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| Project | **IEEE 802.20 Working Group on Mobile Broadband Wireless Access**<br><http://ieee802.org/20/> | |
| Title | **QFDD Performance Report 1 Presentation** | |
| Date Submitted | **2005-10-28** | |
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| Re: | MBWA Call for Proposals | |
| Abstract | This contribution (part of the QFDD proposal package for 802.20), contains the QFDD Performance Report 1 Presentation slide set. | |
| Purpose | For consideration of 802.20 in its efforts to adopt an FDD proposal for MBWA. | |
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# QFDD Performance Report I Presentation

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# Outline

- **Simulation Setups**
- Link level results
- Forward link throughput
- Reverse link throughput

# Simulation Numerology

| | | |
|---|---|---|
| Bandwidth of Operation | 2x5 | MHz |
| FFT Size | 512 | points |
| Chip rate | 4.9152 | Mcps |
| Subcarrier spacing | 9.6 | kHz |
| Guard carriers | 32 | subcarriers |
| Cyclic Prefix | 6.51 | μs |
| Windowing Duration | 3.26 | μs |
| OFDM Symbol Duration (For 6.51μs CP) | 113.93 | μs |

# Channel Models

- Evaluation report I requires the use of Suburban macro correlation model and Ped B/Veh B multipath profile.
- Suburban macro cell:
  - Option I: Laplacian model, simple.
  - Option II: SCM model, multiple cluster scattering is more realistic.
  - Both models are used in link level simulations, and correlation matrices generated from SCM is used for system level simulations.
- Multipath profiles:
  - Ped B (3 km/h), Veh B (120-250 km/h), Veh A (120-250 km/h)

# Link-to-System Interface

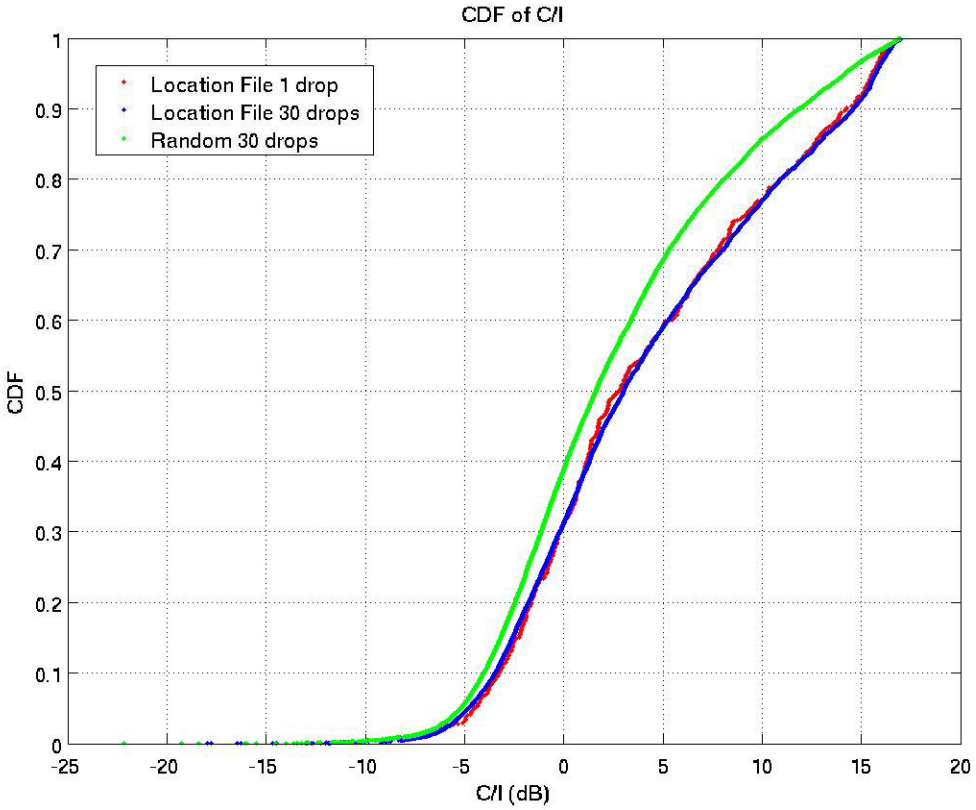
- FER versus effective C/I curves are generated from link simulation, which captures all channel effects and receiver imperfections.
- System simulation computes effective C/I of each packet and looks up the FER link curves.

$$SNR_{eff} = C^{-1}\left(\frac{1}{N}\sum_{i=1}^{N} C(SNR_i)\right)$$

- C(.) denotes the constrained capacity function corresponding to the modulation scheme being used
- When MMSE is used for spatial processing, $SNR_i$ denotes the post MMSE processing SNR.

# Location Calibration

- Calibration run is simulated with the exact cell and user locations as specified.
- Observation: highest geometry is 17 dB due to poor antenna pattern with 20 dB front-to-back ratio.



# Overhead Channel Modeling

- Overhead
  - FL control overhead 10%.
  - RL control overhead 11%.
- Signaling errors
  - CQI erasure 50%.
  - Power control error 10%.
  - Error events of probability < 1% is not modeled explicitly in system simulation for full buffer simulations.

# Outline

- Simulation Setups
- **Link level results**
- Forward link throughput
- Reverse link throughput

# FL Packet Formats

| Packet Format Index | Spectral efficiency on 1st trans-mission | Max number of trans-missions | Modulation order for each transmission | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | 0.2 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 0.5 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 1.0 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1.5 | 6 | 3 | 2 | 2 | 2 | 2 | 2 |
| 4 | 2.0 | 6 | 4 | 3 | 3 | 3 | 3 | 3 |
| 5 | 2.5 | 6 | 6 | 4 | 4 | 4 | 4 | 4 |
| 6 | 3.0 | 6 | 6 | 4 | 4 | 4 | 4 | 4 |
| 7 | 4.0 | 6 | 6 | 6 | 4 | 4 | 4 | 4 |
| 8 | 5.0 | 6 | 6 | 6 | 4 | 4 | 4 | 4 |
| 9 | 6.0 | 6 | 6 | 6 | 4 | 4 | 4 | 4 |
| 10 | 7.0 | 6 | 6 | 6 | 4 | 4 | 4 | 4 |
| 11 | 8.0 | 6 | 6 | 6 | 6 | 4 | 4 | 4 |
| 12 | 9.0 | 6 | 6 | 6 | 6 | 4 | 4 | 4 |
| 13 | 10.0 | 6 | 6 | 6 | 6 | 6 | 4 | 4 |
| 14 | 11.0 | 6 | 6 | 6 | 6 | 6 | 4 | 4 |
| 15 | NULL | | | | | | | |

# RL Packet Formats

| Packet format index | Spectral efficiency on 1st transmission | Max number of transmissions | Modulation order for each transmission | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | 0.25 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 1 | 0.50 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 2 | 1.0 | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 3 | 1.5 | 6 | 3 | 2 | 2 | 2 | 2 | 2 |
| 4 | 2.0 | 6 | 3 | 3 | 2 | 2 | 2 | 2 |
| 5 | 2.67 | 6 | 4 | 4 | 3 | 3 | 3 | 3 |
| 6 | 4.0 | 6 | 4 | 4 | 3 | 3 | 3 | 3 |
| 7 | 6.0 | 6 | 4 | 4 | 4 | 3 | 3 | 3 |
| 8 | 8.0 | 6 | 4 | 4 | 4 | 4 | 4 | 3 |

# FL and RL Peak Rates

| Parameter | Bandwidth 2x5 MHz | |
|---|---|---|
| | Forward Link | Reverse Link |
| Required Peak Rate | 18 Mbps | 9 Mbps |
| MBWA FDD Proposal | 66 Mbps | 9.8 Mbps |

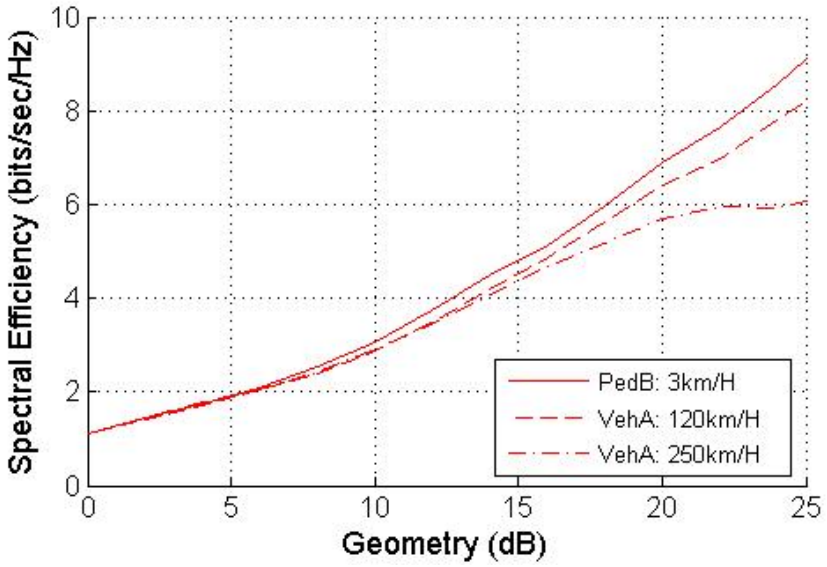
# FL Mobility

- MIMO performance is more sensitive to the channel estimation errors due to mobility and multipath delay.
- Experiments assuming 4x4 MIMO SCW with linear MMSE receiver.
- Simulations capture the loss due to channel estimation error, coding, and hybrid ARQ.
- Spectral efficiency takes into account the pilot overhead.
- Correlation models
  - Laplacian AS distribution.
    - BS: AoD 50°, AS 2°, MS: AoA 67.5°, AS 35 °
  - SCM
    - BS: AoD 50 °, AS 2°, MS: average AoA, AS AS 35 °

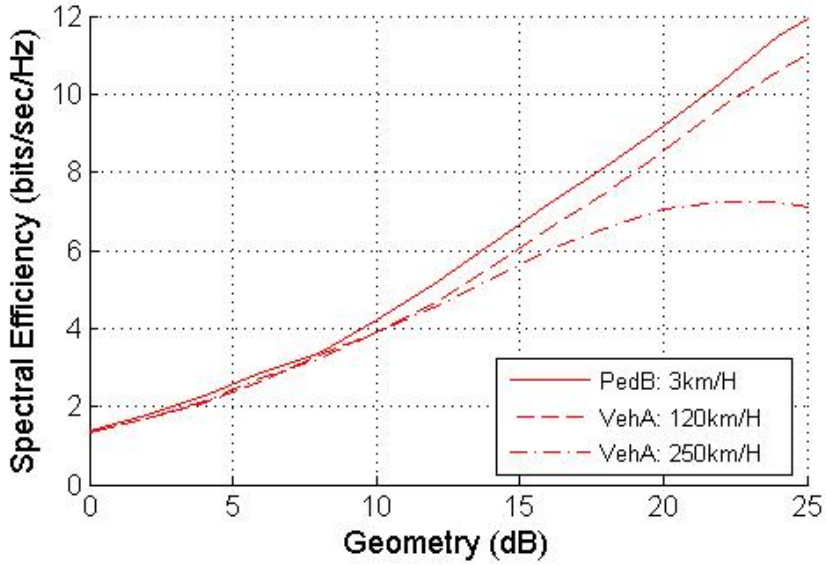
* Spectral efficiency takes into account the pilot overhead.

# FL Mobility

- Slight performance degradation up to 120 km/h.
- Support > 6 bps/Hz at 22 dB with vehA 250 km/h.
- Laplacian model results in unrealistic high channel correlation.



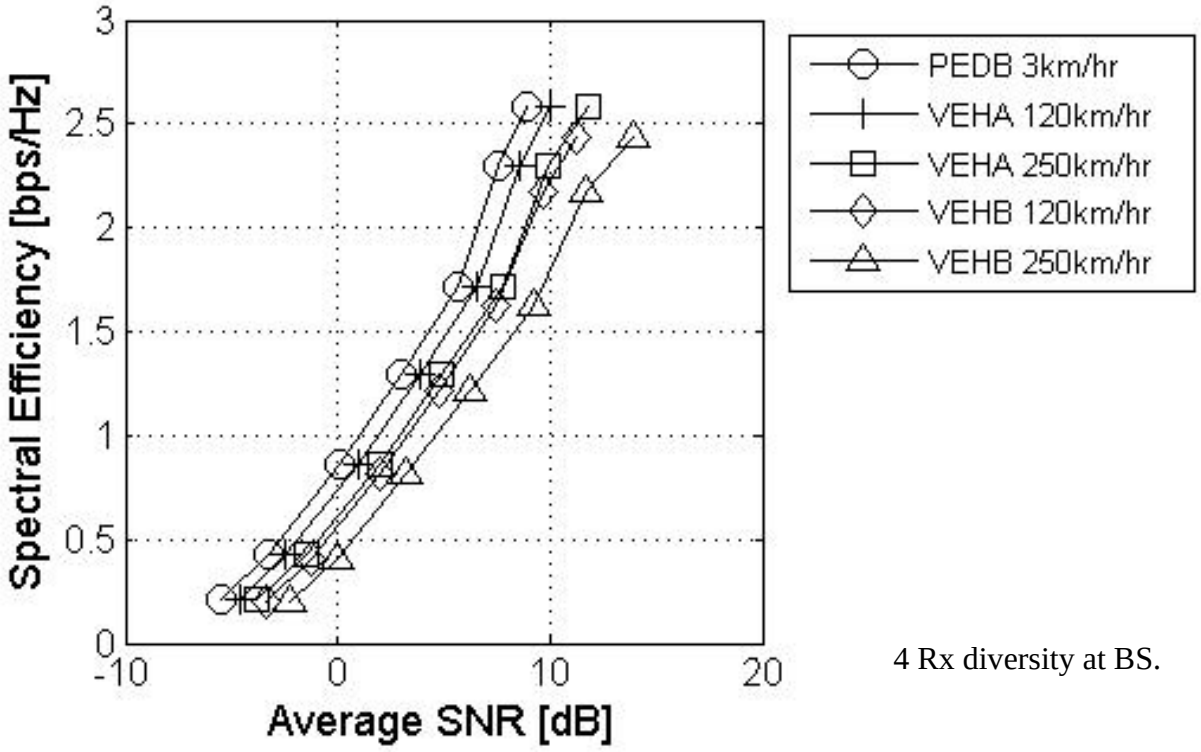

Laplacian Model




SCM Model

# RL Mobility

- For each packet format, an average SNR is obtained to meet the 1% FER.
- Spectral efficiency takes into account the pilot overhead and 1% loss in throughput due to packet error.
- Slight performance degradation at 120 km/h.
- Support approximately 2.5 bps/Hz at 250 km/h.




4 Rx diversity at BS.

# Forward Link Budget

- Mobile station 2 Rx, mobile throughput 1.92 Mbps

| CHANNEL | Maximum pathloss (dB) | Maximum range (meters) |
|---|---|---|
| I (ped-A) | 138.7 | 1156 |
| II (veh-A) | 142.2 | 1455 |
| III (ped-B) | 141.7 | 1408 |
| IV (veh-B) | 142 | 1436 |

# Reverse Link Budget

- Base station 4 Rx, mobile data rate 64 Kbps

| CHANNEL | Maximum pathloss (dB) | Maximum range (m) |
|---|---|---|
| I (ped-A) | 138.5 | 1140 |
| II (veh-A) | 140.6 | 1313 |
| III (ped-B) | 140.3 | 1287 |
| IV (veh-B) | 139.9 | 1254 |

# Outline

- Simulation Setups
- Link level results
- **Forward link throughput**
- Reverse link throughput

# Forward link Spectral Efficiency

- MIMO 4x4 suburban macro spectral efficiency 1km BS to BS

| | PedB 3km/hr | VehA 120km/hr |
|---|---|---|
| Required (b/s/Hz/sector) | 2.0 | 1.5 |
| QFDD (b/s/Hz/sector) | 2.20 | 1.96 |

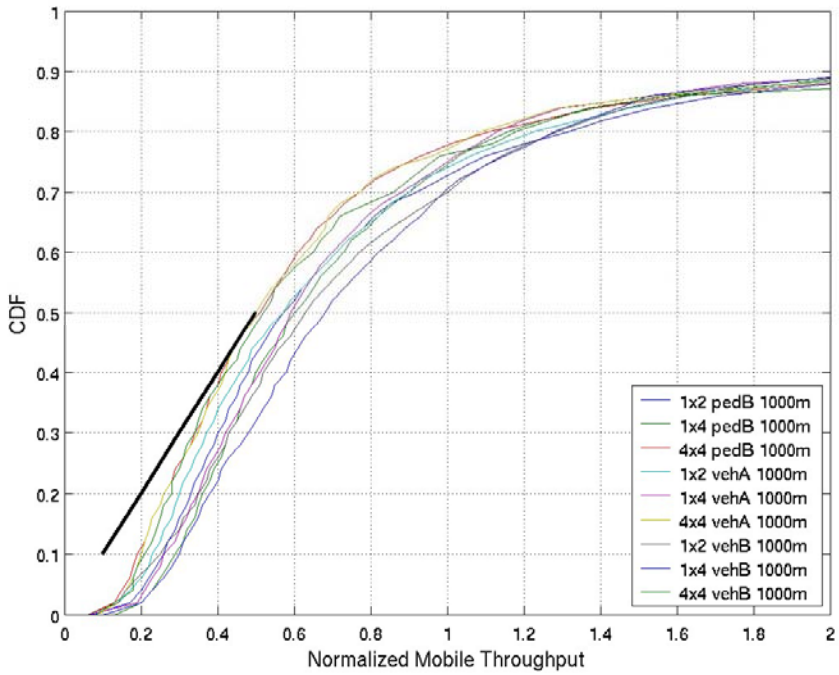
- MIMO 4x4 suburban macro throughput

| Sector Throughput (kbps) | PedB 3km/hr | VehA 120km/hr | VehB 120km/hr |
|---|---|---|---|
| 1km BS to BS | 10857 | 9580 | 6751 |
| 2.5km BS to BS | 9084 | 7707 | 5695 |

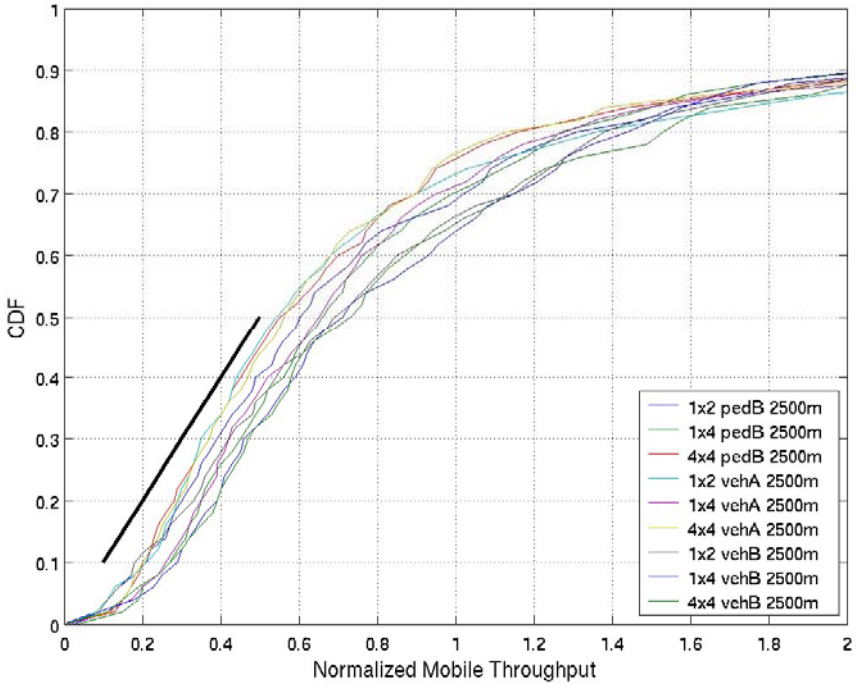
# Forward link Data Throughput

| Sector Throughput (Kbps) | | 1x2 | 1x4 | 4x4 |
|---|---|---|---|---|
| 1km BS to BS | pedB 3km/h | 5912 | 7740 | 10857 |
| | vehA 120km/h | 5366 | 7072 | 9580 |
| | vehB 120km/h | 3103 | 4751 | 6751 |
| 2.5km BS to BS | pedB 3km/h | 5110 | 7000 | 9084 |
| | vehA 120km/h | 4640 | 6233 | 7707 |
| | vehB 120km/h | 2756 | 4299 | 5695 |

# Forward Link Fairness

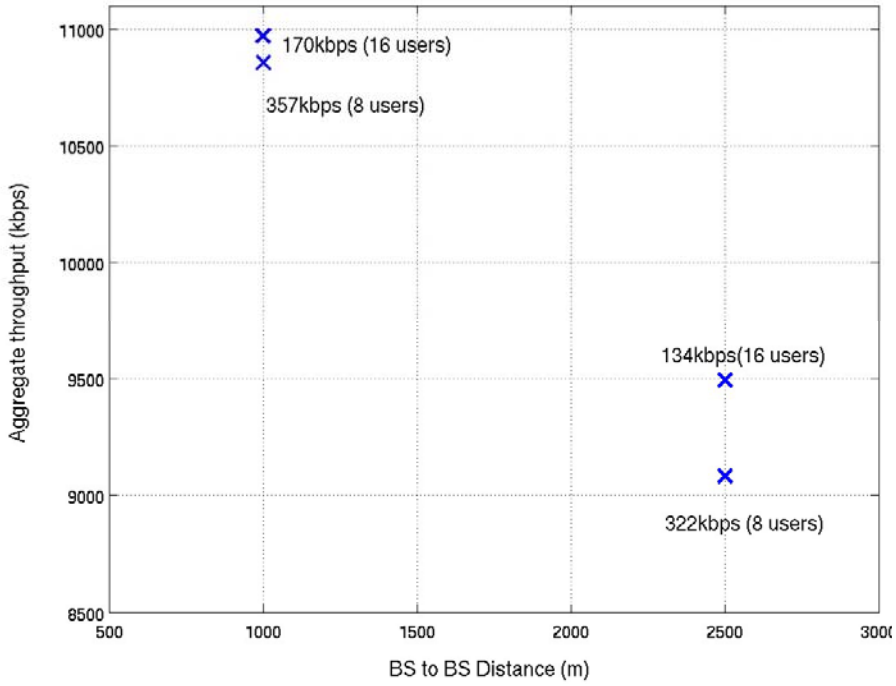


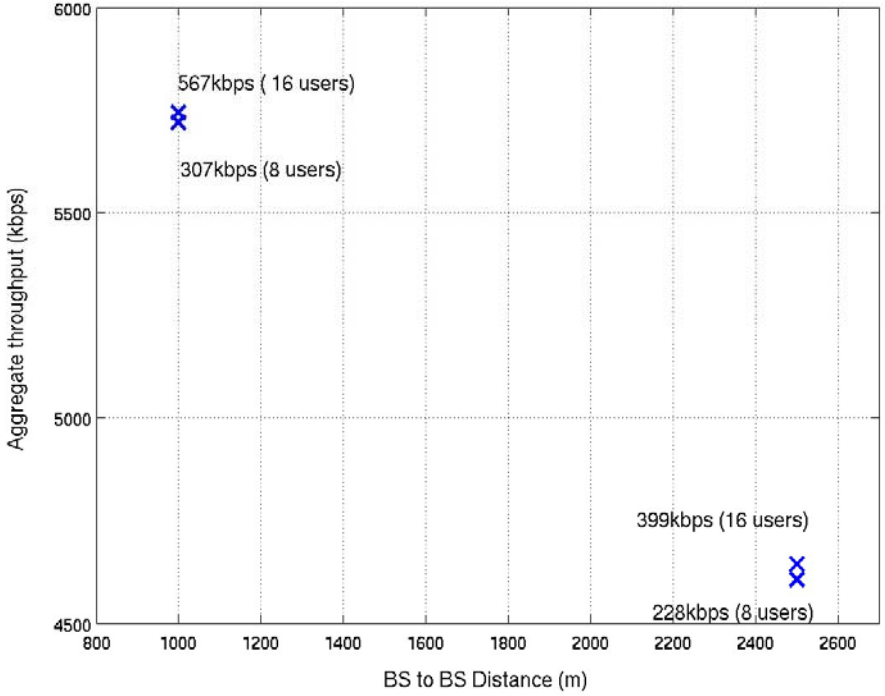

**MIMO 4x4, 1000m BS to BS**




**MIMO 4x4, 2500m BS to BS**

# Forward Link Coverage Tradeoff




802.20 Fariness Scheduling

Equal Grade of Service Scheduling

**Minimum service level (80% user data rate) for a 4x4 MIMO system**

# Outline

- Simulation Setups
- Link level results
- Forward Link throughput
- **Reverse Link throughput**

# Reverse Link Spectral Efficiency

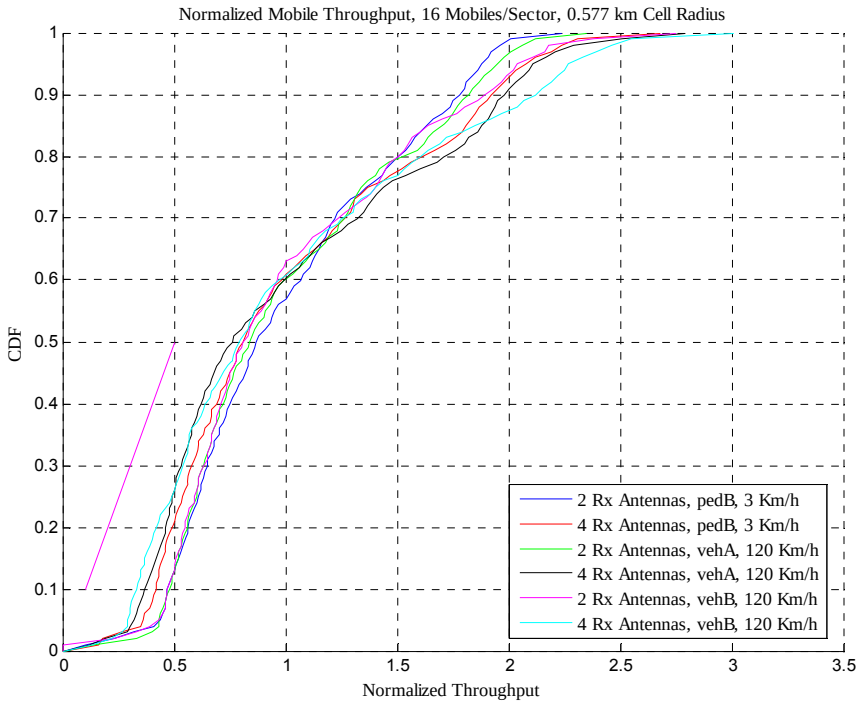
- Suburban macro spectral efficiency with 4 Rx and 1 km BS to BS

| Parameter | **PedB 3km/hr** | **VehA 120km/hr** |
|---|---|---|
| **Required (b/s/Hz/sector)** | **1.0** | **0.75** |
| **QFDD (b/s/Hz/sector)** | **1.42** | **1.25** |

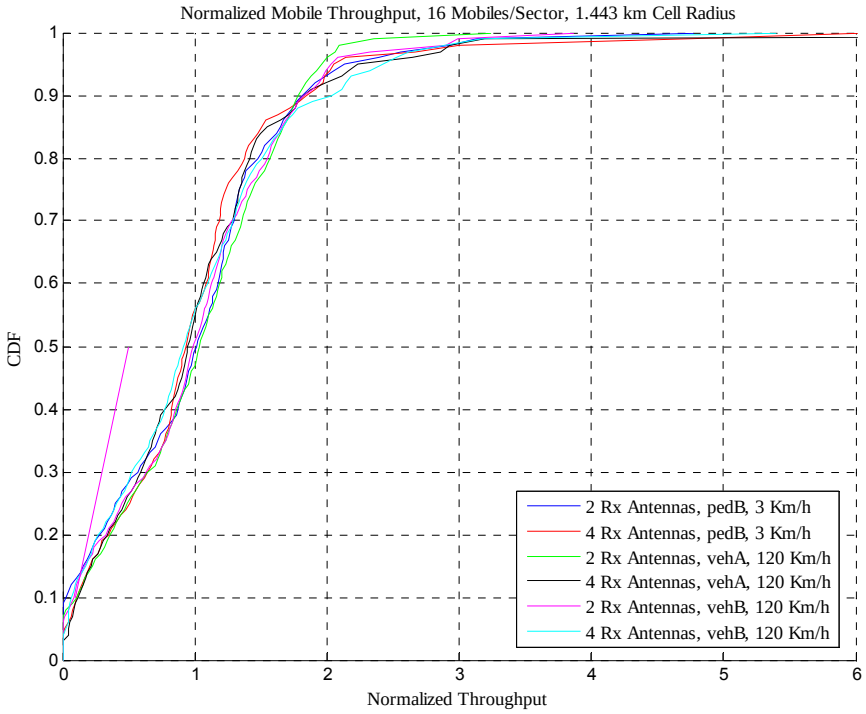
# Reverse Link Data Throughput

| Sector Throughput (Kbps) | | 1x2 | 1x4 |
|---|---|---|---|
| 1km BS to BS | pedB 3km/h | 4109 | 6921 |
| | vehA 120km/h | 3853 | 5883 |
| | vehB 120km/h | 3235 | 5361 |
| 2.5km BS to BS | pedB 3km/h | 3449 | 5109 |
| | vehA 120km/h | 3058 | 4919 |
| | vehB 120km/h | 2717 | 4472 |

# Reverse Link Fairness

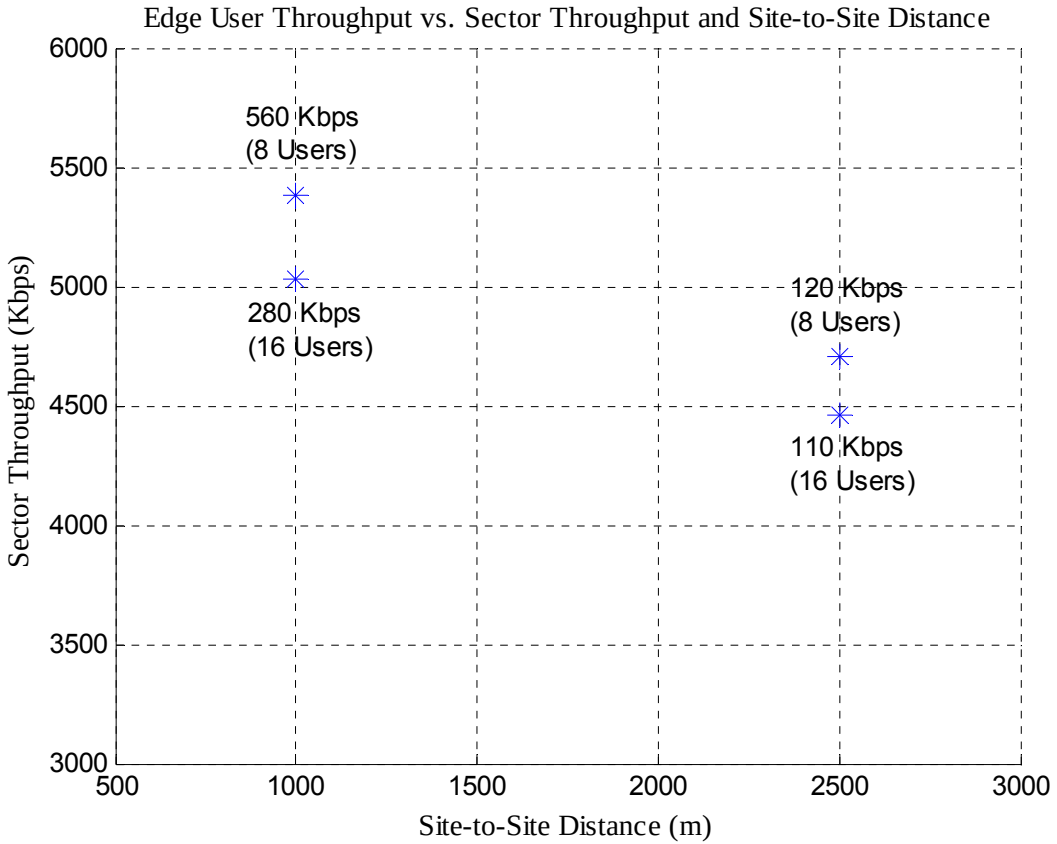



**1000m BS to BS**




**2500m BS to BS**

# Reverse Link Coverage




4 Rx at BS

**Minimum service level (80% user data rate) for a 4 Rx diversity system**