

Reverse Link Performance of Relay-based Cellular Systems in Manhattan-like Scenario

IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE C80216mmr-05_004

Date Submitted:

2006-1-6

Source:

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Venue:

IEEE 802.16 Session#41, New Delhi, India

Base Document:

None

Purpose:

Information

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Reverse Link Performance of Relay-based Cellular Systems in Manhattan-like Scenario

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January, 2006

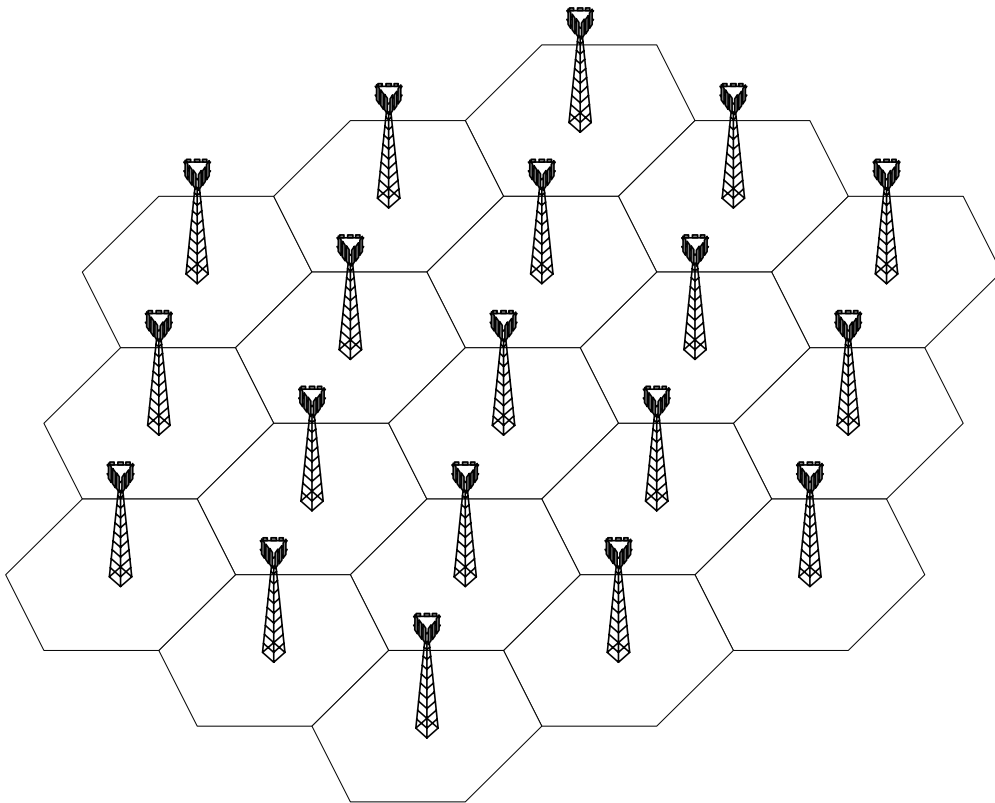
Outline

- Relay Deployment Scenario
- Simulation Models
- Simulation Results
- Summary

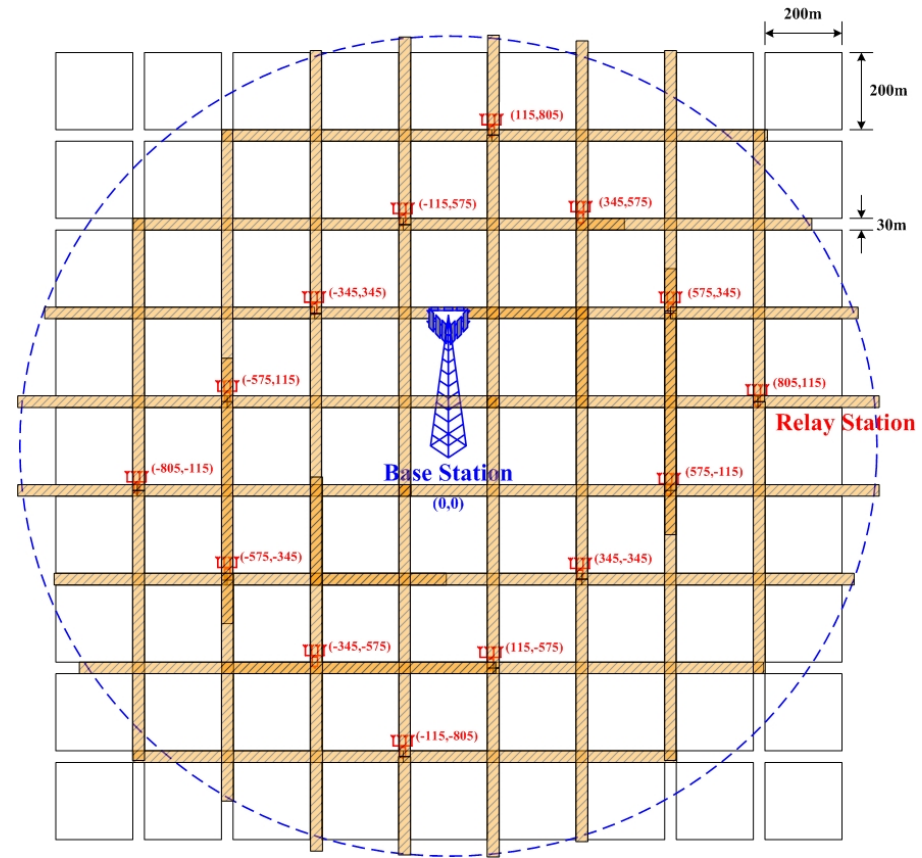
Relay Deployment Scenario

- Consider an existing cellular network with well-planned coverage
 - Fixed Relay Stations (FRS) are deployed within the coverage of each cell
 - FRSs are deployed for throughput enhancement
 - The same deployment scenario as C80216mmr-05_041

multi-cell environment

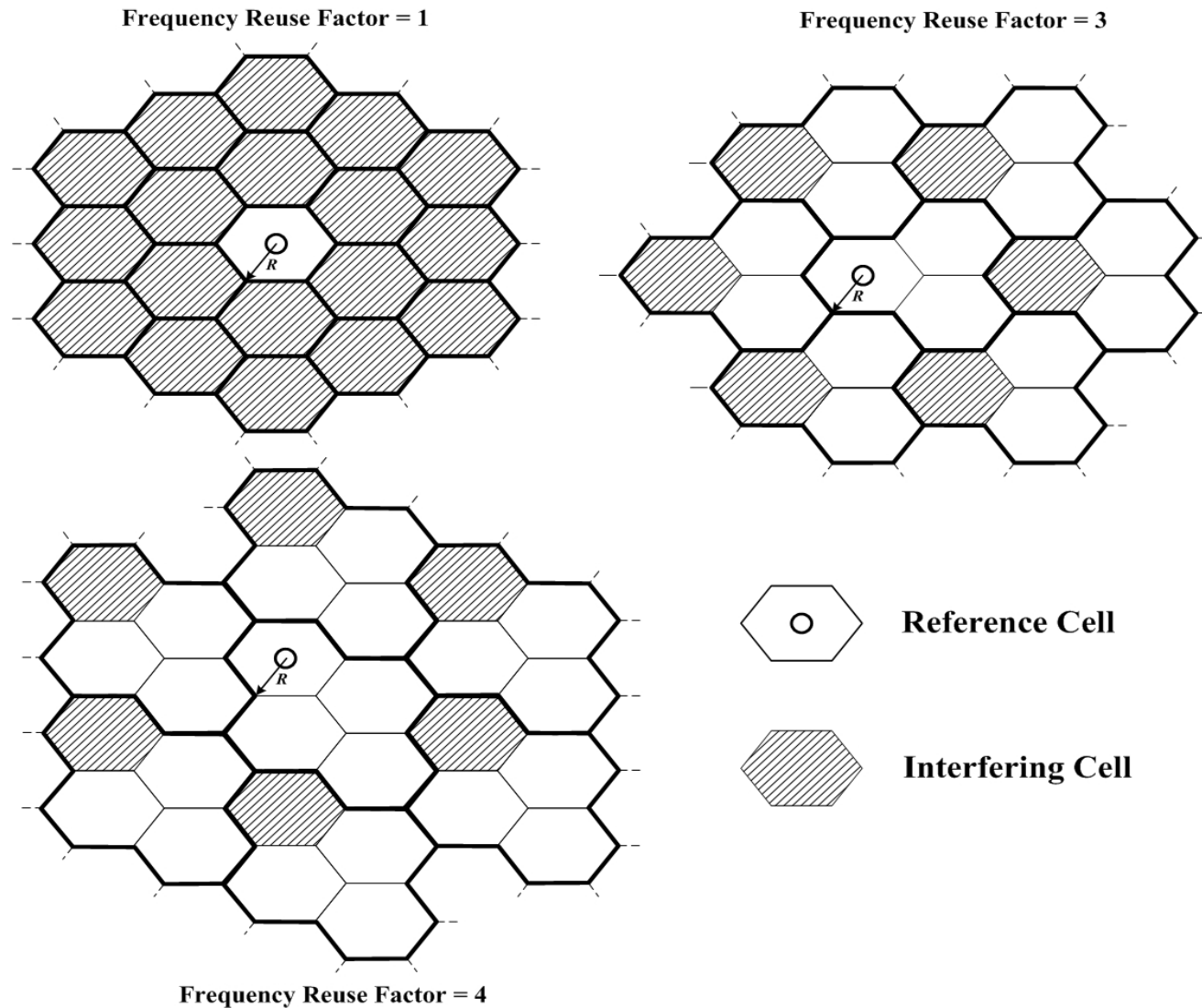


FRSs provide full coverage within each cell



Relay Deployment Scenario

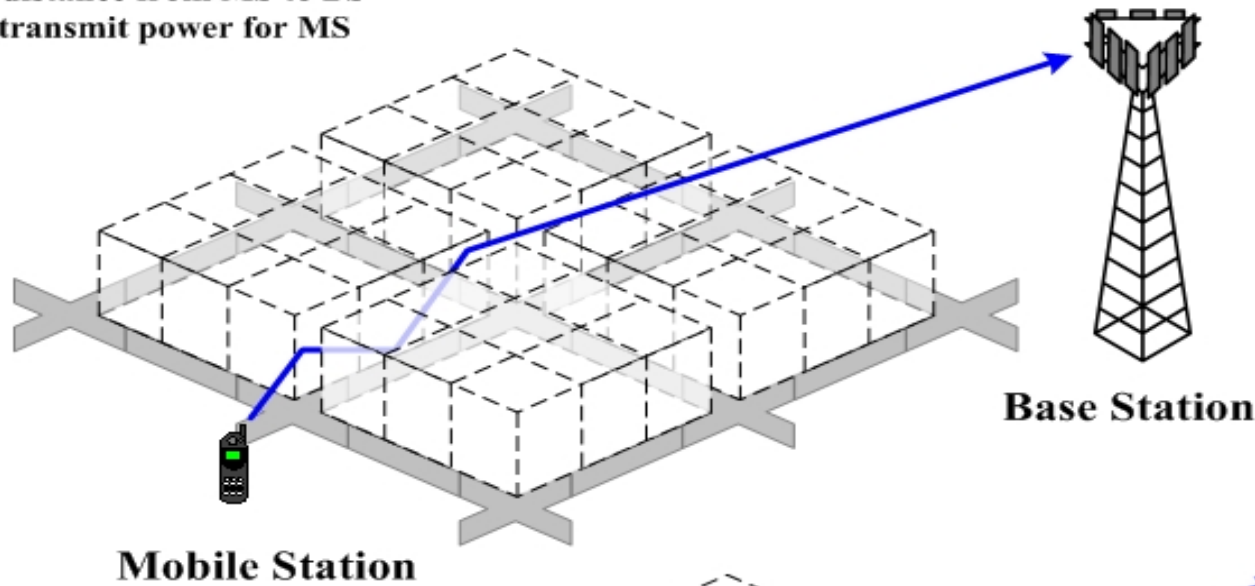
- Interfering cells can be separated by increasing frequency reuse factor (K)
 - However, it takes K times radio bandwidth throughout the system.



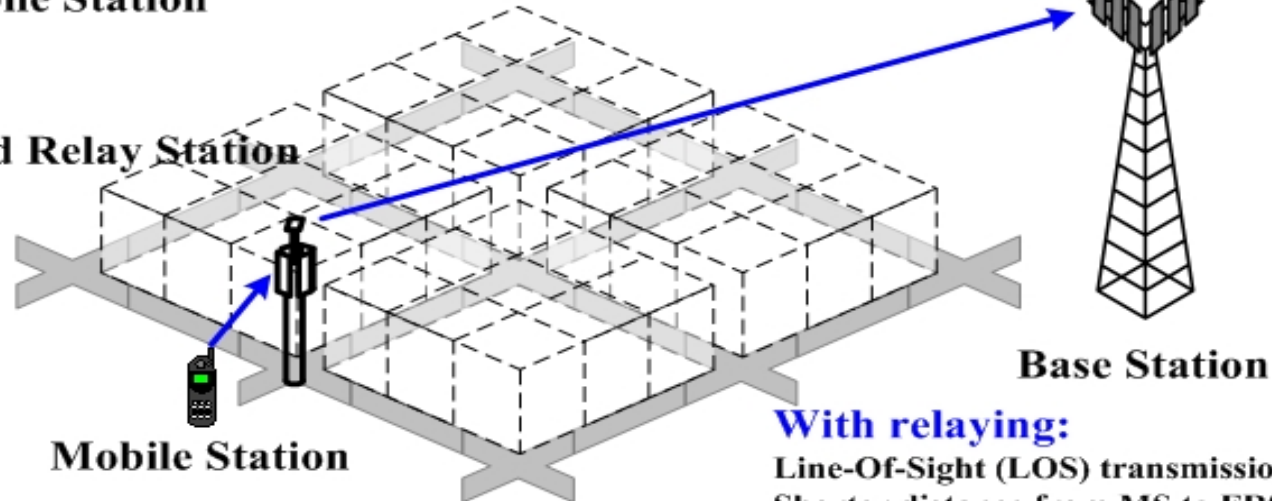
Relay Deployment Scenario

Without relaying:

Non-Line-Of-Sight (NLOS) transmission in general
Longer distance from MS to BS
Higher transmit power for MS



Fixed Relay Station



With relaying:

Line-Of-Sight (LOS) transmission in general
Shorter distance from MS to FRS
Lower transmit power for MS

- Relay Deployment Scenario
- **Simulation Models**
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Simulation Models

- **Mobile Station (MS)**

- Max. transmit power (0.5 Watts) for 1km cell radius
- Power control for reverse link transmission
 - Adaptive resource allocation (ARA) is an alternative solution
- If FUSC permutation is applied for each sector, MS and FRS in different sector can reuse the same sub-channel.
 - Additional intra-cell interference may be raised

- **Fixed Relay Station (FRS)**

- 14 FRSs are deployed to provide full coverage within the cell
 - 4 directional antennas for each main street direction
 - 1 stand alone directional antenna is steering toward the BS's direction
 - Power control for the reverse link transmission between FRS and BS
- Time domain relaying within the same radio bandwidth



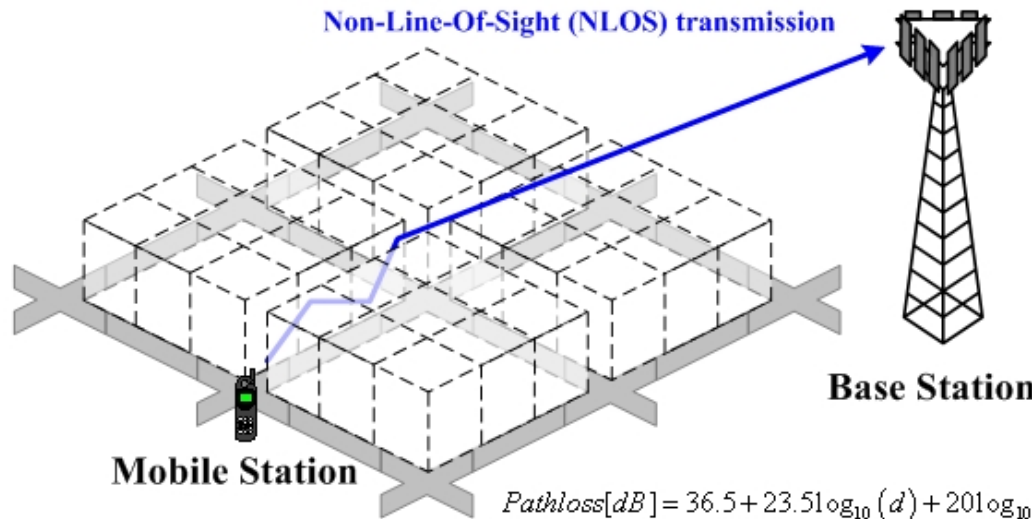
Simulation Models

- Propagation models are the same as C80216mmr-05_041

$$Pathloss[dB] = 38.4 + 35 \log_{10}(d) + 20 \log_{10}(f_c/5)$$

MS ↔ BS $\sigma = 8dB$

Non-Line-Of-Sight (NLOS) transmission

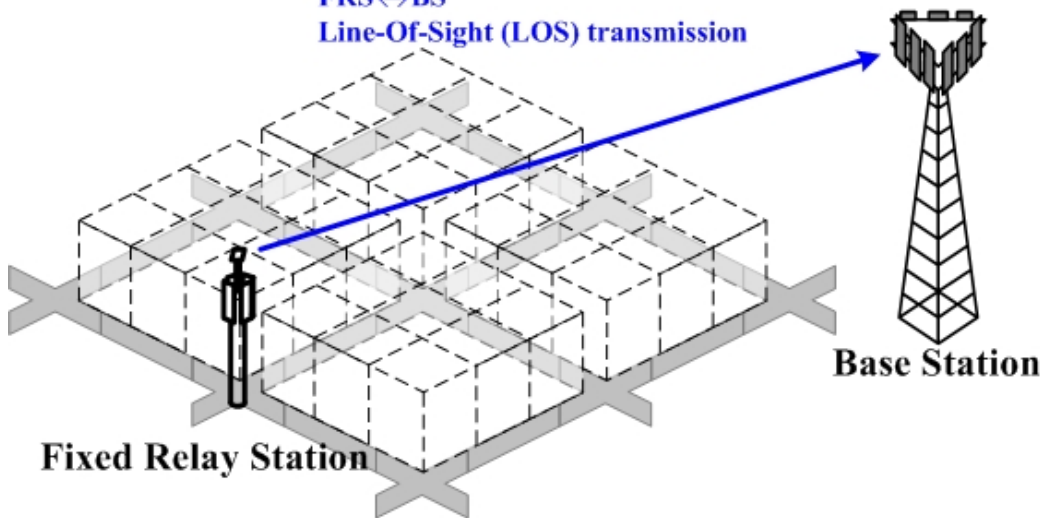


$$Pathloss[dB] = 36.5 + 23.5 \log_{10}(d) + 20 \log_{10}(f_c/2.5)$$

$\sigma = 3.4dB$

FRS ↔ BS

Line-Of-Sight (LOS) transmission



f_c carrier frequency (GHz)

d distance between Tx and Rx (meters)

σ standard deviation of shadow fading (dB)

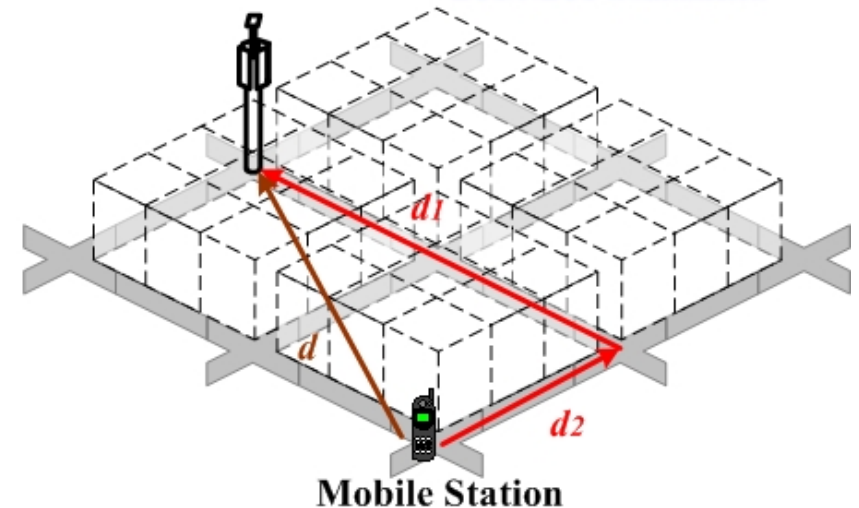
P_{LOS} probability to have LOS condition

$$Pathloss[dB] = \begin{cases} 41 + 22.71 \log_{10}(d) + 20 \log_{10}(f_c/5) & \text{if LOS} \\ 0.096 \cdot d_1 + 65 + 20 \log_{10}(f_c/5) \\ + (28 - 0.024 \cdot d_1) \cdot \log_{10}(d_2) & \text{if NLOS} \end{cases}$$

$$\sigma[dB] = \begin{cases} 2.3 & \text{if LOS} \\ 3.1 & \text{if NLOS} \end{cases}$$

$$P_{LOS}(d) = \begin{cases} 1 & d \leq 15m \\ 1 - \left(1 - (1.56 - 0.48 \log_{10}(d))\right)^3 & d > 15m \end{cases}$$

Fixed Relay Station MS ↔ FRS
LOS/NLOS transmission



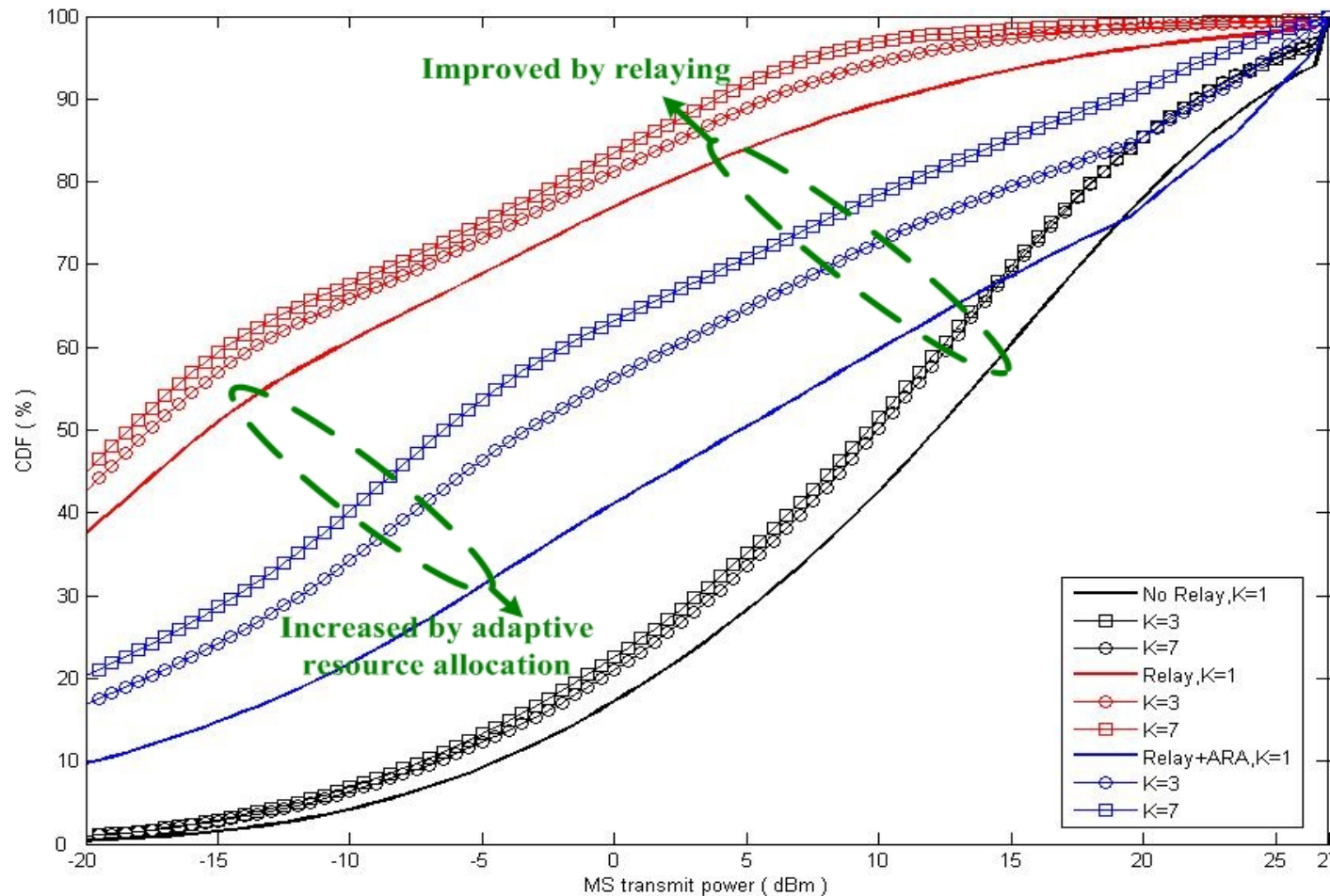
Simulation Models

- Reference System: IEEE 802.16e OFDMA mode
 - Radio bandwidth for each cell: 6MHz
 - Total number of sub-carriers: 2048
 - Carrier frequency: 3.5GHz
 - Number of sub-channels in each sector: 96(FUSC), 32(PUSC)
 - Number of sub-carriers within each sub-channel: 18
 - Number of sectors: 3
 - Max. transmit power of each MS: 0.5W
 - Max. transmit power of each FRS: 5W
 - Antenna height of BS: Above rooftop (35m)
 - Antenna height of FRS: Above / below rooftop (to BS / MS)
 - MS speed: 30km/hr
 - Probability of changing direction at intersection: 50%
 - MS arrival: Poisson process
 - Handoff type: Hard handoff

- Relay Deployment Scenario
- Simulation Models
- **Simulation Results**
- Summary

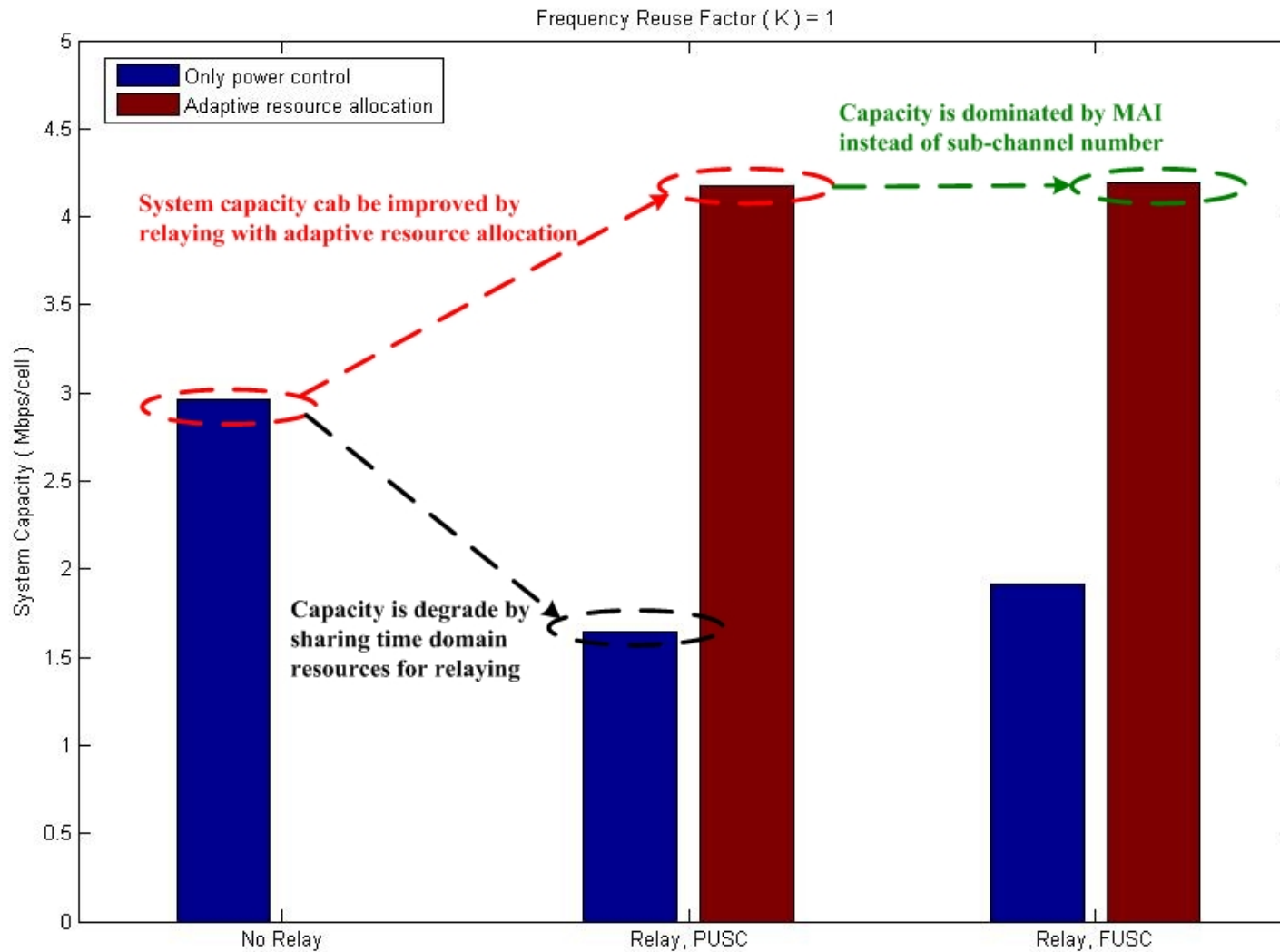
Simulation Results

- CDF (Cumulative Distribution Function) of MS transmit power
 - ARA: Adaptive Resource Allocation
 - PUSC permutation



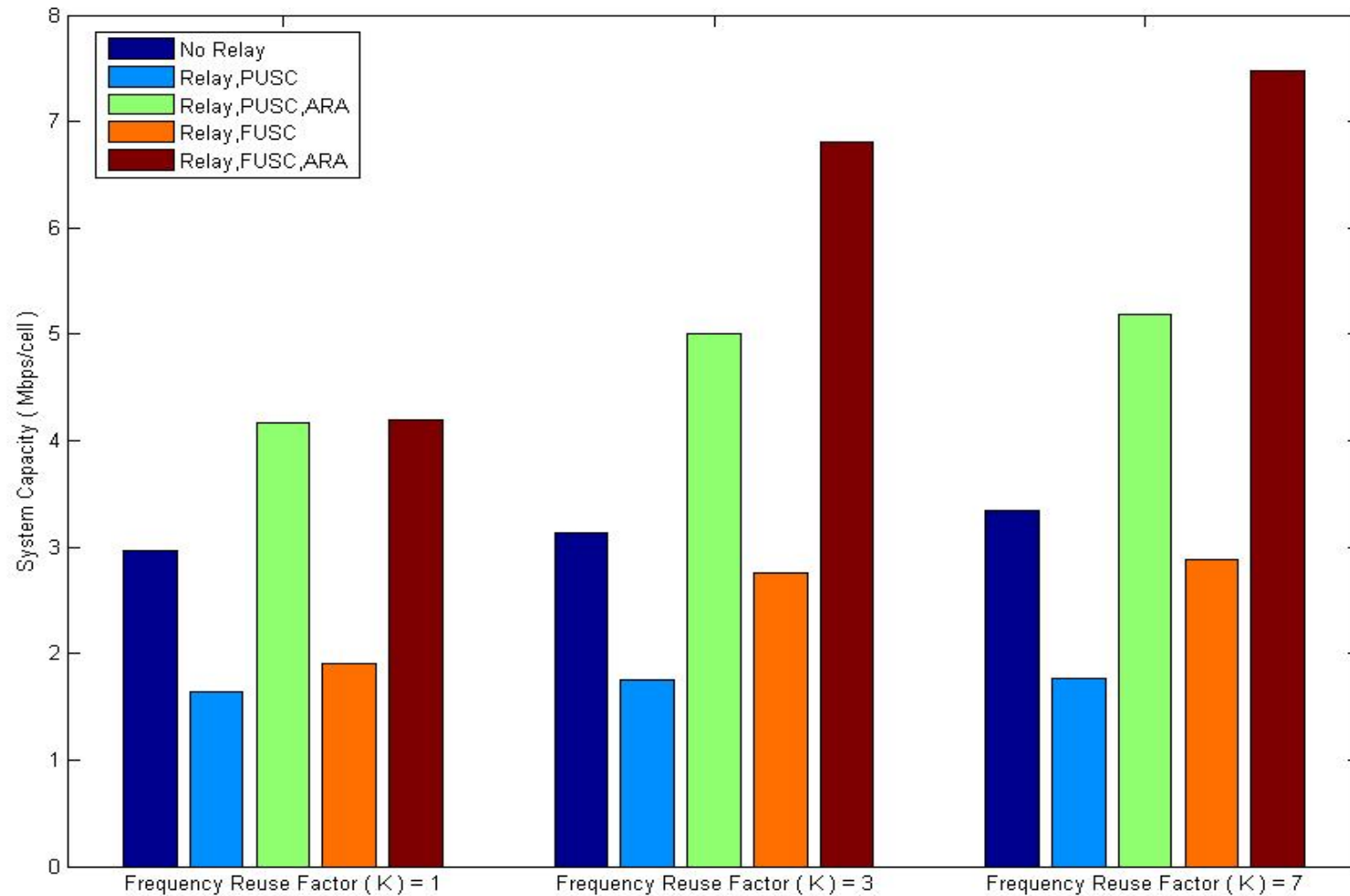
Simulation Results

- System capacity (Mbps/cell)



Simulation Results

- System capacity (Mbps/cell)



Simulation Results

K=1	MS Transmit Power	Cell Throughput
No Relay	<i>Reference case</i> (+0dB)	<i>Reference case</i> (+0%)
Relay, PUSC	-7.21dB	-44.53%
Relay, PUSC + adaptive resource allocation	-0.20dB	+40.95%
Relay, FUSC	-4.30dB	-35.44%
Relay, FUSC+ adaptive resource allocation	+1.19dB	+41.66%

Simulation Results

K=3	MS Transmit Power	Cell Throughput
No Relay	-1.59dB	+5.97%
Relay, PUSC	-11.05dB	-40.99%
Relay, PUSC + adaptive resource allocation	-2.46dB	+69.29%
Relay, FUSC	-6.69dB	-7.67%
Relay, FUSC+ adaptive resource allocation	+0.90dB	+129.96%

Simulation Results

K=7	MS Transmit Power	Cell Throughput
No Relay	-1.60dB	+13.01%
Relay, PUSC	-12.65dB	-40.35%
Relay, PUSC + adaptive resource allocation	-4.67dB	+75.08%
Relay, FUSC	-9.80dB	-2.68%
Relay, FUSC+ adaptive resource allocation	-0.29dB	+152.31%

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Summary

- Relaying provides significant performances improvement on:
 - saving MS transmit power
 - Shorter distance between MS and FRS
 - Higher probability to have LOS transmission condition
→ Propagation loss reduction
 - increasing system capacity
 - Transform the conserved MS transmit power into cell throughput improvement through adaptive resource allocation
 - Overall cell throughput is outperformed to the case without relaying
- Adaptive resource allocation/scheduling mechanism should be an important function for relay-based systems
 - System capacity can be benefited by relaying through this function