# MIMO-OFDM Wireless Communications with MATLAB®

(Intercell Interference Mitigation Techniques)

## Chapter 8. Hücreler Arası Girişim Azaltma Teknikleri

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# Chapter 8. Hücreler Arası Girişim Azaltma Teknikleri

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# Chapter 8. Hücreler Arası Girişim Azaltma Teknikleri

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# Chapter 8. Hücreler Arası Girişim Azaltma Teknikleri

## 8.1 Hücreler Arası Girişim Eşgüdüm Teknikleri

## 8.1.1 Kısmi Frekans Yeniden Kullanımı

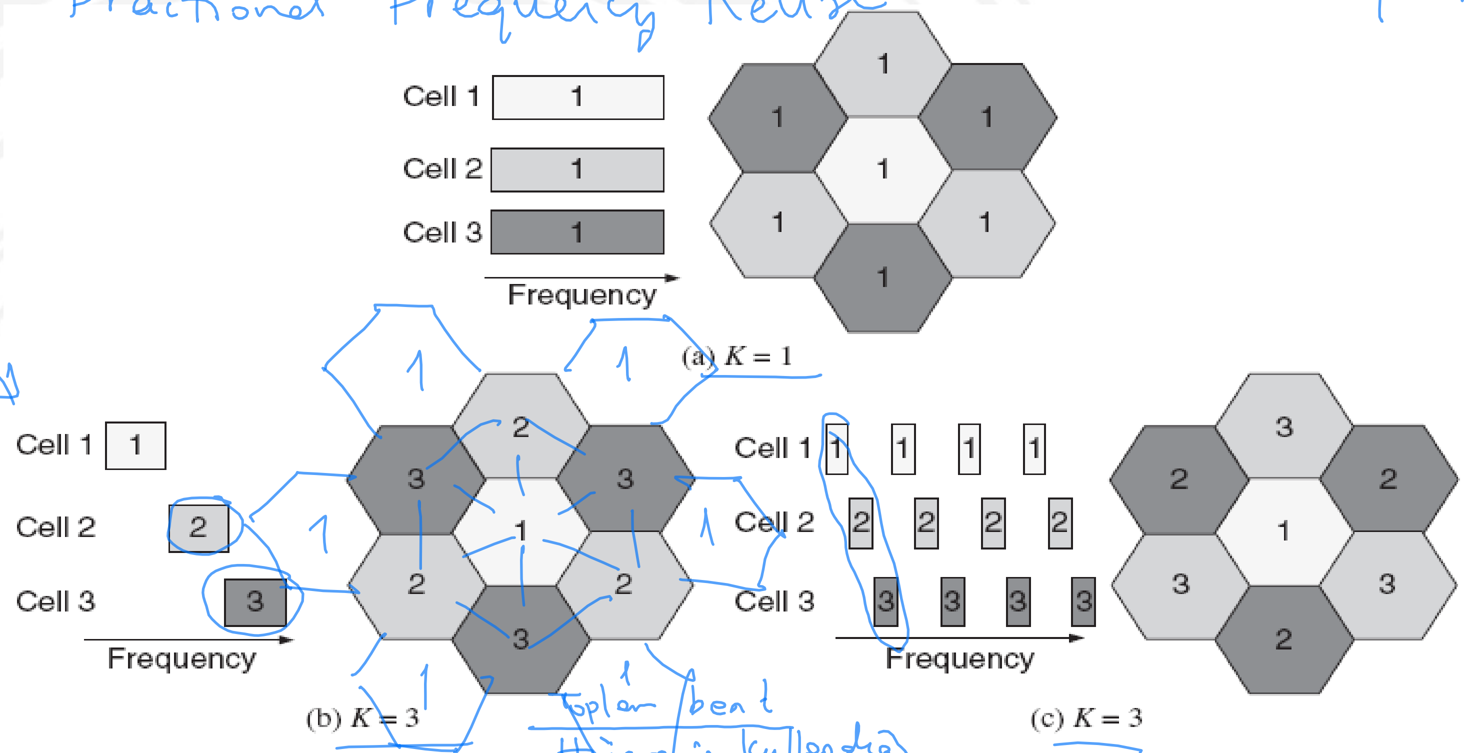


**Figure 8.1** Examples of frequency reuse in an OFDMA cellular system.



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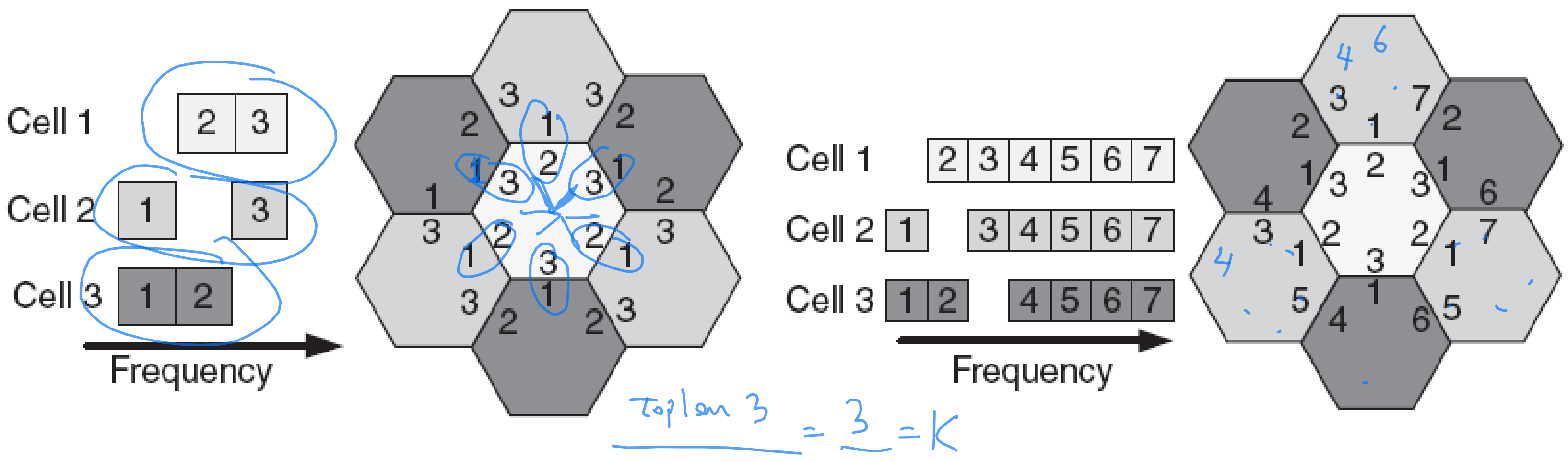
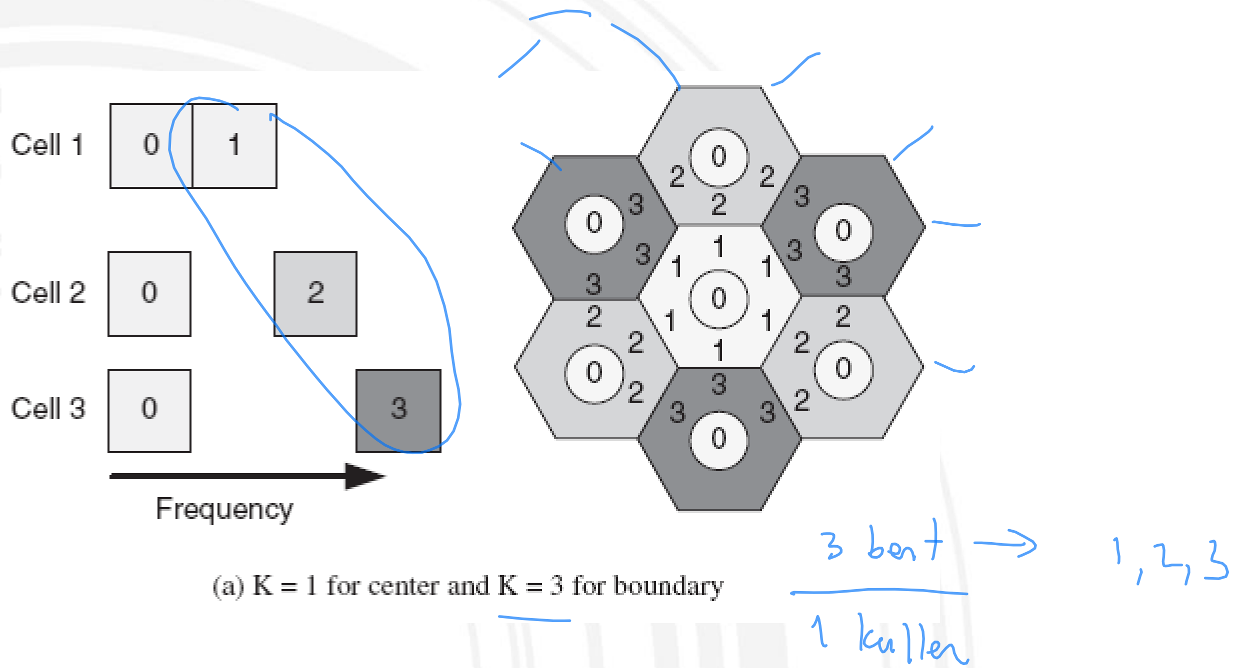
# 8.1.1 Kısmi Frekans Yeniden Kullanımı




(a) K = 3/2 (b) K = 7/6

**Figure 8.2** Fractional frequency reuse (FFR) in an OFDMA cellular system.

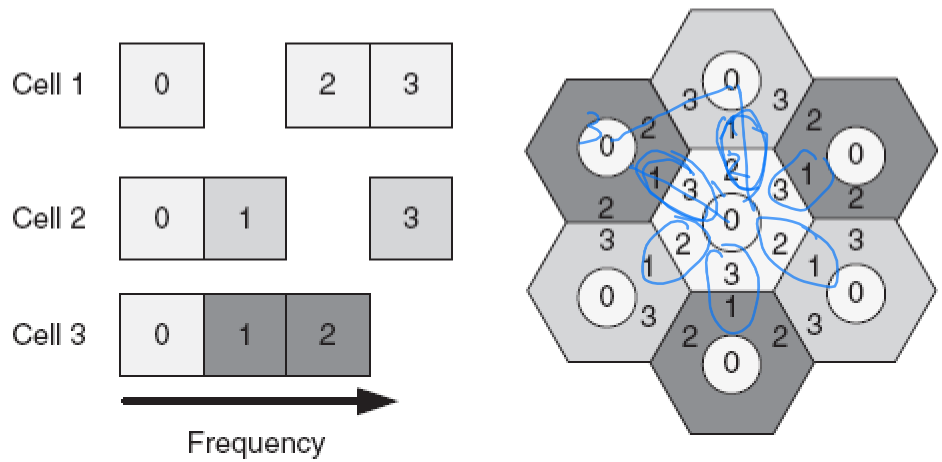
# 8.1.1 Kısmi Frekans Yeniden Kullanımı




(a) K = 1 for center and K = 3 for boundary

**Figure 8.3** Fractional frequency reuse (FFR) with the different FRFs.

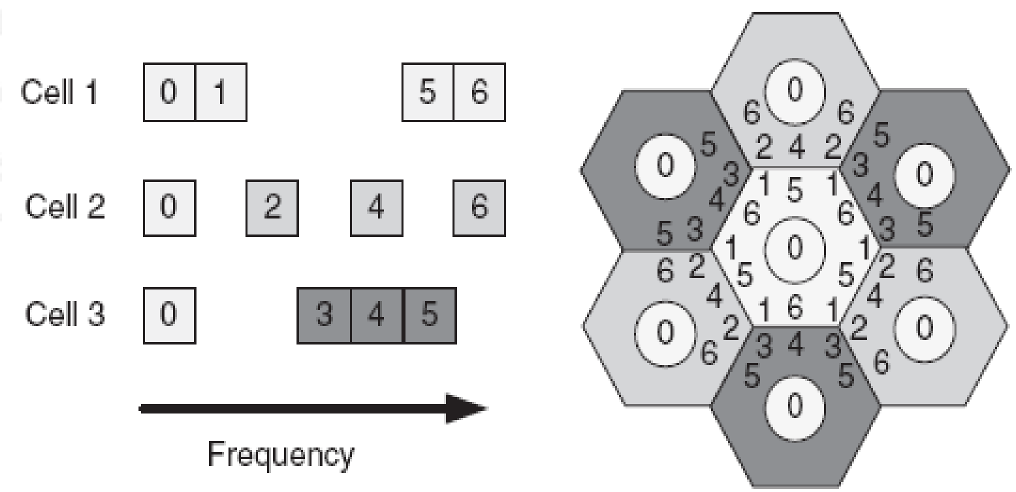
# 8.1.1 Kısmi Frekans Yeniden Kullanımı




(b) K = 1 for center and K = 3/2 for boundary

**Figure 8.3** Fractional frequency reuse (FFR) with the different FRFs.

# 8.1.1 Kısmi Frekans Yeniden Kullanımı



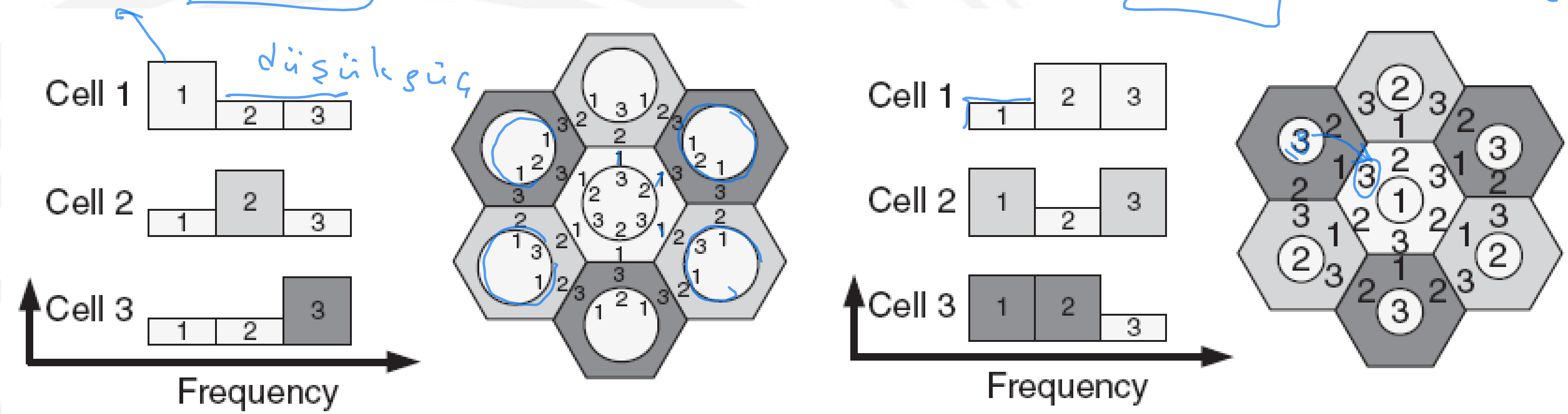

$K = \frac{6}{3} = 2 \rightarrow$ kenarlarda

**Figure 8.3** Fractional frequency reuse (FFR) with the different FRFs.

# 8.1.2 Yumuşak Frekans Yeniden Kullanımı

Soft Frequency Reuse → İletim gücü

yüksek K=1 (Full reuse) K=1 (Full reuse)




(a) Soft frequency reuse (previously 3) (b) Soft frequency reuse (previously 3/2)

**Figure 8.4** Soft frequency reuse: example with three subbands.

Ör: Ortadaki BS:
1 numara yüksek güç.
ama diğer hücrelerde
1 numaradan kendi BS'larına
yakın.

# 8.1.2 Yumuşak Frekans Yeniden Kullanımı

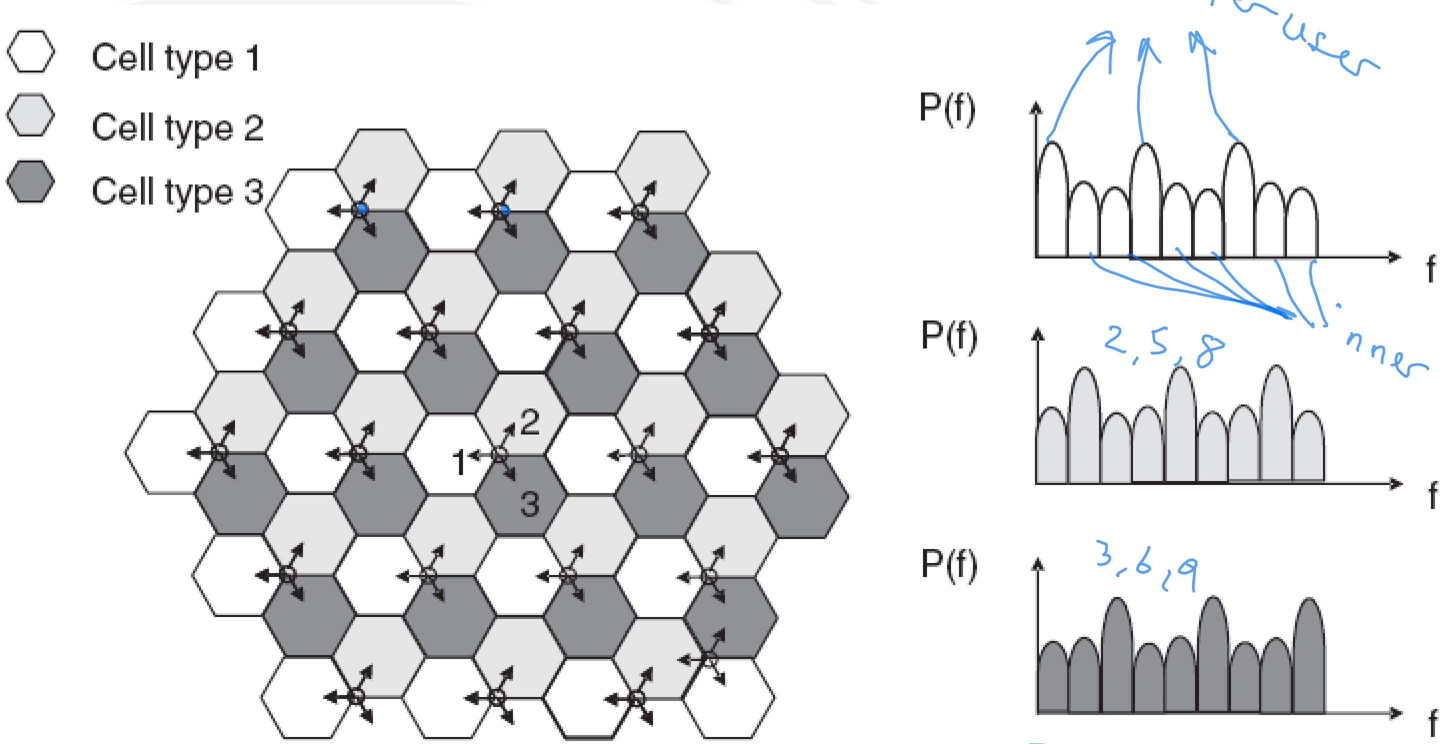



**Figure 8.5** Soft frequency reuse: example with nine subbands.

# 8.1.3 Esnek Frekans Yeniden Kullanımı

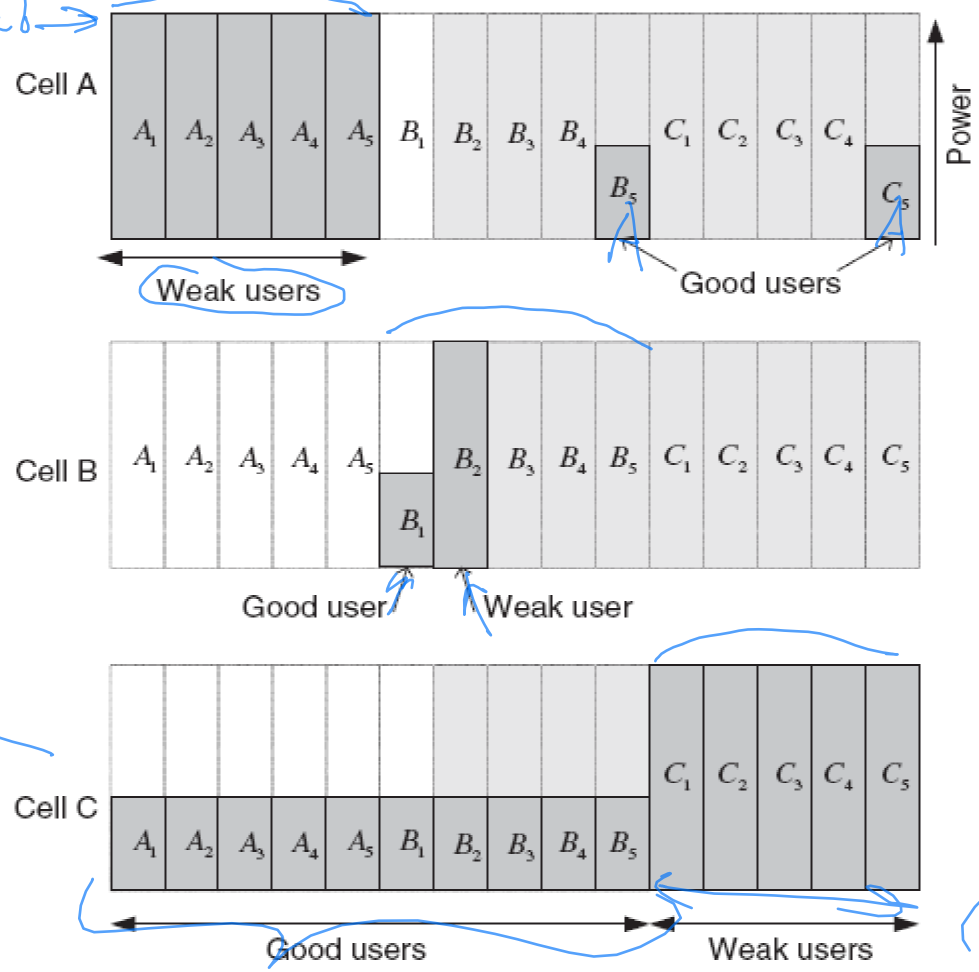



**Figure 8.6** Flexible FFR with five primary subchannels in each cell.

# 8.2 Hücreler Arası Girişim Rastgeleleştirme Teknikleri

(Randomization.)

## 8.2.1 Cell-Specific Scrambling

(Code) Interleaver → $C^{(m)}[k]$

$$Y[k] \approx \sum_{m=0}^{M-1} H^{(m)}[k]\, C^{(m)}[k]\, X^{(m)}[k] + Z[k] \tag{8.1}$$

$$Y[k] \approx H^{(0)}[k]\, C^{(0)}[k]\, X^{(0)}[k] + \sum_{m=1}^{M-1} H^{(m)}[k]\, C^{(m)}[k]\, X^{(m)}[k] + Z[k] \tag{8.2}$$

$$\begin{aligned} Y^{(0)}[k] &\approx \left(C^{(0)}[k]\right)^{*} Y[k] \\ &\approx H^{(0)}[k]X^{(0)}[k] + \sum_{m=1}^{M-1} \left(C^{(0)}[k]\right)^{*} H^{(m)}[k]C^{(m)}[k]X^{(m)}[k] + Z[k] \end{aligned} \tag{8.3}$$

# 8.2.1 Cell-Specific Scrambling

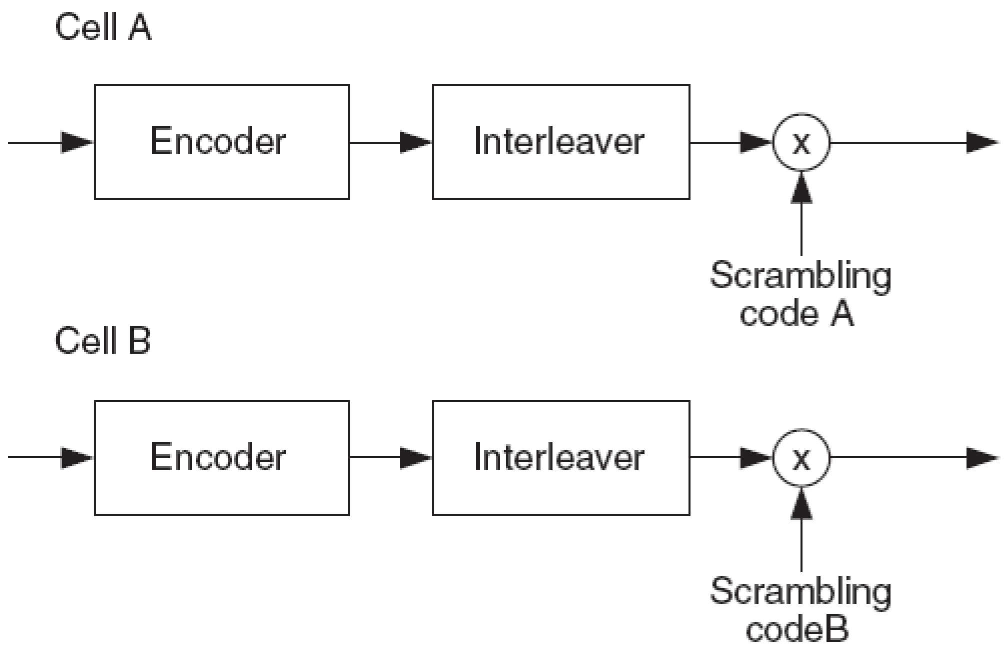



**Figure 8.7** Cell-specific scrambling technique.

# 8.2.3 Frekans Atlamalı OFDMA

Flarion Tech. (Flash-OFDMA)

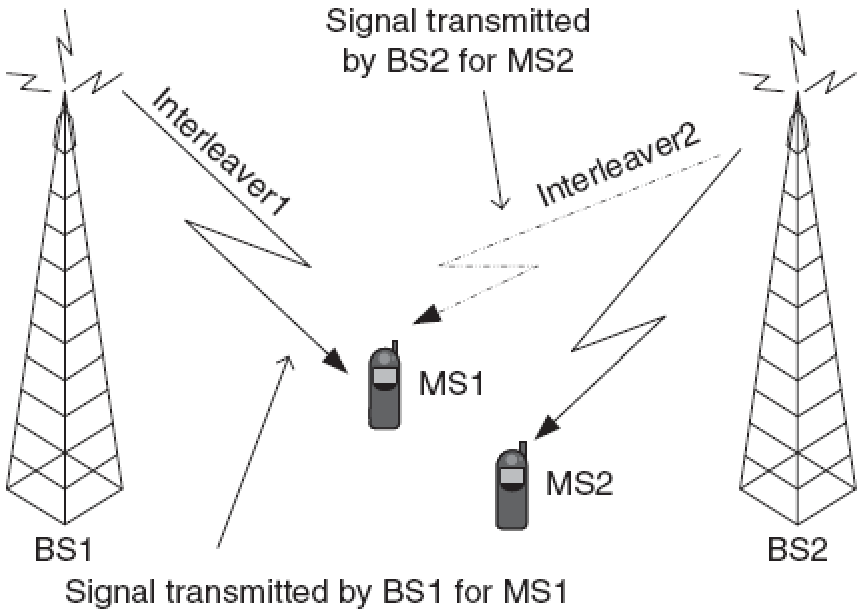
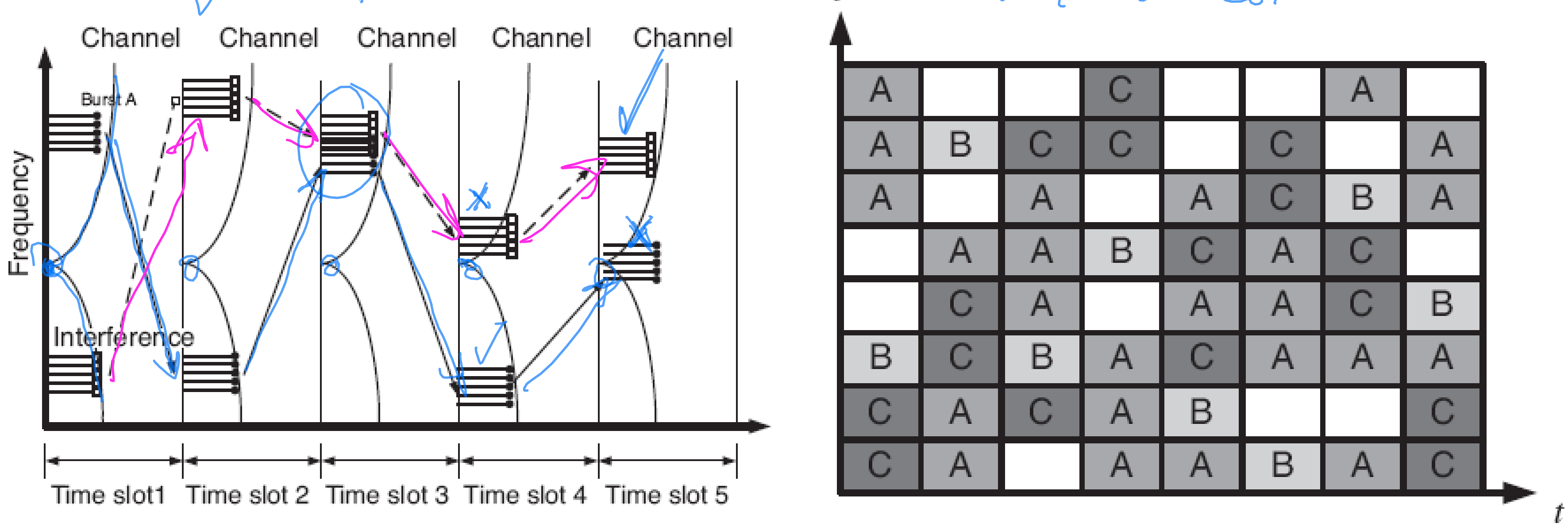



**Figure 8.8** Cell-specific interleaving technique.

# 8.2.3 Frekans Atlamalı OFDMA

1) Girişim rastgeleleştirme (averaging)
2) Frekans çeşitlemesi




(a) Frequency-hopping

(b) Frequency-hopping pattern

**Figure 8.9** Frequency-hopping OFDMA technique: an illustration.

# 8.2.4 Rastgele Alttaşıyıcı Tahsisi

Subcarrierlerden subchannel oluşturma.

nadiren olan çakışmaları hata düzeltme kodlarla düzeltmek mümkün.

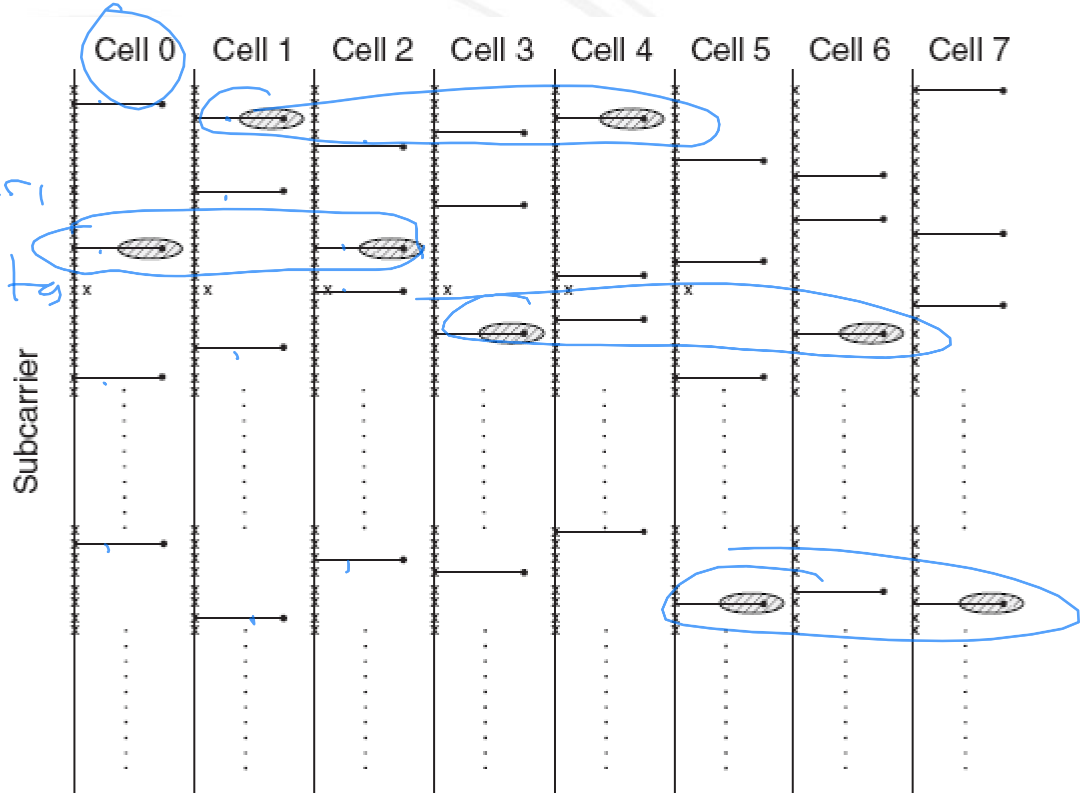



**Figure 8.10** Example of random subcarrier allocation technique.

# 8.3 Hücrelerarası Girişim İptal Teknikleri
## 8.3.1 Interference Rejection Combining Technique

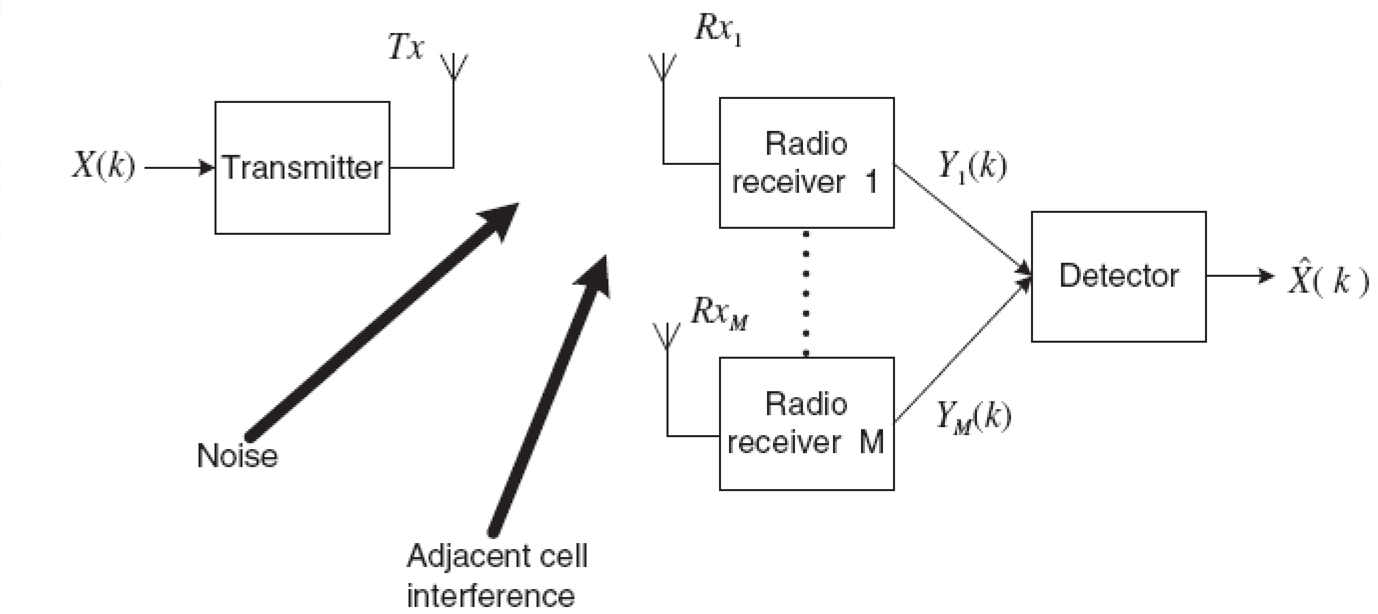



**Figure 8.11** System model for interference rejection combining (IRC) technique.



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# 8.3.1 Interference Rejection Combining Technique

$$Y_i[k] = H_i[k]X[k] + Z_i[k], \quad i = 1, 2, \ldots, M \tag{8.4}$$

$$\mathbf{Y}[k] = \mathbf{H}[k]X[k] + \mathbf{Z}[k] \tag{8.5}$$

$$\mathbf{Y}[k] = [Y_1[k] \; Y_2[k] \cdots Y_M[k]]^T$$
$$\mathbf{H}[k] = [H_1[k] \; H_2[k] \cdots H_M[k]]^T$$
$$\mathbf{Z}[k] = [Z_1[k] \; Z_2[k] \cdots Z_M[k]]^T.$$

# 8.3.1 Interference Rejection Combining Technique

$$\hat{\mathbf{Q}} = \sum_{k=1}^{K} (\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k]) \cdot (\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k])^H \tag{8.6}$$

Maximum likelihood detection

$$\begin{aligned} \hat{X}[k] &= \arg\max_{X[k]} \frac{1}{\pi^M |\hat{\mathbf{Q}}|} \exp\left\{ -\left(\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k]\right)^H \hat{\mathbf{Q}}^{-1} \left(\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k]\right) \right\} \\ &= \arg\min_{X[k]} \left(\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k]\right)^H \hat{\mathbf{Q}}^{-1} \left(\mathbf{Y}[k] - \hat{\mathbf{H}}[k]X[k]\right) \end{aligned} \tag{8.7}$$



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# 8.3.2 IDMA Multiuser Detection

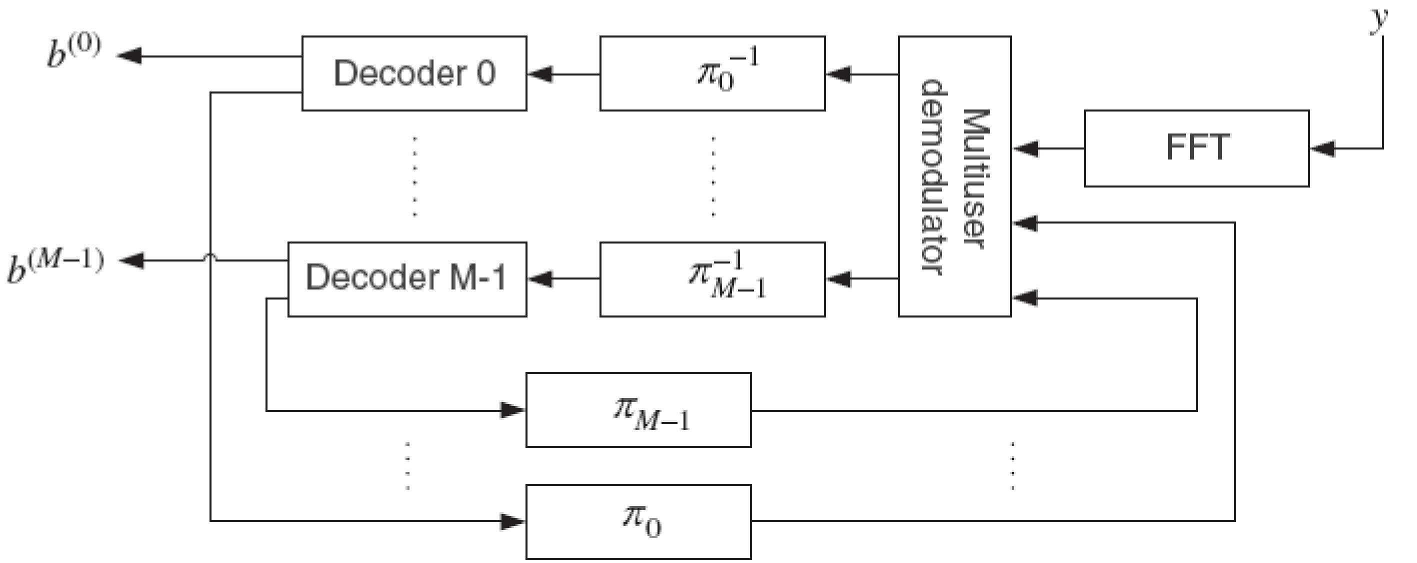



**Figure 8.12** Block diagram for iterative multiuser detector in OFDM-IDMA receiver.

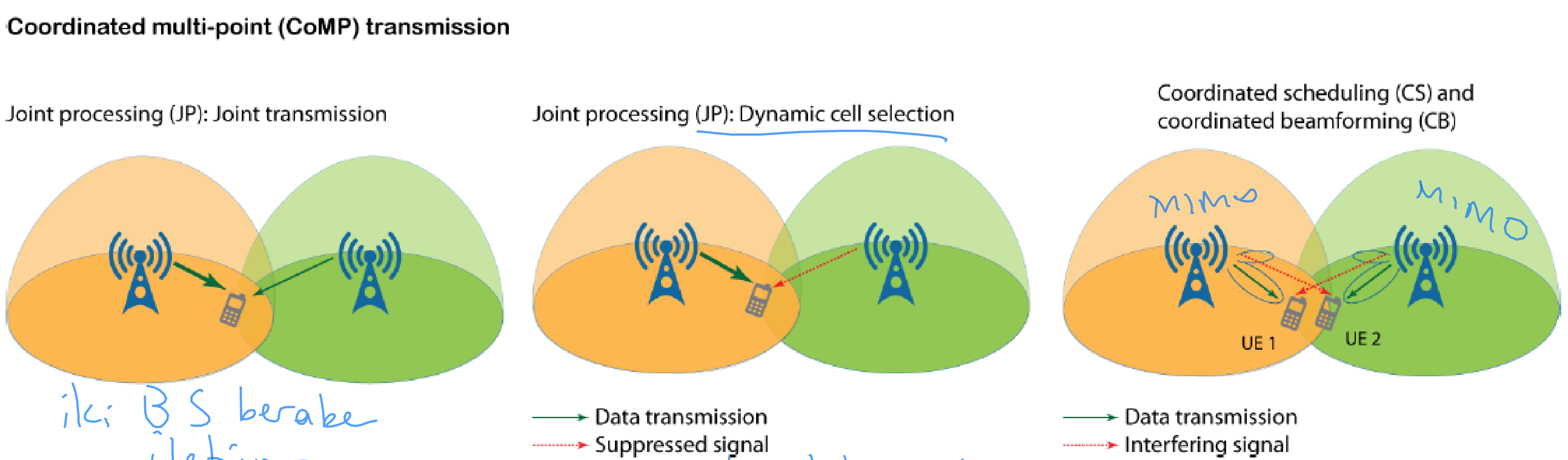
# LTE (Interference management in LTE networks and devices Monica Paolini Senza Fili Consulting 2012)

| Table 3. Managing interference in LTE | | | | |
|---|---|---|---|---|
| | Advantages | What it does | Requirements | Standardization |
| RAN | | | | |
| ICIC<br>Intercell | Improves cell-edge performance.<br>Interference Concell | Network resource coordination among neighboring cells.<br>Fractional frequency reuse. | If the X2 interface is used, low latency backhaul is required. | LTE Rel 8<br>2008 |
| eICIC<br>enhanced | Increases in capacity and utilization of network resources in HetNets.<br>Heterogeneous networks | Real-time traffic coordination, with alternating transmission from macro and small cells over the time domain.<br>Power management at the small cell for range expansion. | Tight coordination between macro cells and HeNBs through the X2 interface.<br>Low latency backhaul is required. | LTE Rel 10<br>2011 |
| CoMP<br>Coordinated Multipoint | Improves cell-edge performance and cell capacity. | Used when a UE device at the cell edge receives a signal from two cells.<br>With CS, only one cell transmits to the UE, to reduce impact from the interfering signal on the second cell.<br>With JP, both cells transmit to and receive from the UE by coordinating the signal.<br>Joint Processing | Software-based, additional complexity and processing overhead in the RAN.<br>Higher power and network resource requirements, more signaling traffic, requiring additional backhaul capacity.<br>Low backhaul latency is required.<br>Ideally implemented in conjunction with MIMO. | LTE Rel 11<br>Mart 2013 |

# LTE girişim azaltma teknikleri

| RAN/UE | | | | |
|---|---|---|---|---|
| MU-MIMO | Improves data rates and capacity, mostly in high- SINR environments. | Concurrent transmission through multiple beams to multiple UEs. | Hardware upgrade requires additional funding and deployment time and effort. Multiple antennas in the UE mean additional cost and complexity. | LTE Rel 8 and Rel 10 |
| SU-MIMO | Provides higher data rates for enabled UE, mostly in high-SINR environments (both at cell edge and in HetNets). | Concurrent transmission from single UE over multiple beams. | | |
| UE | | | | |
| MRC | Increases link reliability | Receiver-diversity method (time domain) | UE support | LTE Rel 8 |
| IRC | Improves SINR | Receiver-diversity method (space and time domain) | | LTE Rel 8 |
| UE-based IC | Improves cell-edge throughput, UE data rates, and battery life. | Receiver beamforming, to direct antenna toward serving cell and ignore interfering one. | Firmware update at the UE. It does not affect the RAN or add complexity or cost to the network. | N/A |

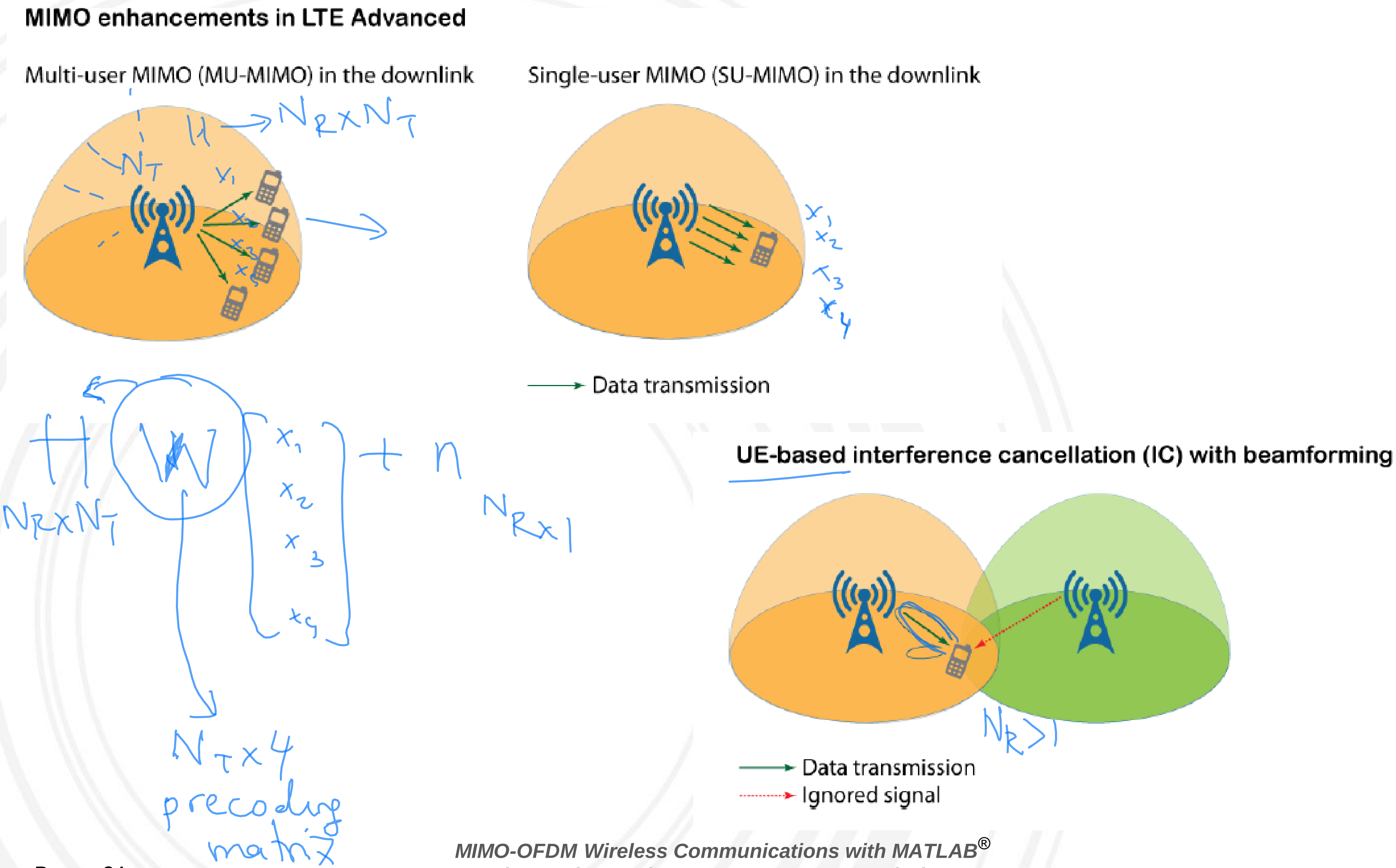
# LTE'de Coordinated MultiPoint (CoMP)




iki BS beraber iletiyor (MIMO) senkronizasyon gerektirir.

msn mertebesinde koordinasyon.

# MIMO/Hüzme oluşturma ile girişim denetimi (LTE)



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