Nagysebességű Mobil Távközlés

Távközlési és Médiainformatikai Tanszék

Long Term Evolution

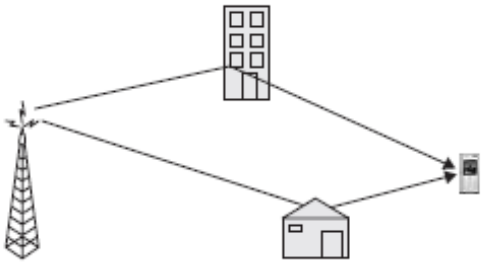
http://hgmyung.googlepages.com/3gppLTE.pdf

OFDM

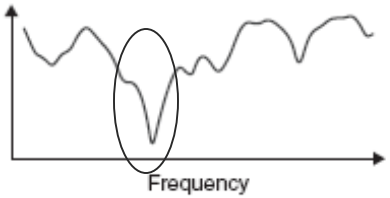
OFDM

- LTE uses OFDM for the downlink
  - requirement for spectrum flexibility
  - enables cost-efficient solutions for very wide carriers with high peak rates
  - uses a large number of narrow sub-carriers for multi-carrier transmission
- The basic LTE downlink physical resource = a time-frequency grid
  - In the frequency domain the spacing between the subcarriers Δf=15kHz
  - In the time domain the symbol duration time is $1/\Delta f$ + cyclic prefix
  - The cyclic prefix is used to maintain orthogonality between the sub-carriers
    - even for a time-dispersive radio channel
- Modulation in resource elements
  - QPSK, 16QAM or 64QAM
  - 2, 4 or 6 bits
- OFDM symbols are grouped into resource blocks
  - Total size of a resource block: 180kHz in the frequency domain
  - Total size of a resource block: 0.5ms in the time domain
  - Each 1ms Transmission Time Interval (TTI) consists of two slots (Tslot)

Radio details



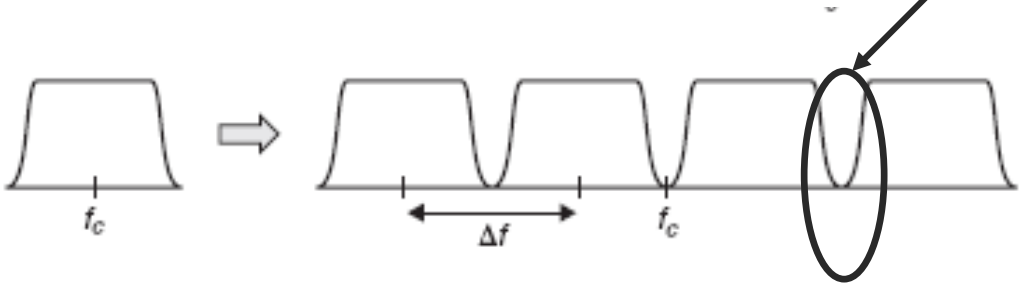
Time dispersion

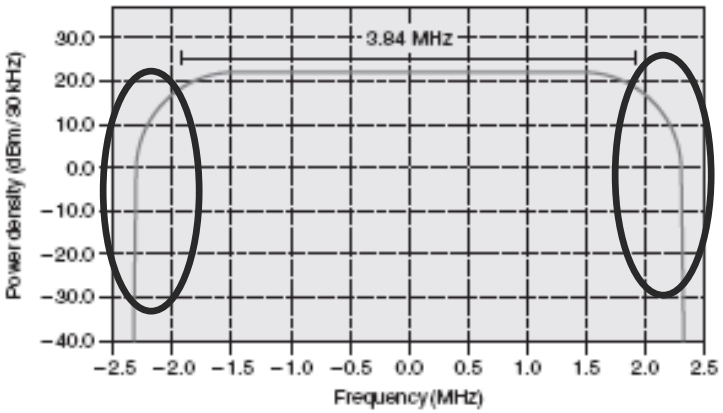


Freq. selection

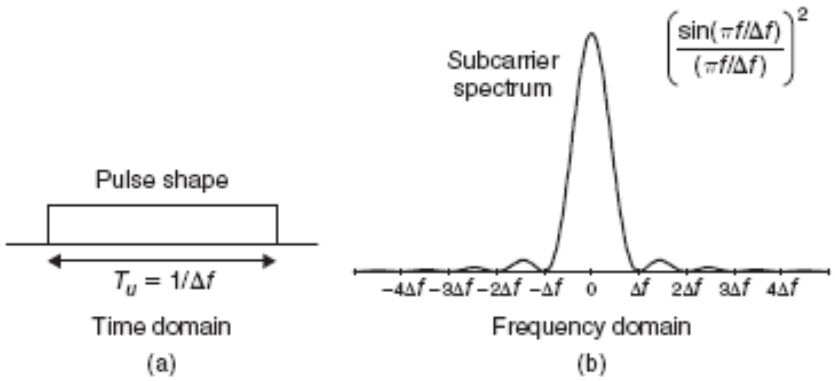
Multi-carrier transmission

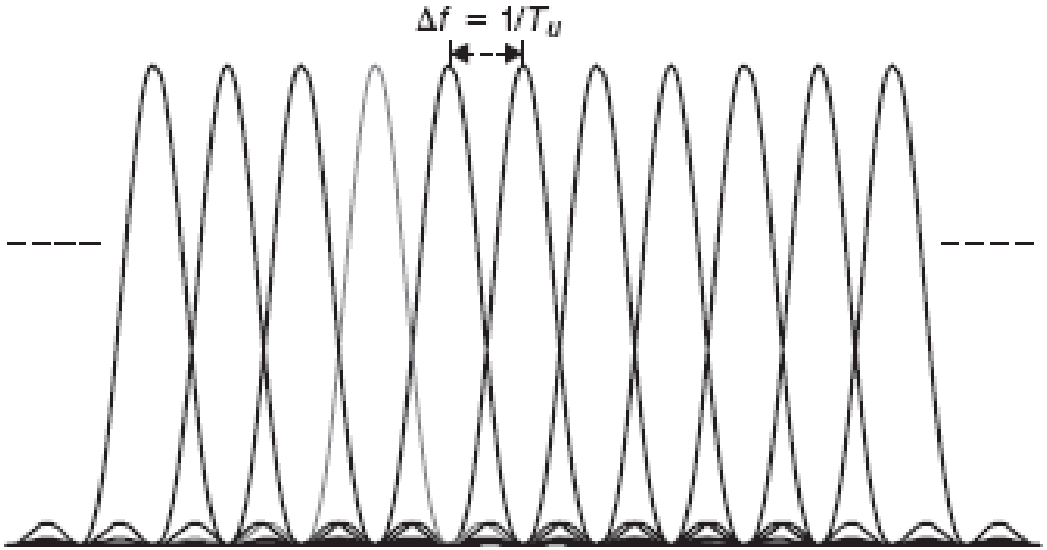
- Freq. selectivity affects only one carrier
- Lost spectrum at the band-edges



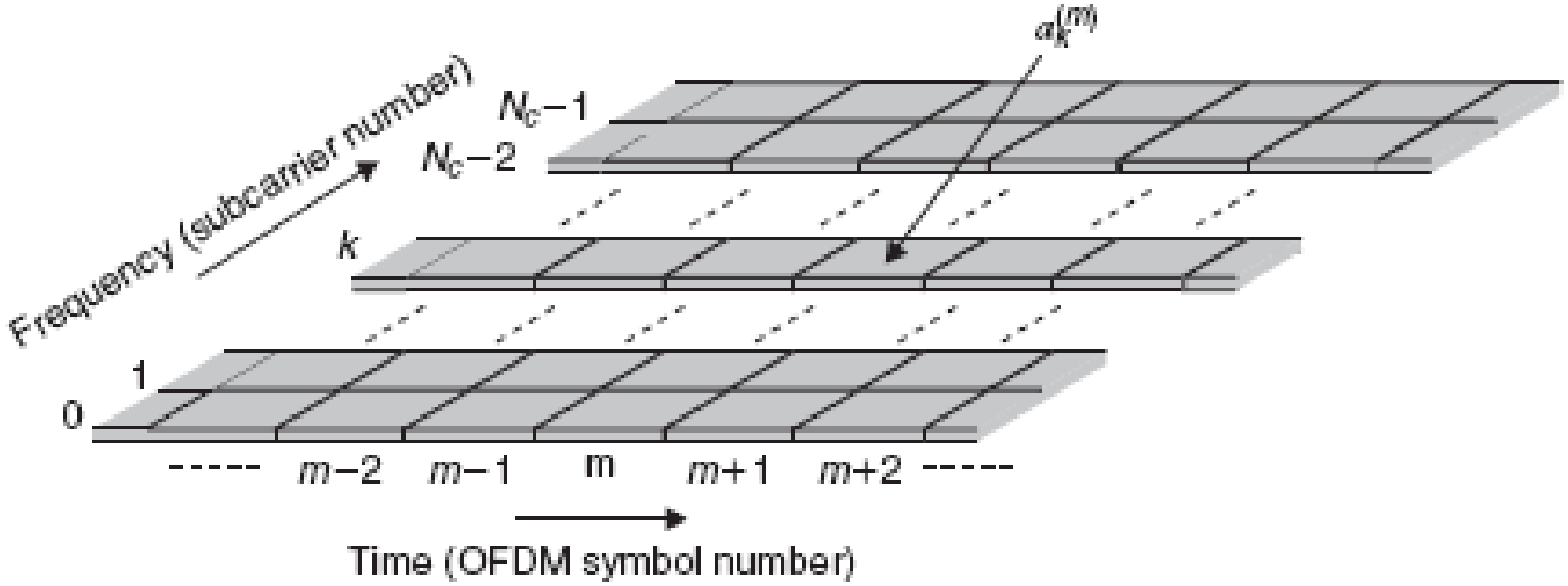


OFDM

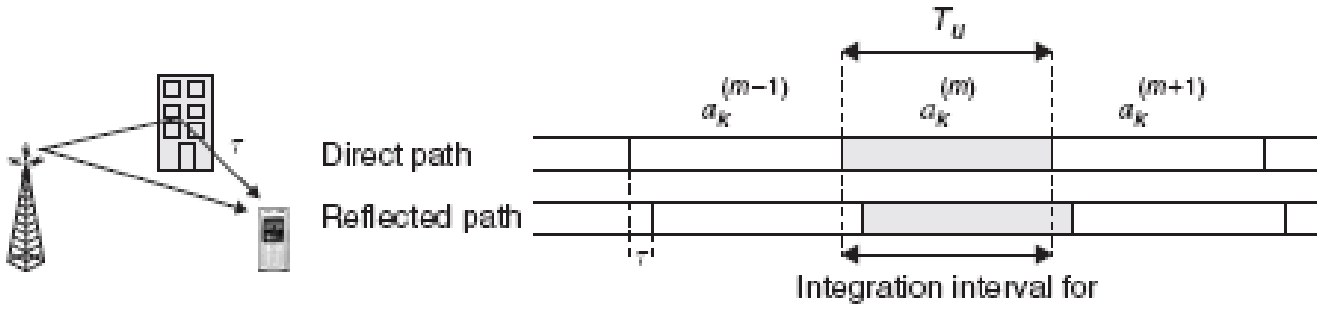

Pulse shape
$T_u = 1/\Delta f$
Time domain
(a)
Subcarrier spectrum
$\left(\frac{\sin(\pi f/\Delta f)}{(\pi f/\Delta f)}\right)^2$
$-4\Delta f$ $-3\Delta f$ $-2\Delta f$ $-\Delta f$ 0 Δf $2\Delta f$ $3\Delta f$ $4\Delta f$
Frequency domain
(b)

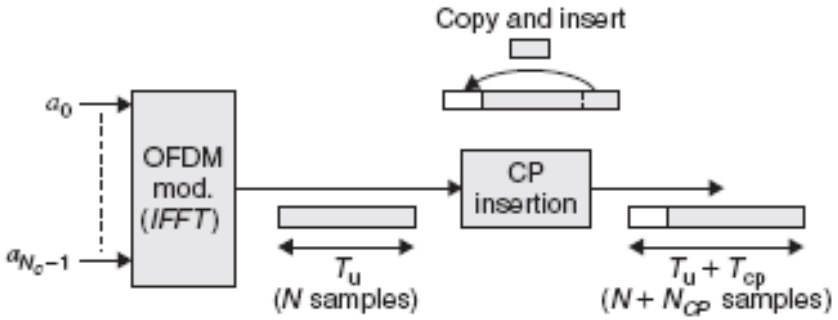

$\Delta f = 1/T_u$

OFDM

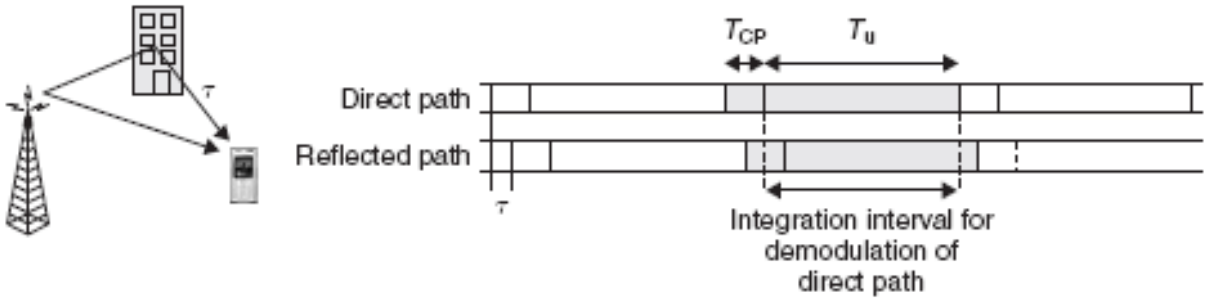

$a_k^{(m)}$
N_c-1
N_c-2
k
Frequency (subcarrier number)
1
0
----- m−2 m−1 m m+1 m+2 -----
Time (OFDM symbol number)

Cyclic-prefix insertion

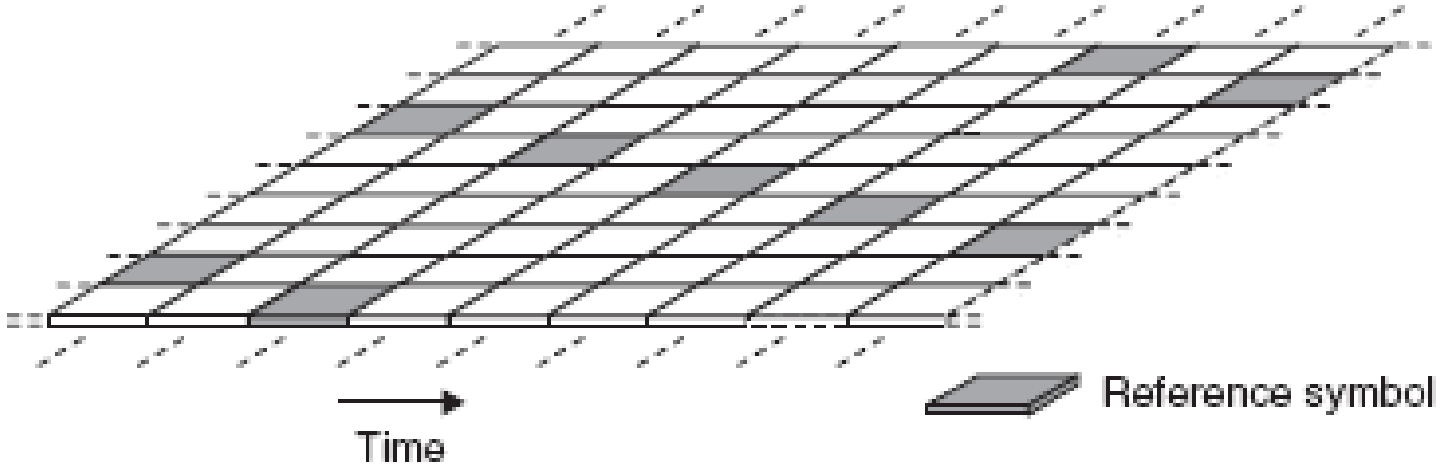




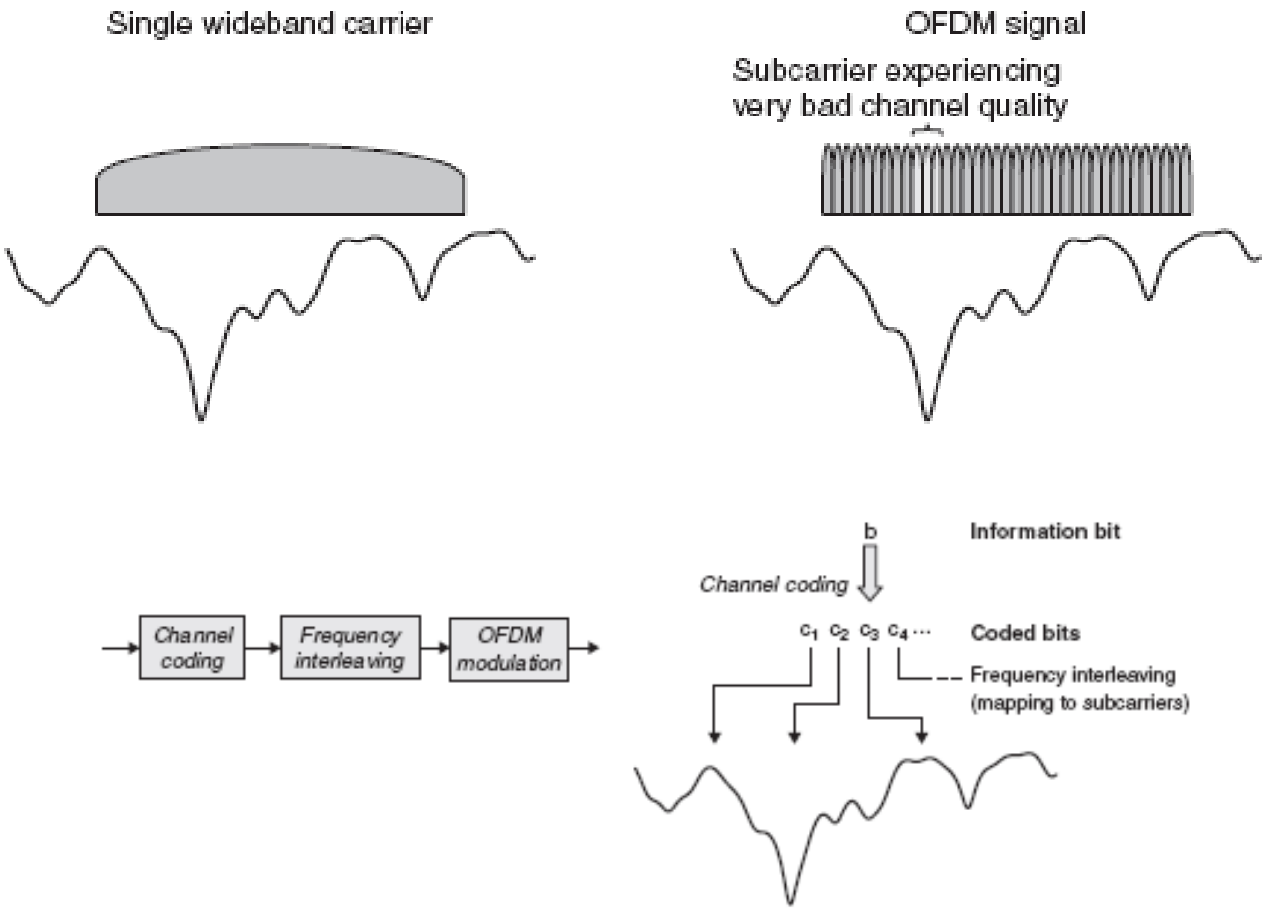
Instead of timing advance…



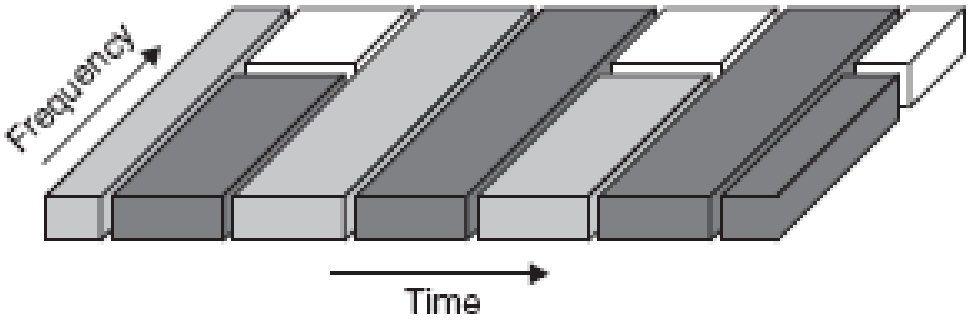
Reference signal (pilot)

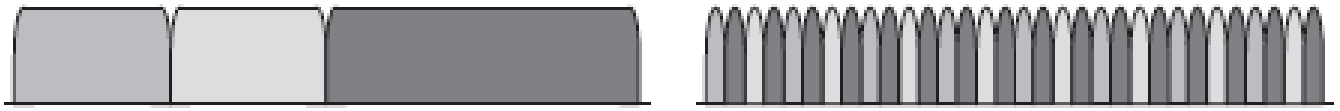


Interleaving



Flexibility in radio resource alloc.

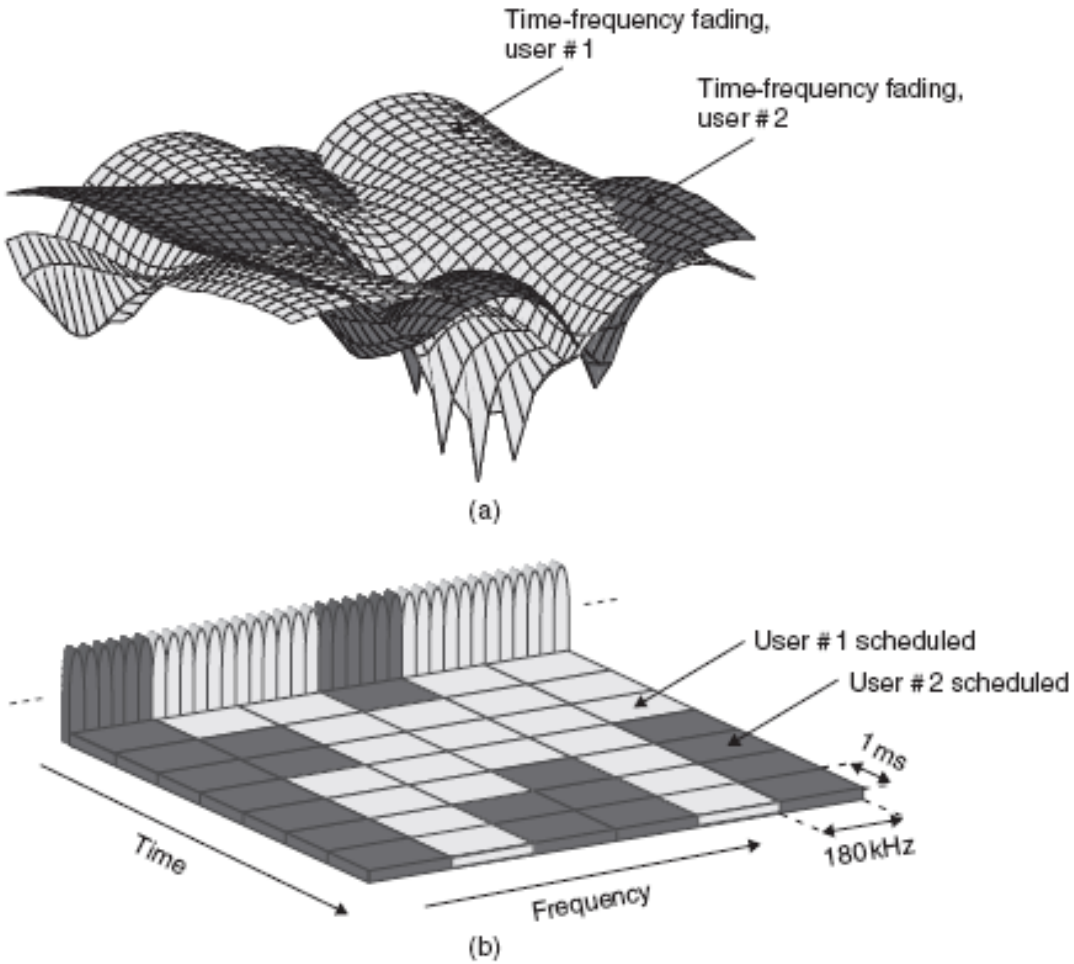




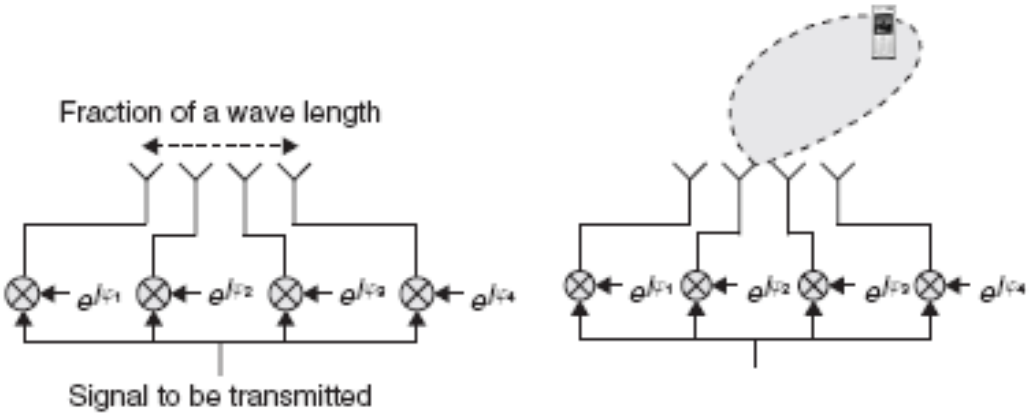
Localized transmission

Distributed transmission

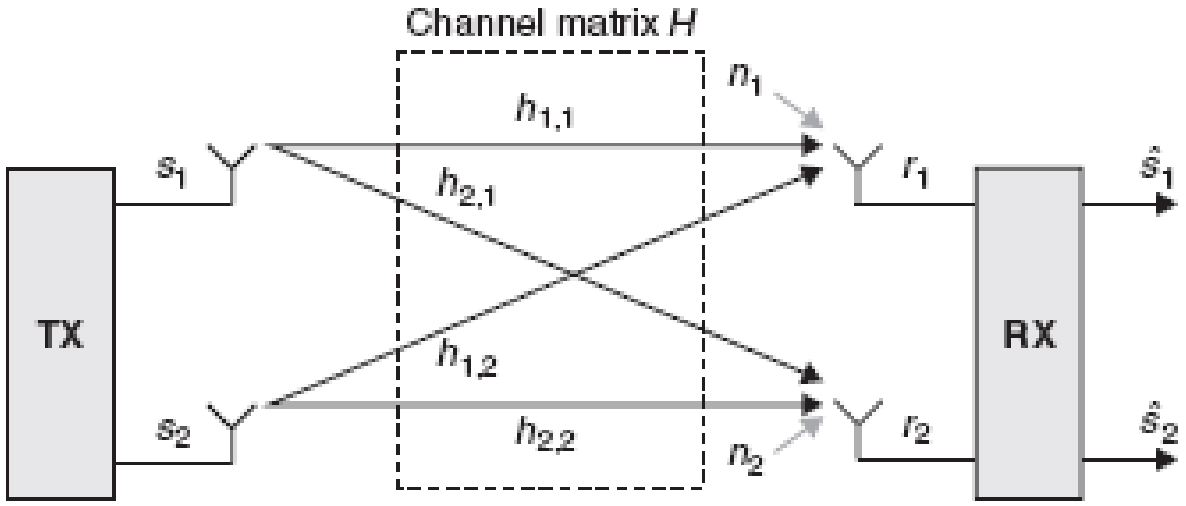
Example: downlink scheduling



Multiple antennas - beamforming



MIMO – spatial multiplexing



Multiple Antenna Techniques

- **MIMO employs multiple transmit and receive antennas to substantially enhance the air interface.**

- **It uses spacetime coding of the same data stream mapped onto multiple transmit antennas, which is an improvement over traditional reception diversity schemes where only a single transmit antenna is deployed to extend the coverage of the cell.**

- **MIMO processing also exploits spatial multiplexing, allowing different data streams to be transmitted simultaneously from the different transmit antennas, to increase the end-user data rate and cell capacity.**

- **In addition, when knowledge of the radio channel is available at the transmitter (e.g. via feedback information from the receiver), MIMO can also implement beam-forming to further increase available data rates and spectrum efficiency**

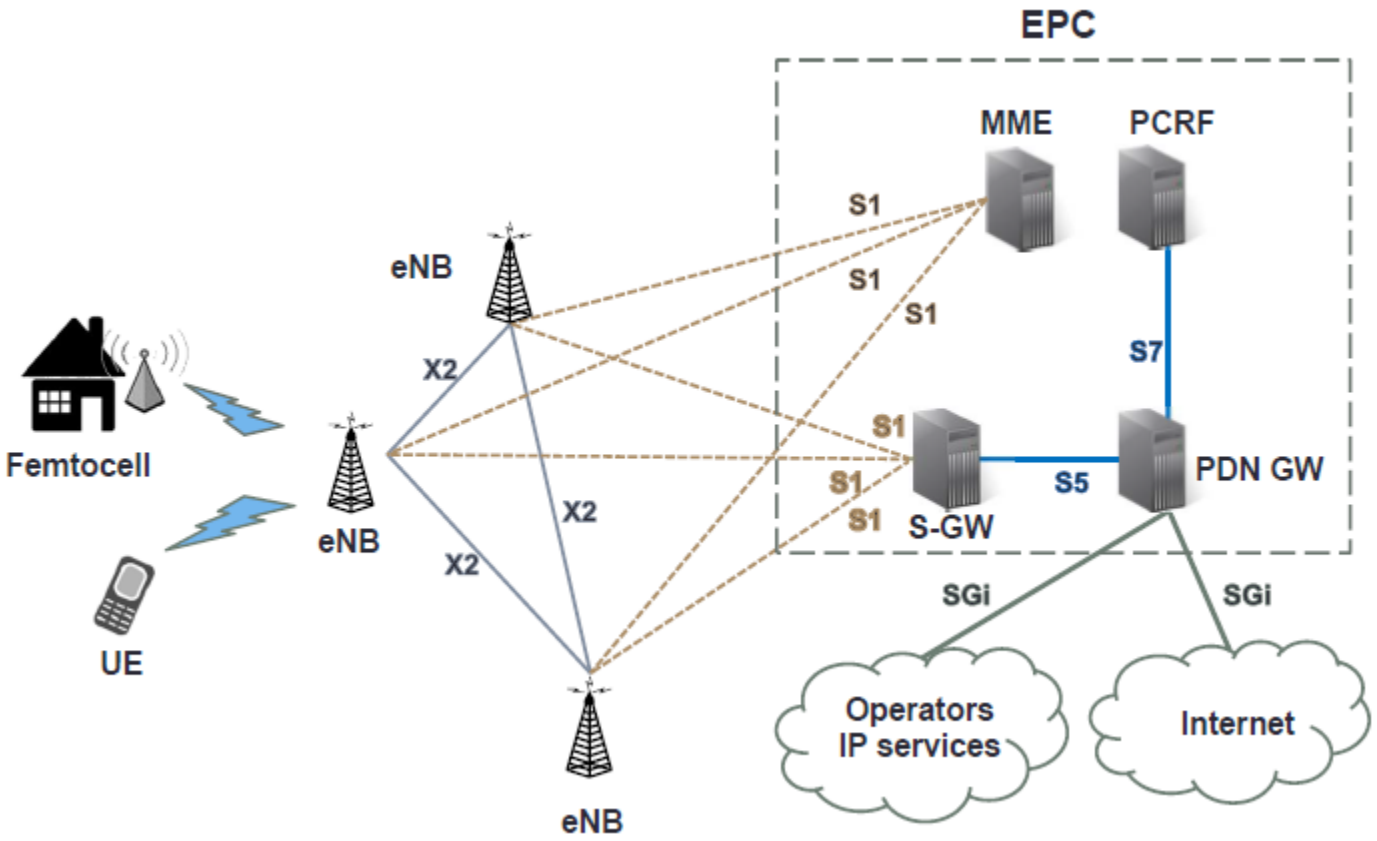
SC-FDMA

SC-FDMA

- **LTE uplink**
  - **FDD és TDD esetében is**
  - **SC-FDMA (Single Carrier Frequency Division Multiple Access)**
- **Kiküszöböli az OFDMA egyik hátrányát**
  - **Magas Peak to Average Power Ratio (PAPR)**
  - **Magas PAPR = Alacsony hatékonyság**
  - **Drága és hamar lemeríti az akkut**
- **SC-FDMA megoldás**
  - **Átrendezi az erforrás-blokkokat**
  - **Azért a DL / UL erforrások kiosztásában (frek.tartomány, moduláció) hasonló**

SC-FDMA

- További részletekért lásd:
  - **csatolt LTE_SCFDMA.pdf-et (Agilent White Paper)**
  - **(nem része a vizsgaanyagnak)**


EPC
MME
PCRF
S1
S1
S1
S7
eNB
X2
Femtocell
S1
S1
S1
S5
PDN GW
S-GW
eNB
X2
X2
UE
SGi
SGi
Operators
IP services
Internet
eNB