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

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

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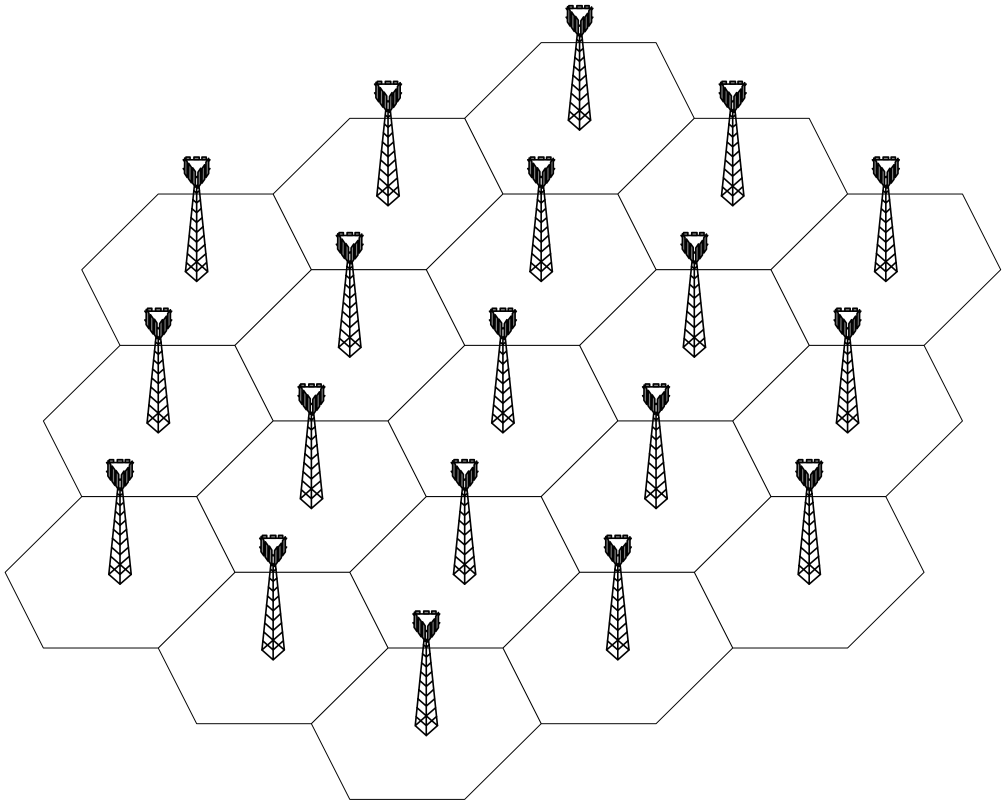
Outline

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

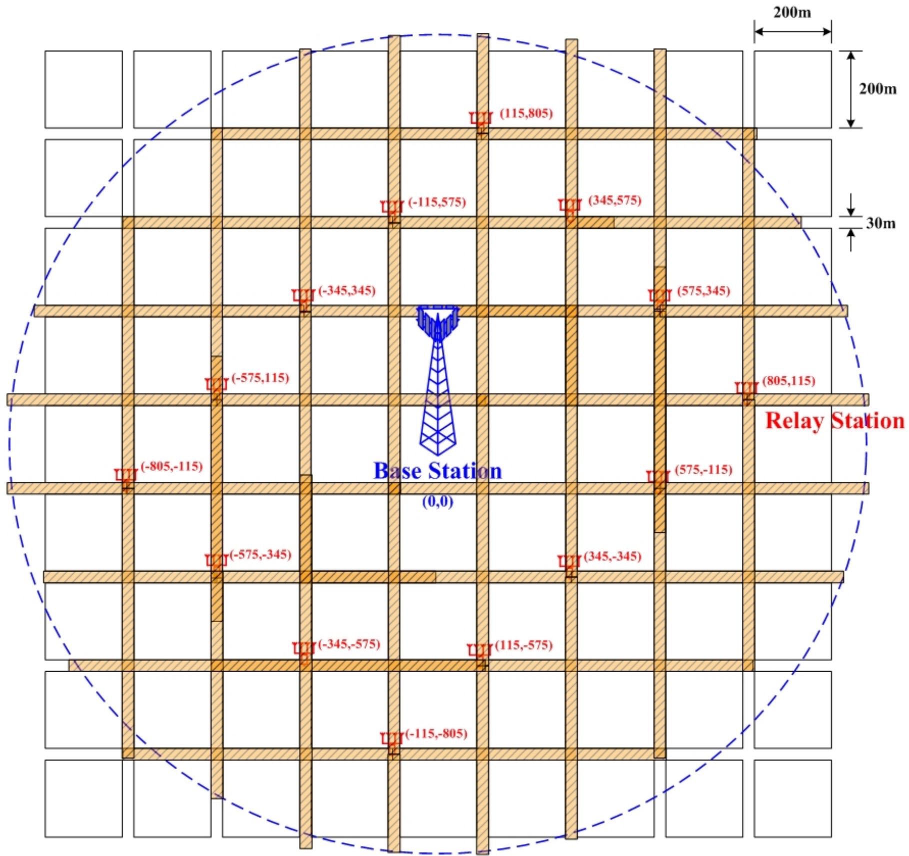
Relay Deployment Scenario

- 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

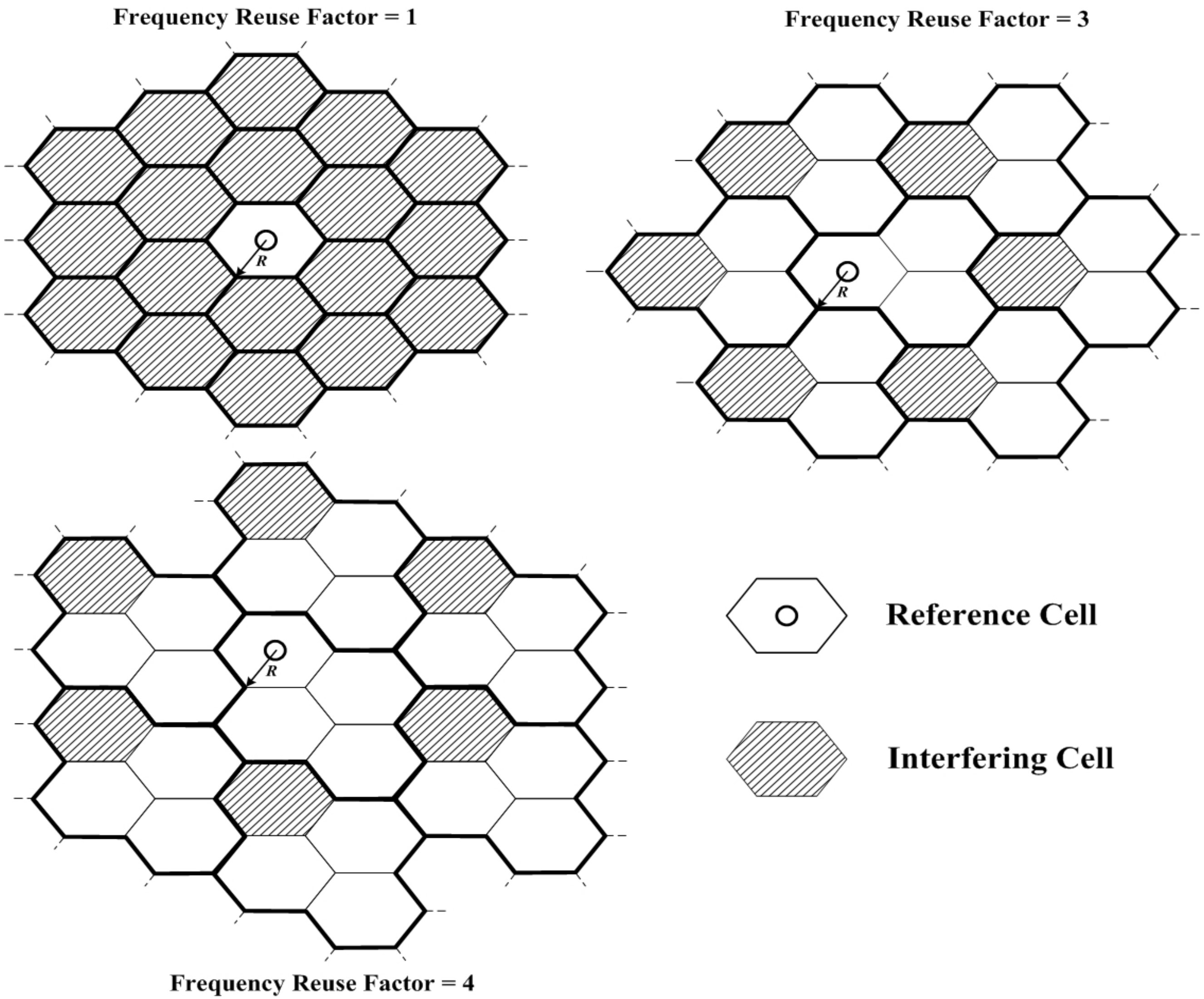


FRSs provide full coverage within each cell

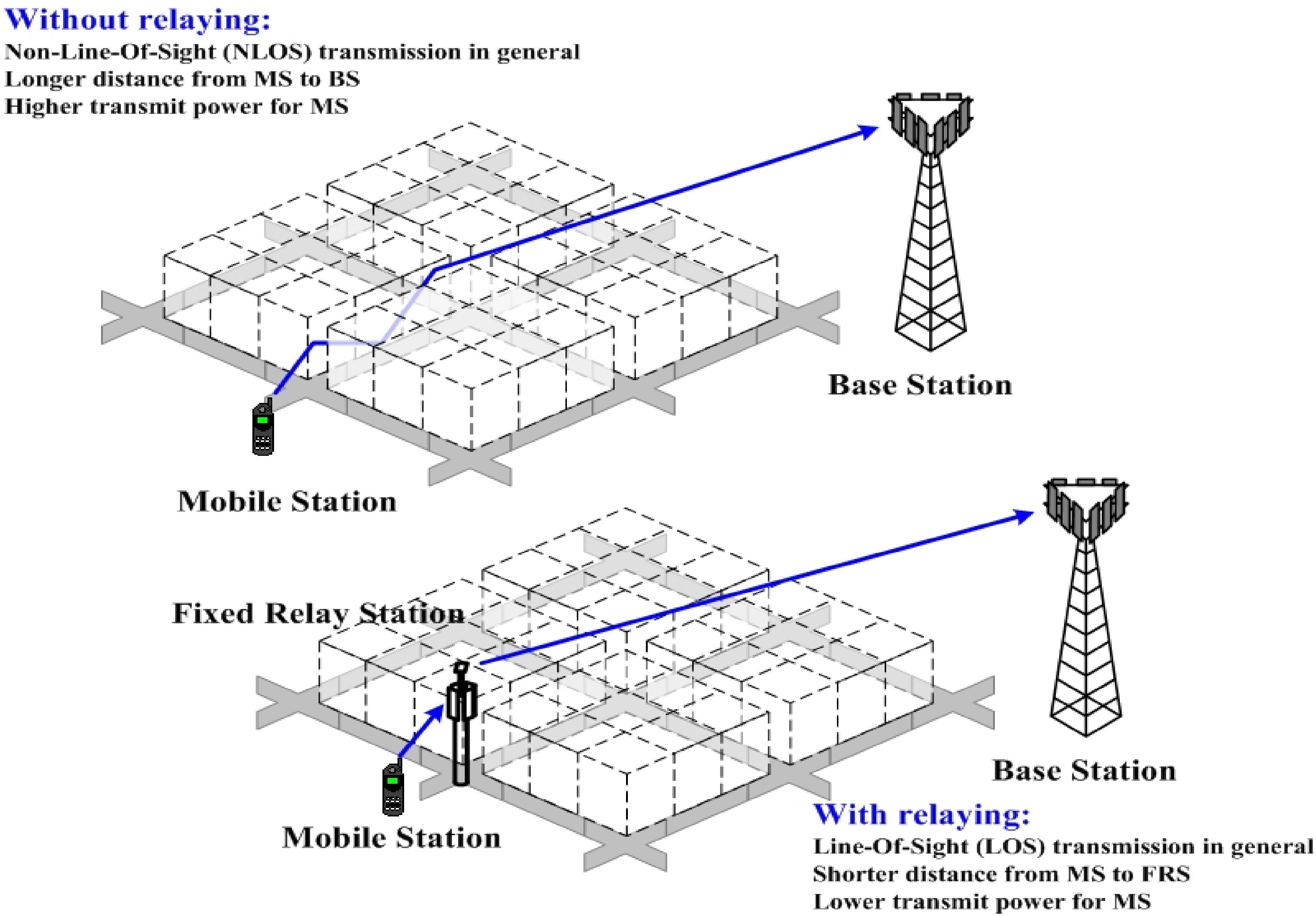


Relay Deployment Scenario

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



Relay Deployment Scenario



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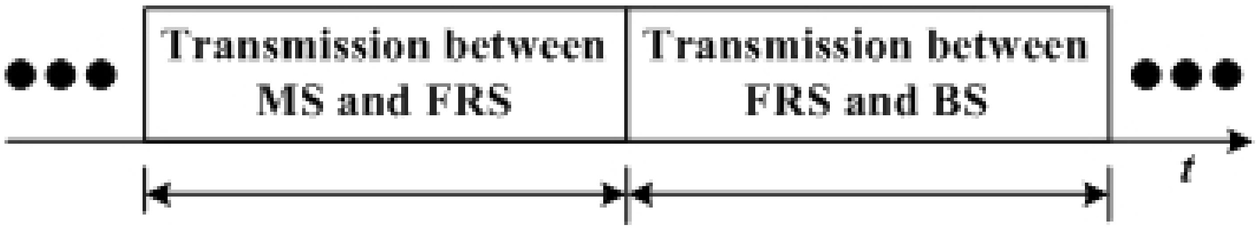
Simulation Models

- **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

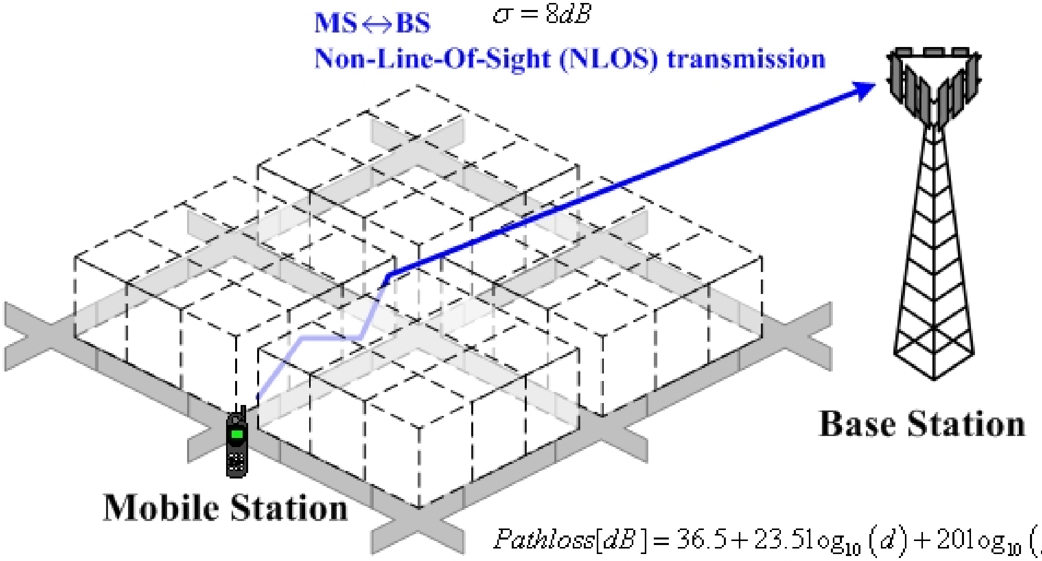


Simulation Models

- Propagation models are the same as C80216mmr-05_041

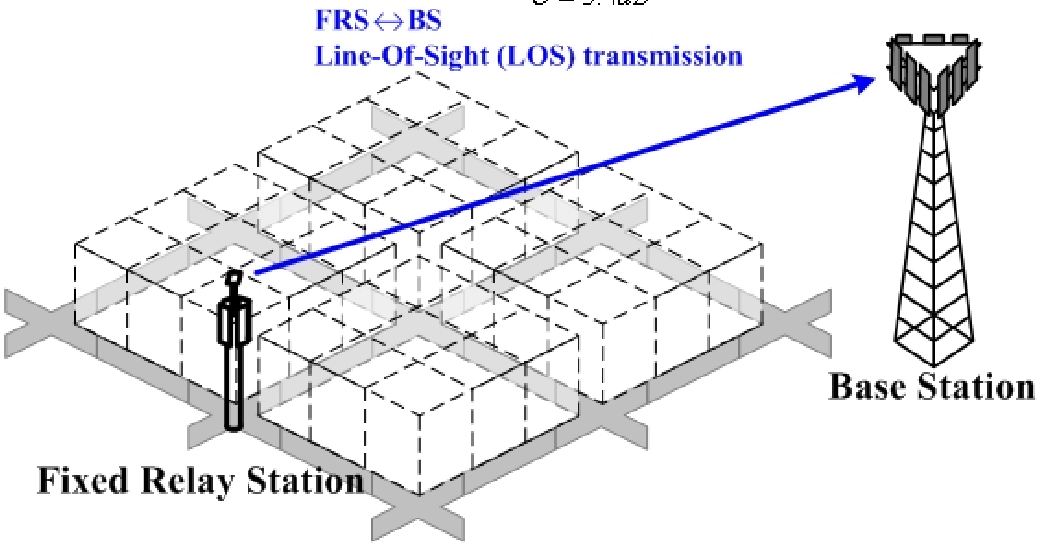
$$Pathloss[dB] = 38.4 + 35\log_{10}(d) + 20\log_{10}(f_c/5)$$

$$\sigma = 8dB$$



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

$$\sigma = 3.4dB$$



f_c carrier frequency (GHz)

d distance between Tx and Rx (meters)

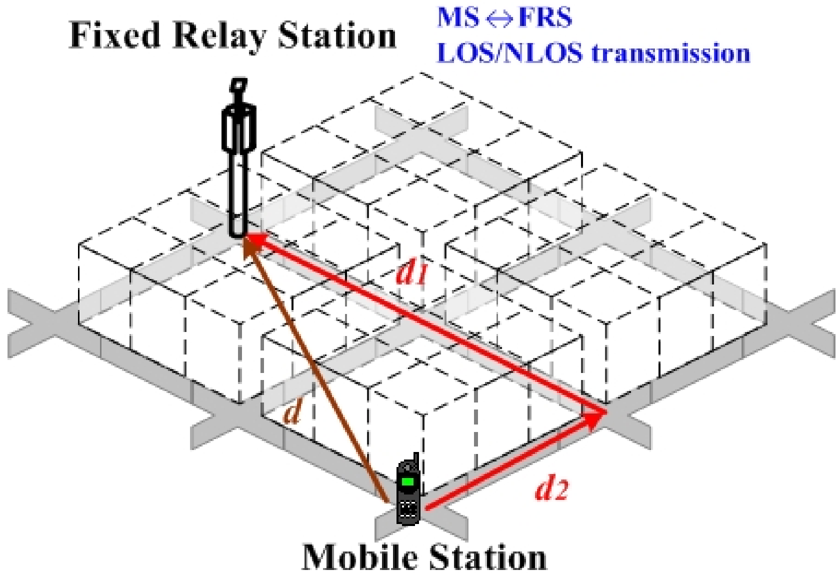
σ standard deviation of shadow fading (dB)

P_{LOS} probability to have LOS condition

$$Pathloss[dB] = \begin{cases} 41 + 22.7\log_{10}(d) + 20\log_{10}(f_c/5) & \text{if } LOS \\ 0.096 \cdot d_1 + 65 + 20\log_{10}(f_c/5) + (28 - 0.024 \cdot d_1) \cdot \log_{10}(d_2) & \text{if } NLOS \end{cases}$$

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

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



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

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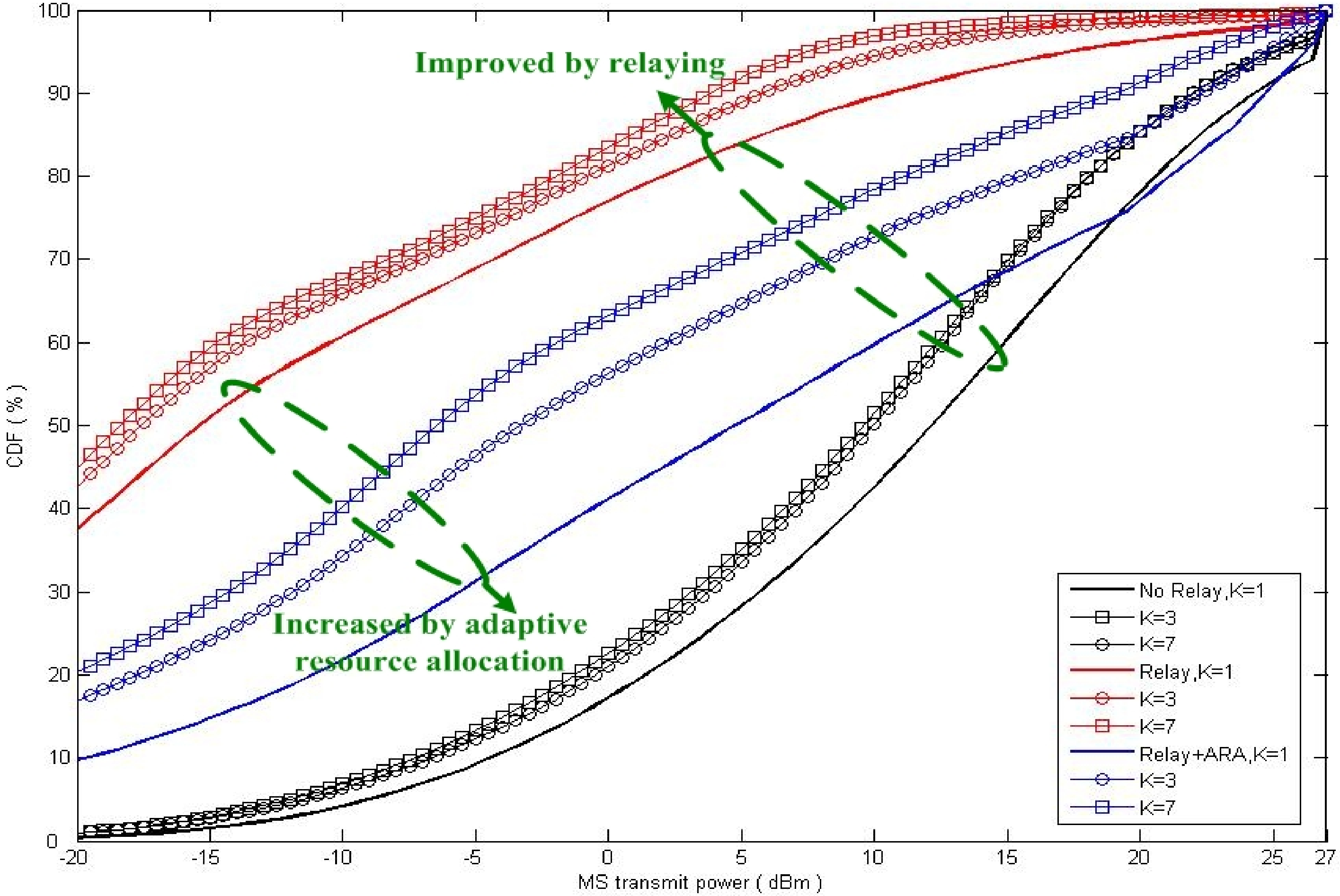
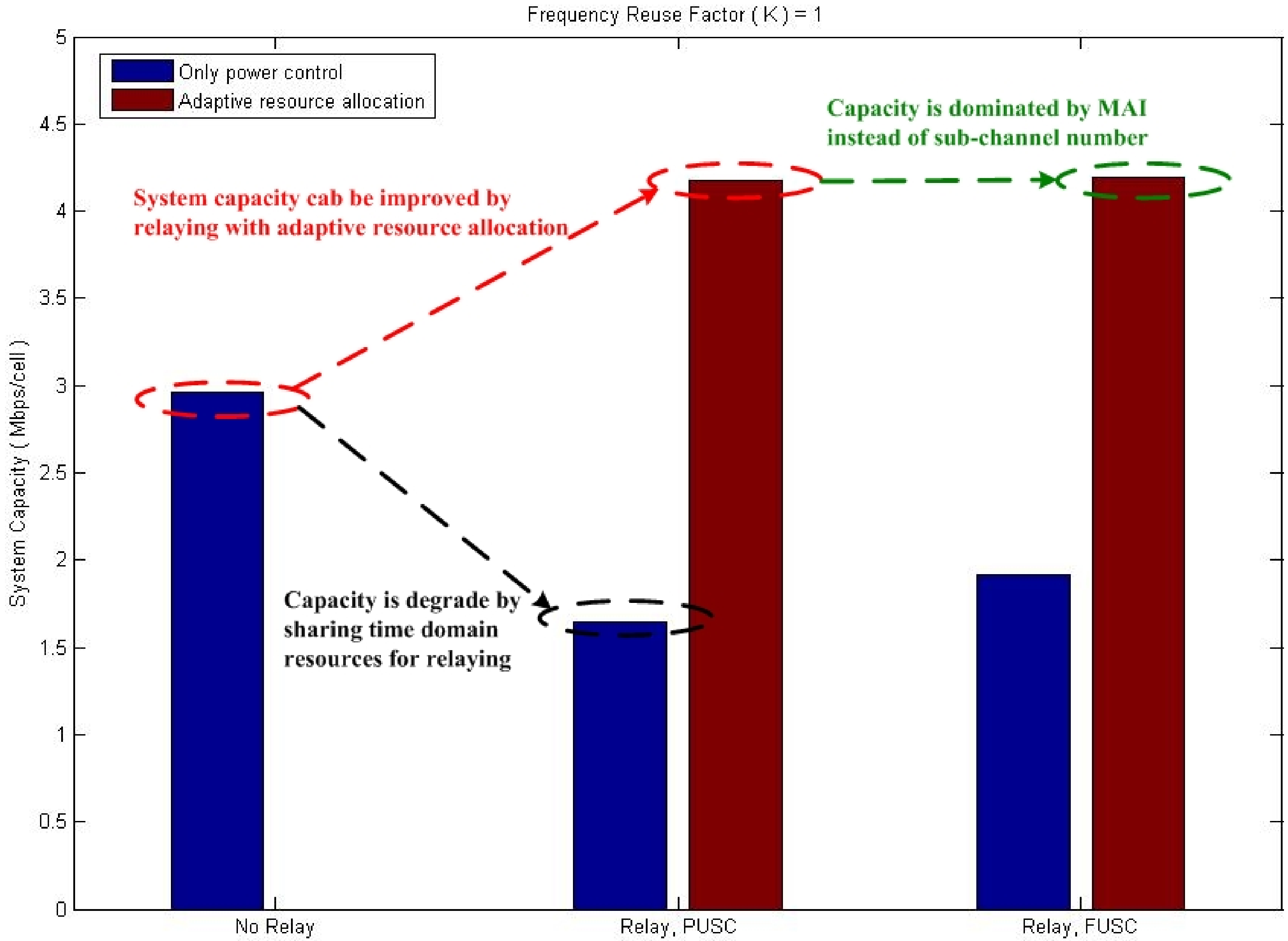
Simulation Results

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



Simulation Results

- System capacity (Mbps/cell)



Simulation Results

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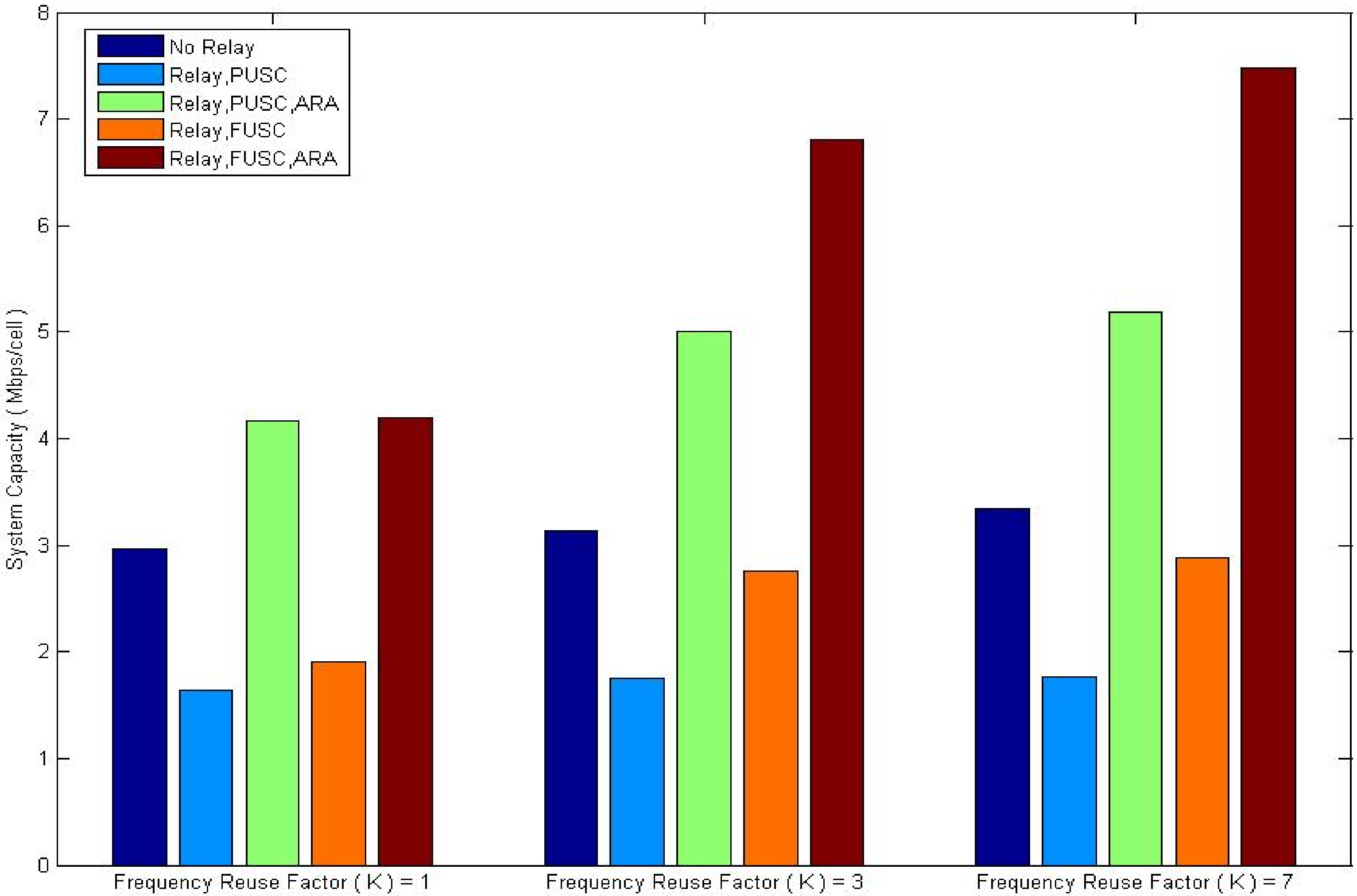

Simulation Results

K=1	**MS Transmit Power**	**Cell Throughput**
No Relay	***Reference case*** **(+0dB)**	***Reference case*** **(+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