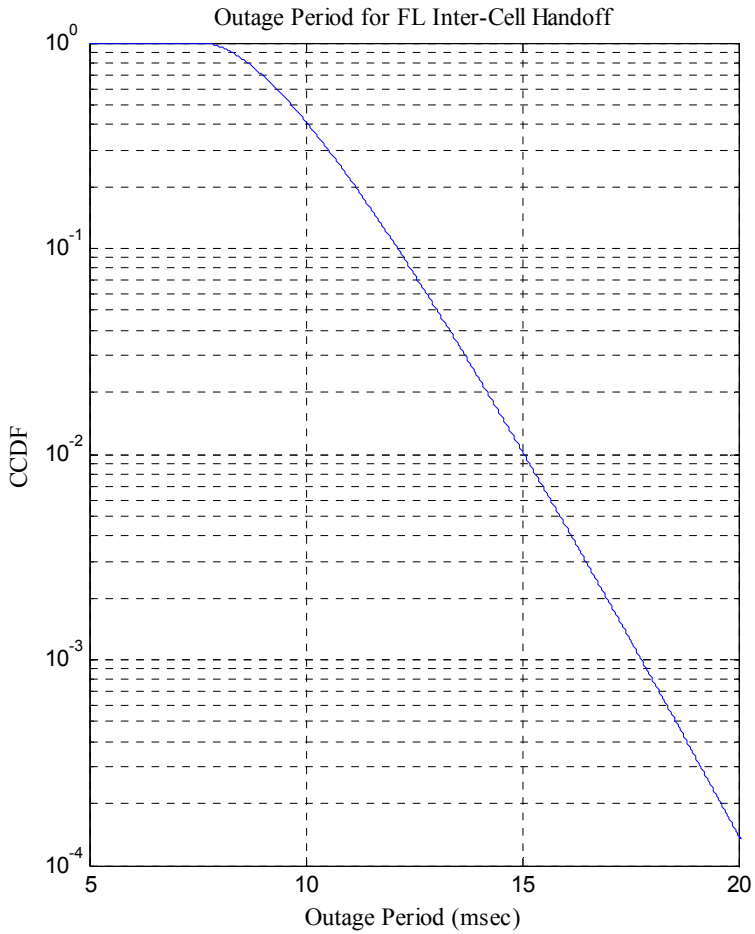
- Report II Requirements:
  - Traffic mix simulations.
    - Overhead channel modeling.
    - QoS arbitration.
    - Performance of each individual QoS class.
  - Mobility and handoff
- Performance of Salient Features:
  - Antenna techniques.
    - MIMO Multiple Code Word with Successive Interference Cancellation.
    - Pseudo-eigen Beamforming.
  - System enhancements.
    - Quasi-Orthogonal Reverse Link (QORL).
    - Fractional Frequency Reuse (FFR).
    - Spatial Division Multiple Access (SDMA).
    - Beamforming.

Mobility and Handoff

- Handoff decision
  - FL: based on FL pilot measurements
  - RL: based on R-CQICH erasure indicators
- Handoff indication to the desired sector
  - FL: using R-CQICH
  - RL: using R-REQCH
- Handoff completion
  - When AT receives assignment from the new sector

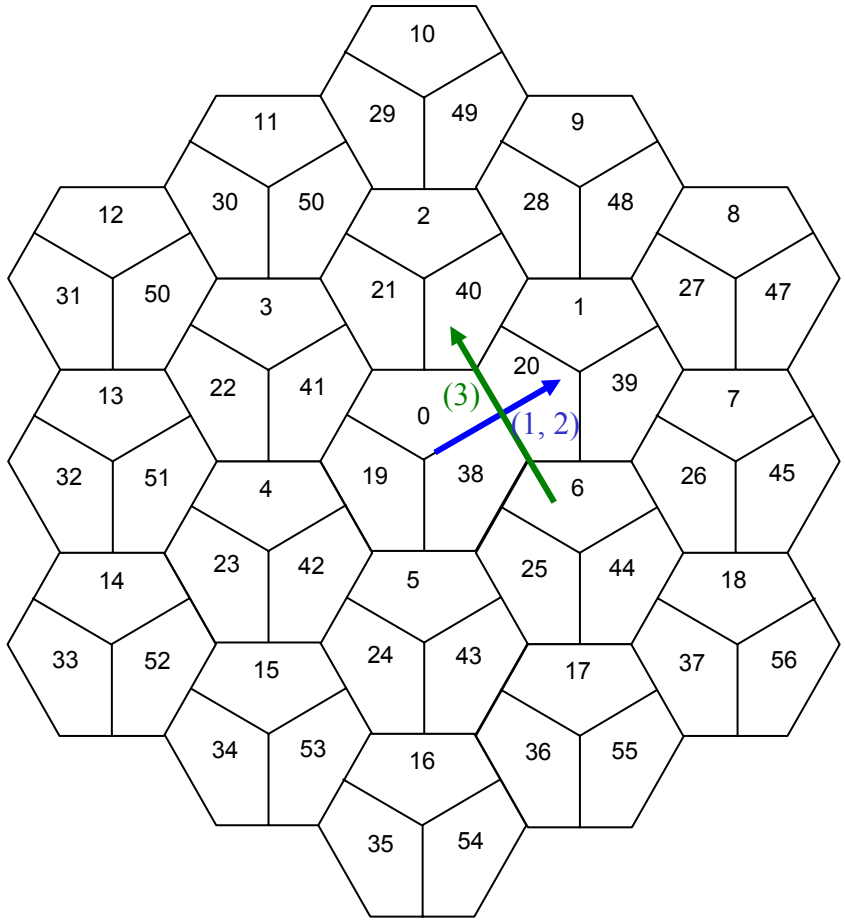
Outage and Connection Drop

- Current serving sector continues to serve the terminal during L1 handoff signaling (and even part of L2 handoff negotiation).
- Outage may happen only during FL handoff (inter-cell)
- Outage period is equal to one-way backhaul delay.
- Connection drop probability is practically zero.

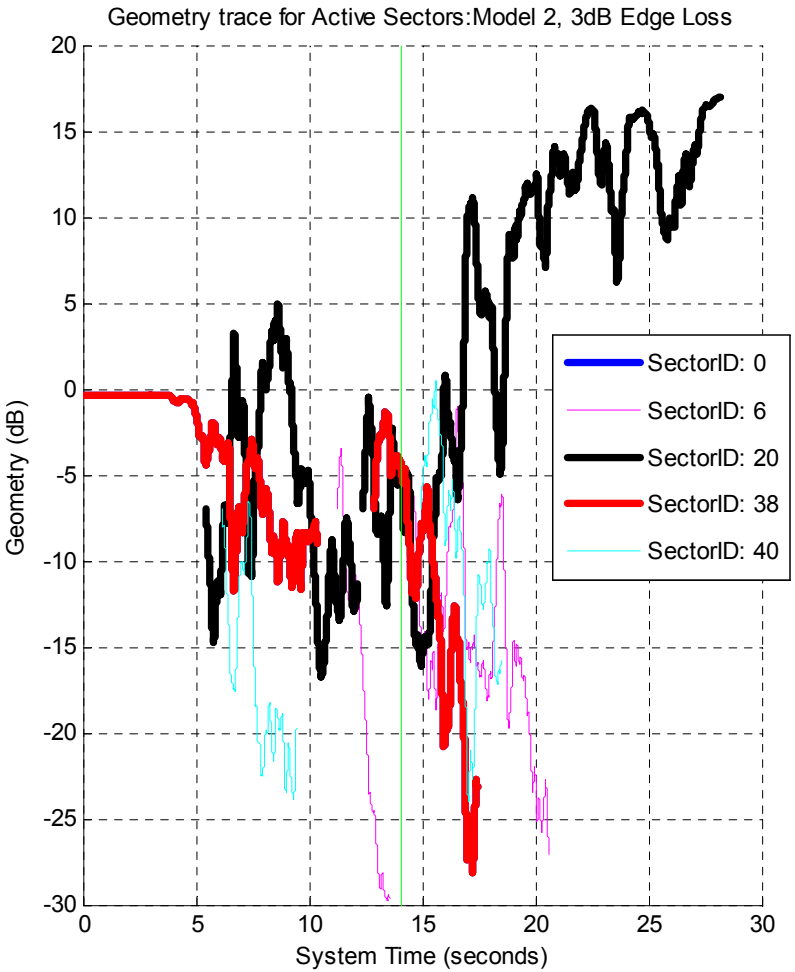


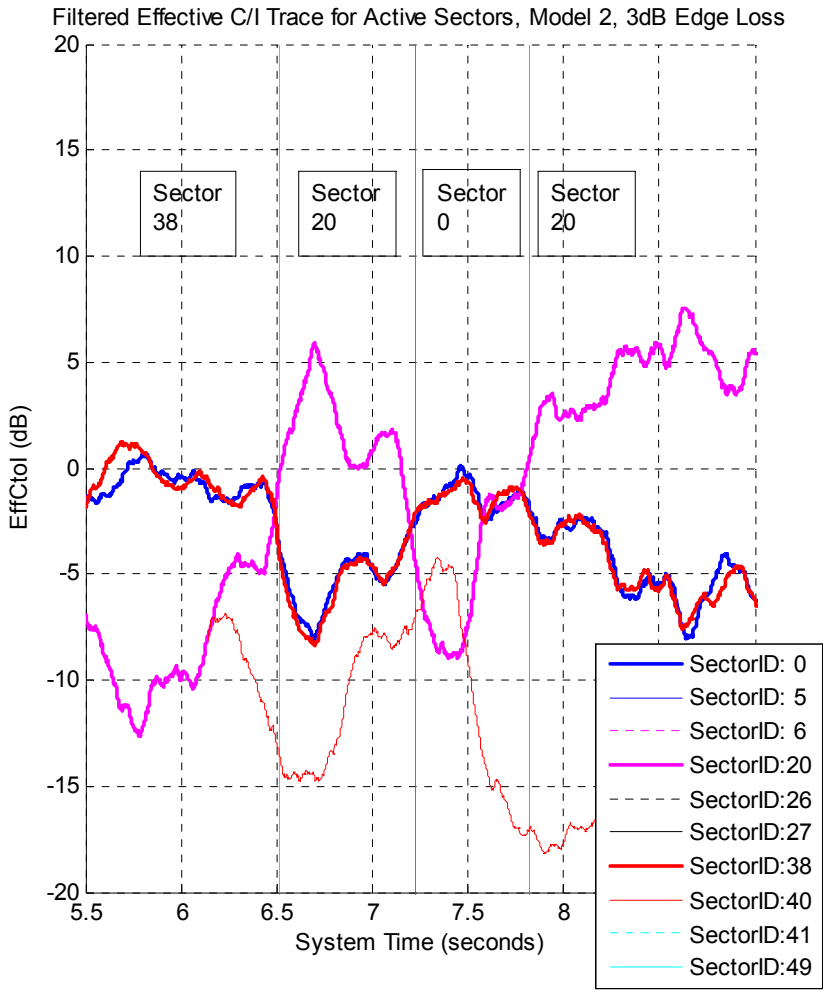
Mobility Simulation Models

Parameter Name	Interpretation	Value
R	Site-to-site distance	1000 m
EdgeLoss	Sudden propagation loss at cell edge for model 2	3, 6, 9 dB
V	Mobile Speed	3, 30, 120 Km/h
D_{corr}	Shadow Fading Corr. Distance	30 m
D_0	Distance of starting point from A in paths 1 and 2 (same as distance of ending point from B)	30 m
D_3	Total distance covered by terminal in path 3	1000 m
FilterTimeConstant	SINR and C/I filter time constant for active set management and handoff decision	100 msec
AddThreshold	Active set add threshold (on filtered SINR)	-7 dB
DropThreshold	Active set drop threshold (on filtered SINR)	-9 dB
DropTimer	Active set drop timer (if the SINR of an active set sector remains below DropThreshold for this period, it is dropped from the active set.)	2 sec
FLHandoffHysteresis	Forward link handoff hysteresis (on filtered effective C/I)	2 dB
RLHandoffHysteresis	Reverse link handoff hysteresis (on CQI erasure indicator rate)	0.1

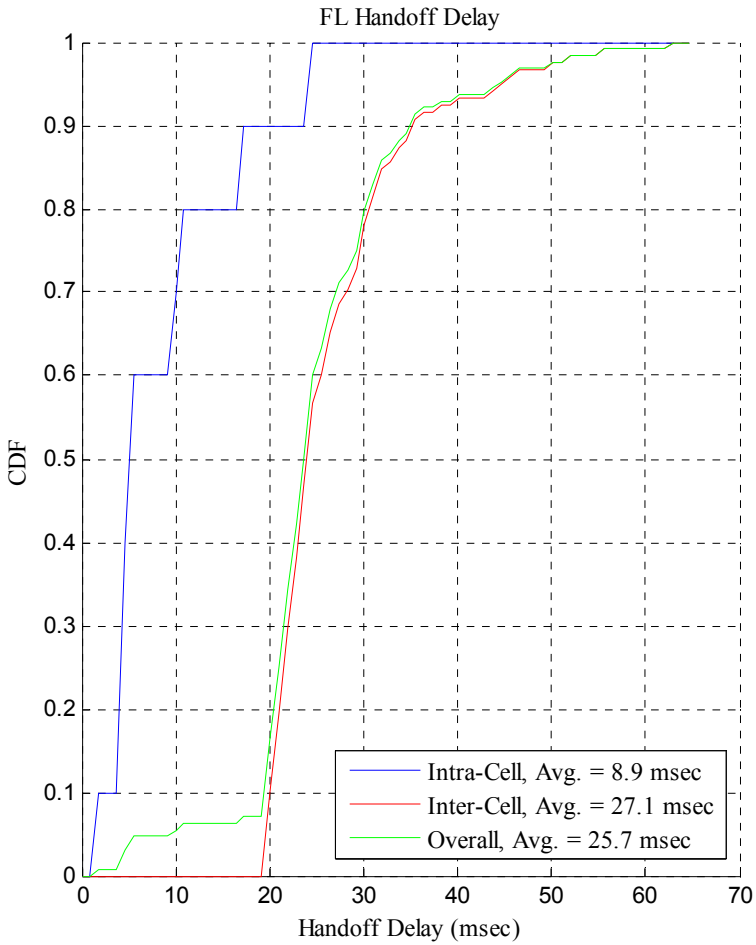


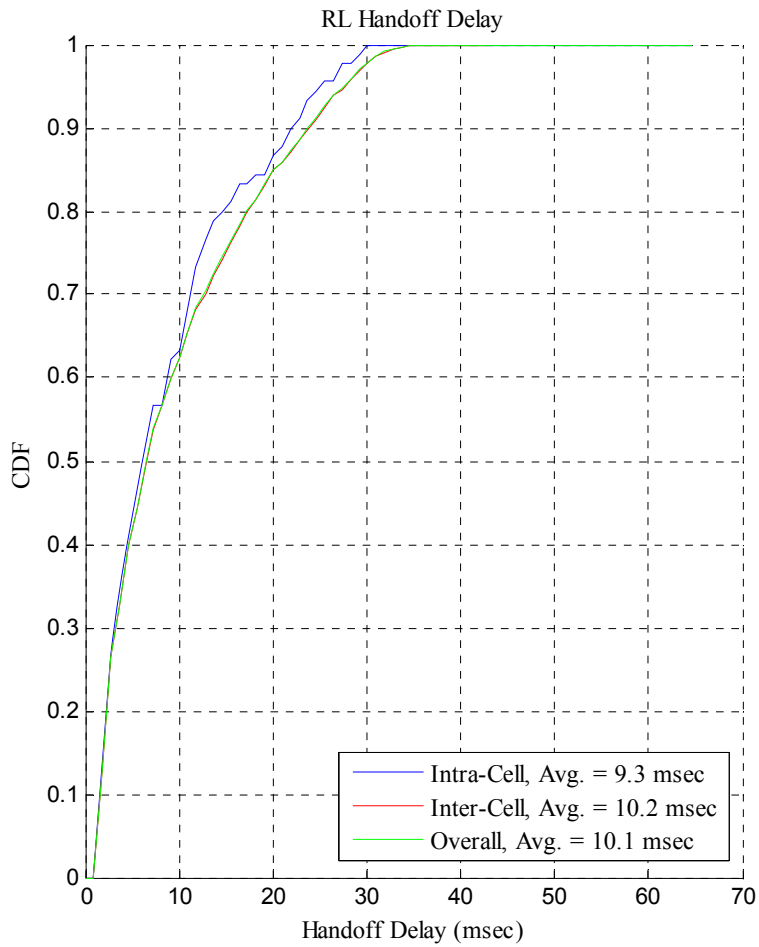
Mobility Simulations, Models 2





Handoff Delay Distributions





Idle State Performance

- Duty cycle in idle state
  - Required to read 8 OFDM symbols every page period

Paging period in superframes	Paging period in seconds	Duty Cycle (%)
2	0.04588	2.3
16	0.367	0.29
64	1.468	0.072.
128	2.94	0.036

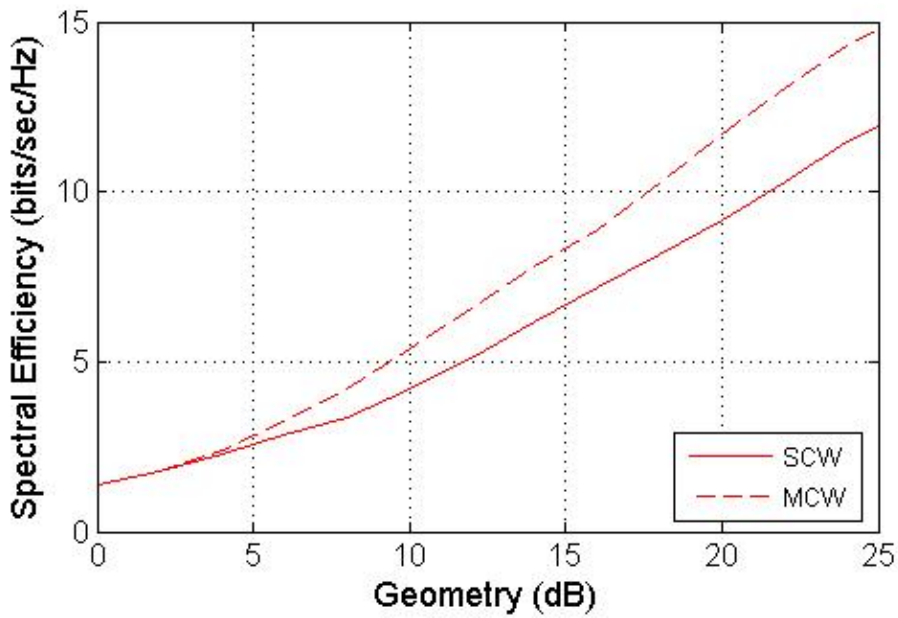
- Access delay
  - Access opportunity occurs every six frames (5.5msec)
- Paging overhead: 1.55%
  - Assuming 20 pages/second/sector, 5 MHz system
  - QuickPage: 1.25% and Paging on traffic channel: 0.3%

Outline

- Report II Requirements:
  - Traffic mix simulations.
    - Overhead channel modeling.
    - QoS arbitration.
    - Performance of each individual QoS class.
  - Mobility and handoff
- Performance of Salient Features:
  - Antenna techniques.
    - MIMO Multiple Code Word with Successive Interference Cancellation.
    - Pseudo-eigen Beamforming.
  - System enhancements.
    - Quasi-Orthogonal Reverse Link (QORL).
    - Fractional Frequency Reuse (FFR).
    - Spatial Division Multiple Access (SDMA).
    - Beamforming.

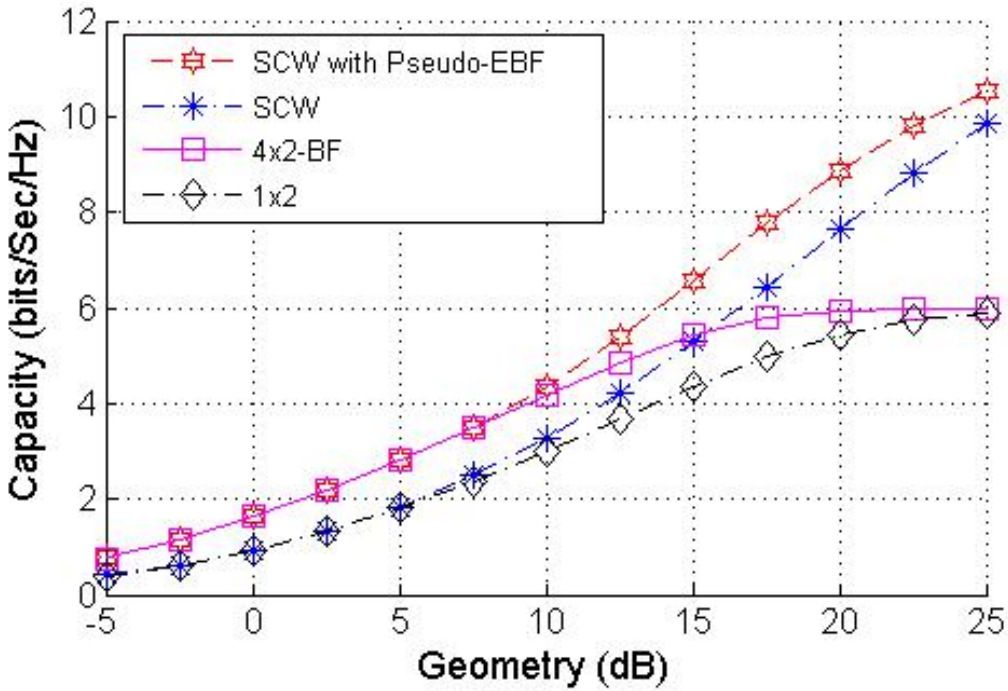
MCW vs. SCW

- Performance captures rate prediction, HARQ, coding and channel estimation performance.
- Channel model: pedB@3km/hr,
- Spatial correlation:
  - suburban macro, AoD: 50 degree; AS: 2 degree,
  - Antenna configuration: 4x4 with 10 λ spacing at AP and 0.5 λ spacing at AT.



Pseudo-Eigen Beamforming

- Assume gap to capacity of 3 dB to model coding, rate prediction and channel estimation loss.
- Channel model: pedB@3km/hr.
- No antenna correlation is assumed.



Outline

- Report II Requirements:
  - Traffic mix simulations.
    - Overhead channel modeling.
    - QoS arbitration.
    - Performance of each individual QoS class.
  - Mobility and handoff
- Performance of Salient Features:
  - Antenna techniques.
    - MIMO Multiple Code Word with Successive Interference Cancellation.
    - Pseudo-eigen Beamforming.
  - System enhancements.
    - Quasi-Orthogonal Reverse Link (QORL).
    - Fractional Frequency Reuse (FFR).
    - Spatial Division Multiple Access (SDMA).
    - Beamforming.

Simulation Numerology

Parameters	Values
Transmission Bandwidth	10MHz
Subcarrier Spacing	9.6kHz
Sampling Frequency	9.8304MHz
FFT Size	1024
Guard Carriers	32
Cyclic Prefix Length	6.51 μs
Windowing Duration	3.26 μs
OFDM Symbol Duration	113 μs
Number of OFDM Symbols Per Frame	8

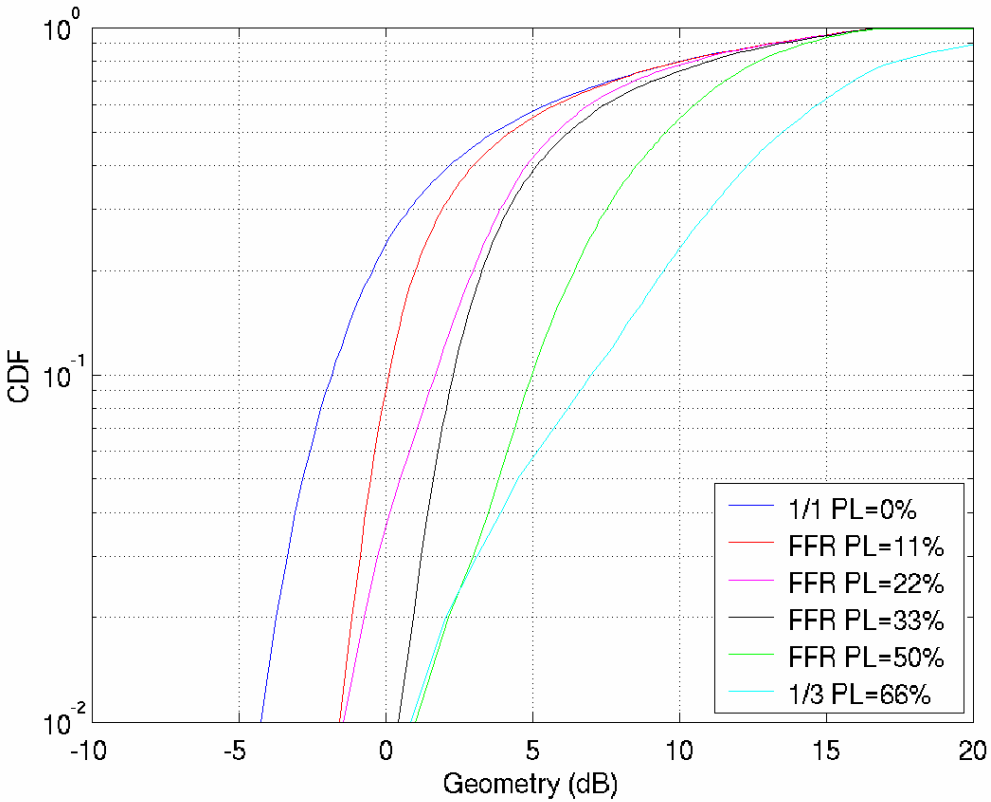
Quasi-Orthogonal Reverse Link

- Antenna configuration: 1x4 (diversity antennas)
- Channel model: pedB@3km/h, vehA@30km/h.
- Spatial correlation: urban micro (500m site-to-site distance).
- MMSE
  - Estimate spatial structure of all intra-sector users.
  - Additional estimation loss due to QORL is modeled.
  - Other sector interference is modeled as spatially uncorrelated.
- Results are conservative
  - Same multiplexing order for all users.
  - No user clustering has been implemented in simulations.

Sector Throughput (Kbps)	QORL Gain
PedB at 3 Km/h	27%
VehA at 30 Km/h	24%

Fractional Frequency Reuse

- Partial loading range: 0 – 66%.
- 500 meters site-to-site distance, urban micro propagation loss.



Fractional Frequency Reuse

- Antenna configuration: 1x2.
- Channel model: urban macro – Ped B
- Partial loading range: 0 – 50%.
- FL simulations with proportional fairness scheduling.

	1/1 Reuse	FFR 11% PL	FFR 22% PL	FFR 33% PL	FFR 50% PL
Normalized Sector Throughput	1.00	1.02	0.98	0.92	0.76
Normalized 5% User Spectral efficiency	1.00	1.27	1.37	1.69	2.00

FL SDMA

- Channel model: pedB@ 3km/h, spatial correlation: suburban macro.
- Codebook size: 2, users select one beam at the beginning of each simulation run.
- Receiver structure:
  - MRC: no estimation of spatial structure of intra and inter-sector interference.
  - MMSE: spatial processing based on estimates of spatial structure of intra-sector and inter-sector interference.
- Baseline for 4x2 is 1x2 system and baseline for 4x4 is 1x4 system.

Sector Throughput Gain over Baseline System	SDMA			
	4x2 with AT antenna spacing 0.5λ		4x4 with AT antenna spacing 0.5λ	
	MRC	MMSE	MRC	MMSE
1km BS to BS Suburban Macro PedB 3km/h	47%	76%	49%	96%

Beamforming (I)

- Channel model: pedB@ 3km/h, spatial correlation: suburban macro.
- Channel estimation error -13 dB.
- Calibration phase error STD 20 degree, amplitude STD 1 dB.
- Feedback delay is modeled.
- 802.20 fairness.

Sector Throughput (Kbps) Gain over Baseline system		Beamforming			Baseline
		4x2		8x2	1x2
		0.5 λ (Tx)	10 λ (Tx)	0.5 λ (Tx)	
		MRC	MRC	MRC	MRC
1km BS to BS Suburban Macro	pedB 3km/h	9179 (59%)	8831 (53%)	9858 (71%)	5775
	vehA 120km/h	8484 (58%)	5268 (-2%)	8786 (64%)	5366
2.5km BS to BS Suburban Macro	pedB 3km/h	8948 (58%)	8348 (48%)	9717 (72%)	5659
	vehA 120km/h	8118 (61%)	4981 (-1%)	8375 (66%)	5048

Beamforming (II)

- Channel model: pedB@ 3km/h, spatial correlation: suburban macro.
- Channel estimation error -13 dB.
- Calibration phase error STD 20 degree, amplitude STD 1 dB.
- Feedback delay is modeled.
- Equal grade of service.

Sector Throughput (Kbps) and Gain over Baseline System		Beamforming			Baseline
		4x2		8x2	1x2
		0.5λ (Tx)	10λ (Tx)	0.5λ (Tx)	
		MRC	MRC	MRC	MRC
1km BS to BS Suburban Macro	pedB 3km/h	6816 (70%)	5986 (50%)	8219 (105%)	4000
	vehA 120km/h	5423 (82%)	3418 (15%)	5958 (100%)	2973
2.5km BS to BS Suburban Macro	pedB 3km/h	5928 (98%)	5338 (78%)	7214 (141%)	2993
	vehA 120km/h	4681 (95%)	2785 (16%)	5217 (117%)	2406