

# Throughput Improvement with Relay-augmented Cellular Architecture

## IEEE 802.16 Presentation Submission Template (Rev. 8.3)

Document Number:

IEEE C80216mmr-05\_008

Date Submitted:

2005-9-14

Source:

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Venue:

IEEE 802.16 Session#39, Taipei, Taiwan

Base Document:

None

Purpose:

Information

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# Throughput Improvement with Relay-augmented Cellular Architecture

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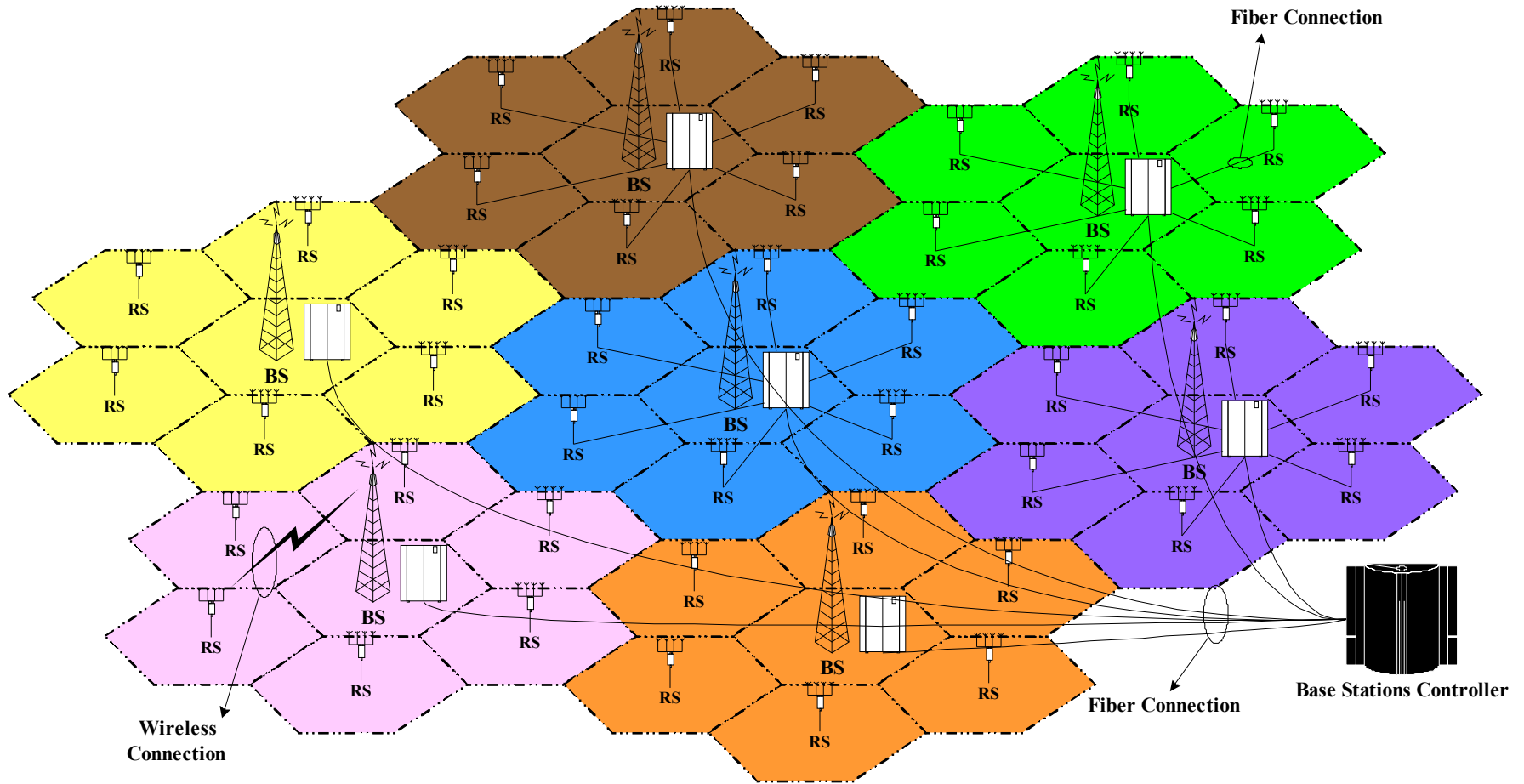
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September, 2005

# Outline

- Relay-augmented Cellular Architecture
- Classification of Relay Scenarios
- Simulation Results
- Summary

# Relay-augmented Cellular Architectures



# Classification of Relay Scenarios

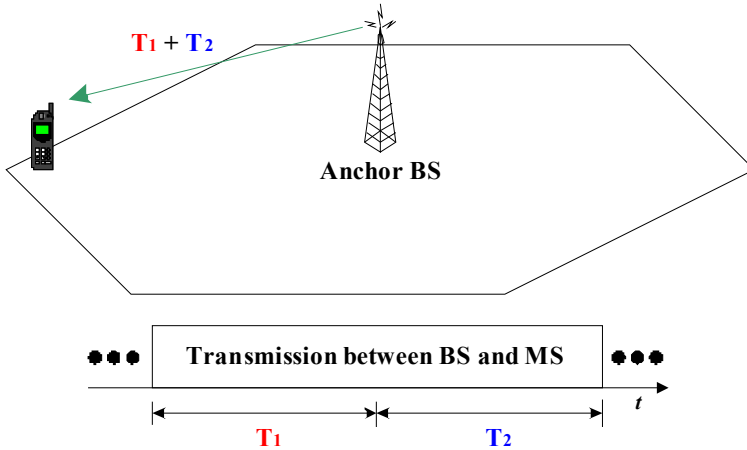
- Classified by function of relay station (RS)
  - **Amplify-and-Forward**
    - Analog repeater, less delay.
  - **Decode-and-Forward**
    - Digital repeater, more delay.
- Classified by interfaces of BS $\leftrightarrow$ MS and RS $\leftrightarrow$ MS transmission
  - **Homogeneous**
    - BS $\leftrightarrow$ MS and RS $\leftrightarrow$ MS transmissions are both in the same interface
      - Ex. Both interfaces are in IEEE 802.16 air-interface
  - **Heterogeneous**
    - BS $\leftrightarrow$ MS and RS $\leftrightarrow$ MS transmissions are in difference interfaces
      - Ex. BS $\leftrightarrow$ MS in analog fiber interface, RS $\leftrightarrow$ MS in IEEE 802.16 air-interface
- Classified by the mobility of relay station
  - **Fixed relay** (considered in following study cases)
  - **Mobile relay**

# Classification of Relay Scenarios

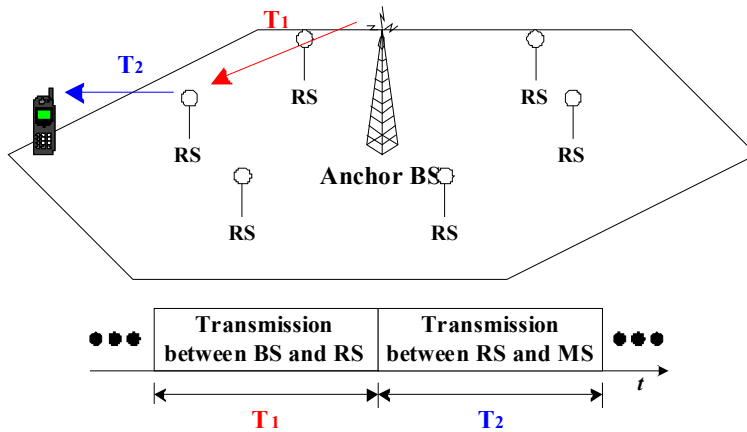
## Downlink Homogeneous Relaying

### Signal Reception Scenario

No Relaying

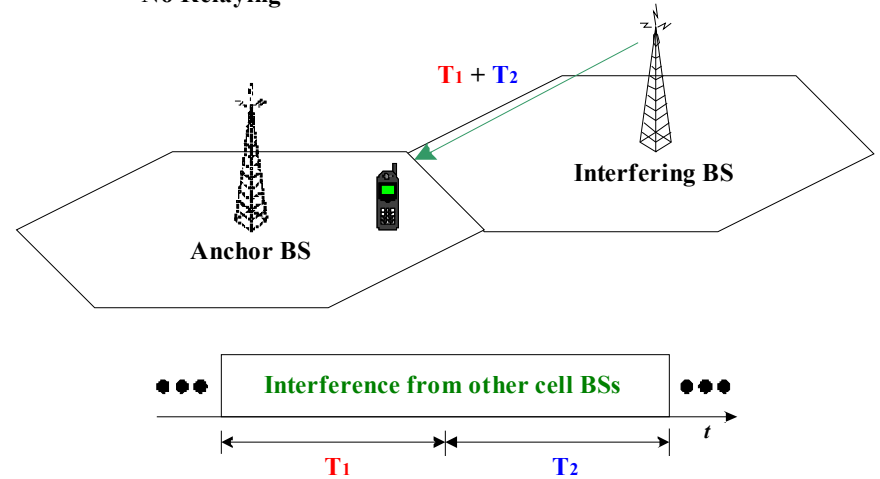


Decode-and-Forward Relaying

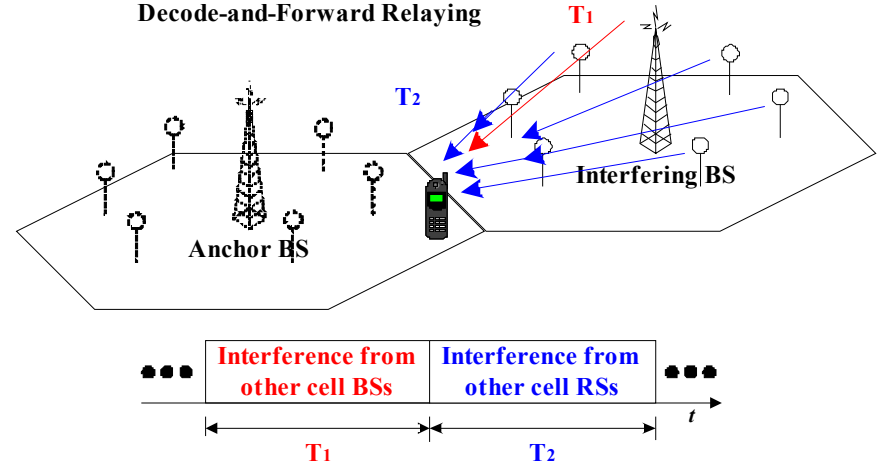


### Interference Reception Scenario

No Relaying



Decode-and-Forward Relaying

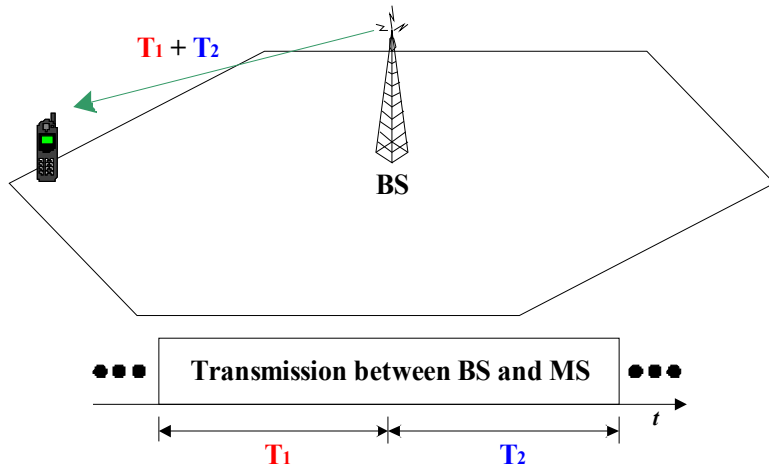


# Classification of Relay Scenarios

## Downlink Heterogeneous Relaying

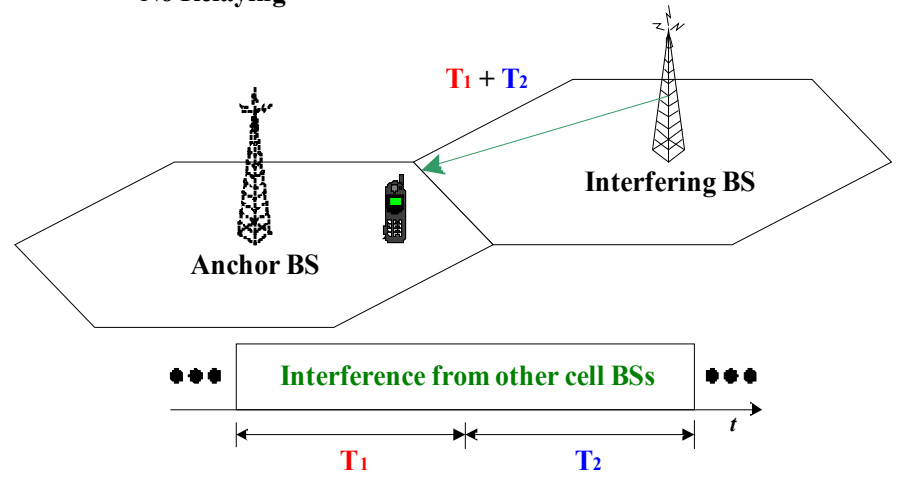
### Signal Reception Scenario

No Relaying

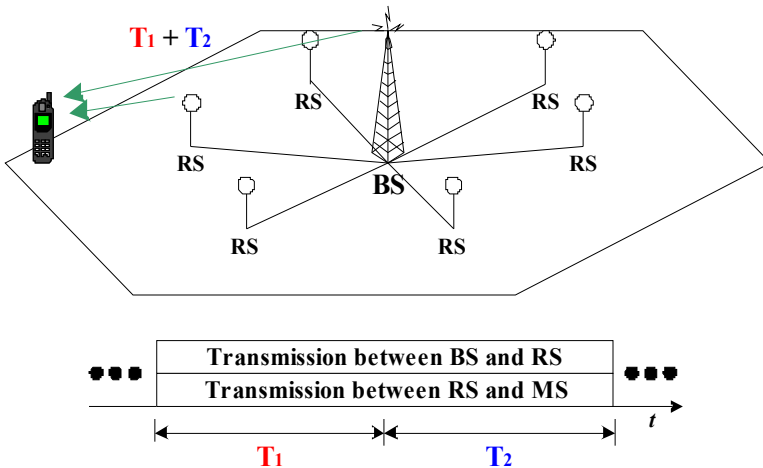


### Interference Reception Scenario

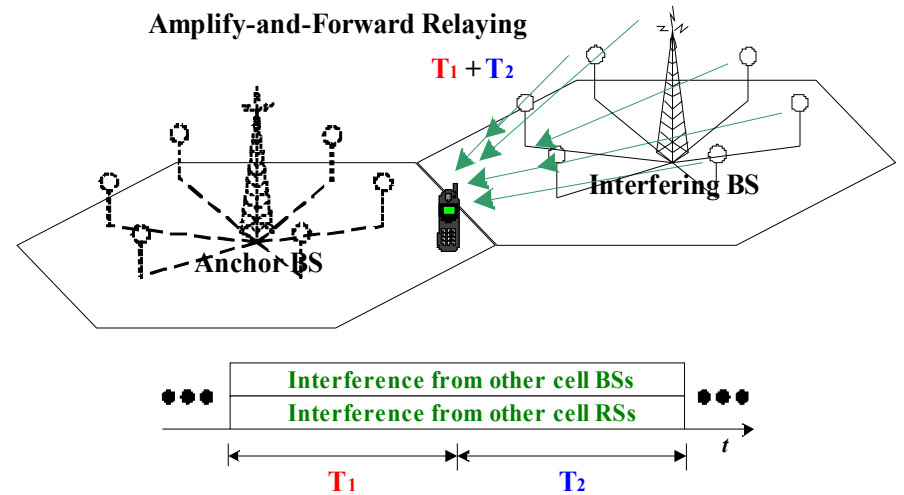
No Relaying



Amplify-and-Forward Relaying

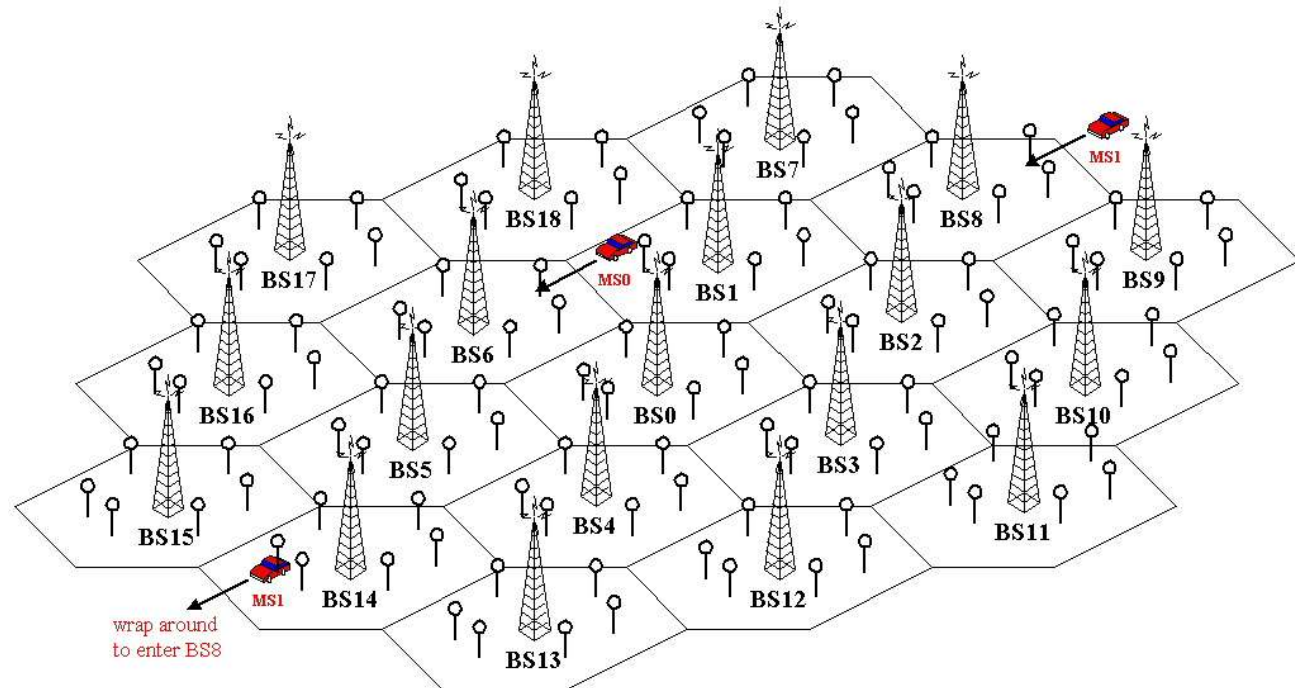


Amplify-and-Forward Relaying



# Simulation Results

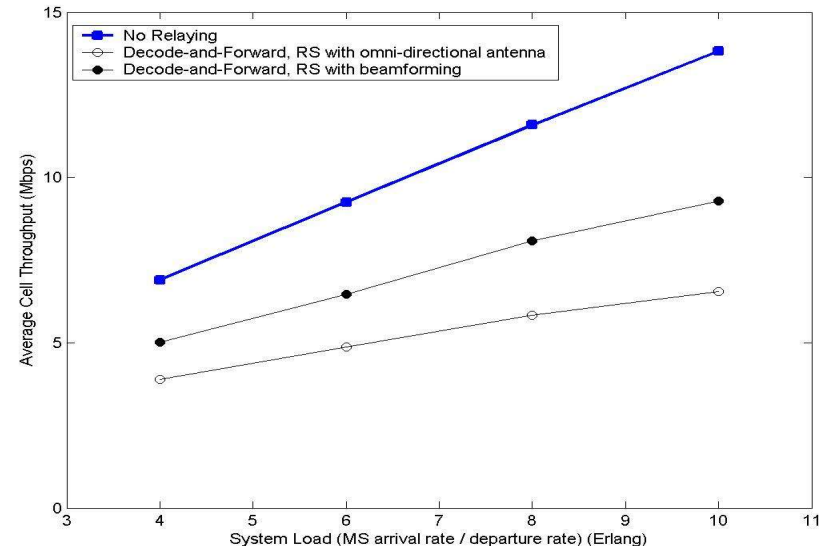
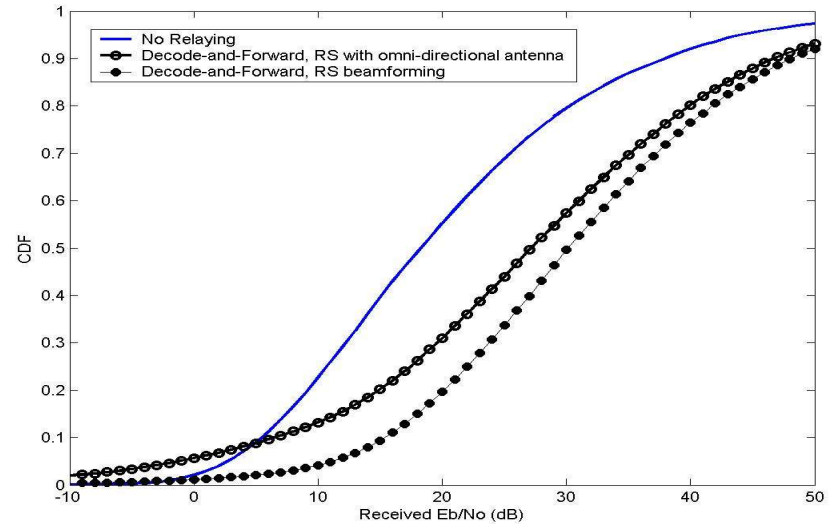
- Relay-augmented cellular OFDMA system
  - Downlink transmission
  - 19 cells with universal frequency reuse and FUSC permutation
  - Each cell has with 6 sectors and 2km coverage
  - Each cell has 6 relay stations (RS) with half base station (BS) coverage
  - Radio bandwidth: 6MHz (2048 sub-carriers)
  - Vehicular test environment





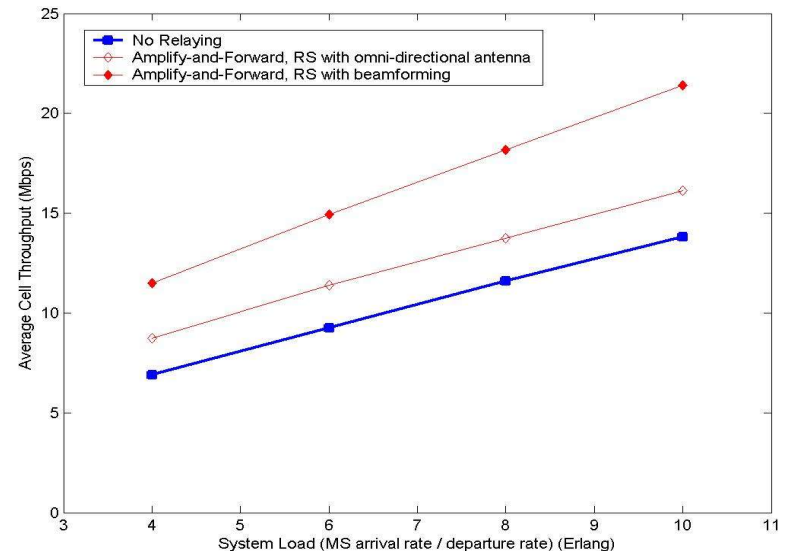
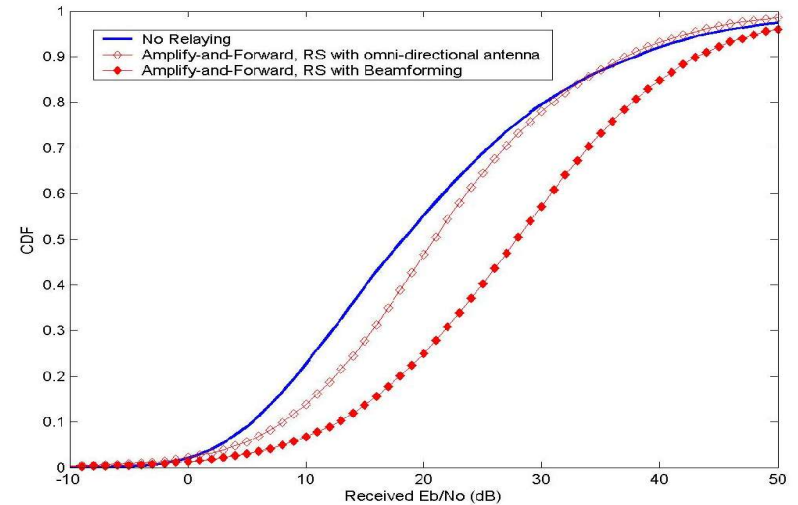
# Simulation Results

- Case I
  - Homogeneous decode-and-forward relaying
- Observations
  - **Data rate coverage becomes more uniform** by increasing the percentage of high order modulation usage
  - **Throughput is reduced** by time division for BS $\leftrightarrow$ MS and RS $\leftrightarrow$ MS transmissions
  - **Beamforming** on RS can further improve performances by increasing antenna gain and reducing interference



# Simulation Results

- Case II
  - **Heterogeneous amplify-and-forward** relay
- Observation
  - **Data rate coverage becomes more uniform** by increasing the percentage of high order modulation usage
  - **Throughput is increased** by higher percentage of high order modulation usage
  - **Beamforming** on RS can further improve performances by **increasing antenna gain** and **reducing interference**



# Summary

- Different relay deployment scenarios may lead to various performances tradeoffs
  - Ex. Tradeoff between uniform data rate coverage enhancement and throughput incensement in previous study cases
  - Before choosing relay scenarios, design objective should be ensured first.
- **Interference avoidance** may achieve substantial performances improvement in relay-augmented cellular systems
  - Up to **36%** throughput improvement was achieved in simulation results by applying **beamforming** on RSs
  - For decode-and-forward relaying, **cooperation on RSs transmission** may be beneficial to reduce the interference from other cell RSs.