3G Evolution

Chapter: 14

LTE radio access: An overview

Deepak Dasalukunte
Department of Electrical and Information Technology

Outline

- LTE transmission schemes
  - OFDM in downlink
  - DTFS-OFDM/SC-FDMA in uplink
- Channel dependent scheduling and rate adaptation
  - Uplink/downlink scheduling
  - Inter-cell interference coordination
- Hybrid-ARQ
- Multiple antenna support
- Multicast broadcast support
- Spectrum flexibility

Changes introduced in LTE as compared to HSPA

LTE transmission schemes

- OFDM based
- Robust channel frequency selective channels
- Though frequency selective channels can handled by equalization, the complexity becomes extremely high for mmobile terminals operating at bandwidth > 5MHz
- OFDM can be better in such scenarios where BW>5MHz.
- Additional benefits
  - Access to frequency domain for channel dependent scheduling vs. time domain only scheduling in HSPA
  - Flexible Tx bandwidth – varying number of sub-carriers (BB perspective)
  - Broadcast and multicast transmission straightforward with OFDM

LTE transmission schemes (2)

- Uplink : DFT spread OFDM
  - Low Peak-to-average power ratio
  - Efficient usage of PA in mobile terminal
  - Equalization of frequency selective channel in uplink is not an issue
    - No low-power requirements
    - More powerful signal processing
- LTE uplink: orthogonal separation of uplink transmissions in time and/or frequency
  - Avoids intra-cell interference
- The available bandwidth is shared between terminals for uplink transmissions: referred to as SC-FDMA (multiple access in freq domain)

Channel dependent scheduling and rate adaptation

- Shared channel transmission
  - Similar to HSDPA: time and channelization codes are shared
  - LTE: time and frequency shared
- Scheduler determines overall downlink system performance
- Channel dependent scheduling
  - LTE has access to frequency domain as well (OFDM and DTFS-OFDM)
  - LTE can also account for channel variations in frequency domain when scheduling
  - Useful when channel is varying slowly in time (slow speeds)

Channel dependent scheduling and rate adaptation (2)

- Downlink scheduling
  - Channel status reports from terminal.
  - Instantaneous channel quality in both time and frequency.
  - Scheduled terminal can be assigned arbitrary combination of 180KHz wide resource blocks in 1ms duration.
- Uplink scheduling
  - Orthogonal separation of uplink transmissions.
  - Uplink scheduler: allocates resources in time and frequency.
  - Decisions about scheduling once per 1ms: what mobile terminals, time intervals, frequency resources, what transport format

Channel dependent scheduling and rate adaptation (3)

- Inter-cell interference coordination
  - no intra-cell interference due to orthogonal transmissions.
  - LTE performance: mostly about inter-cell interference vs. WCDMA
  - Limit how U/L D/L schedulers use the frequency bands (between the cells)
    - Restricted band used for higher data rate transmissions in adjacent cell.
  - Scheduling strategy to co-operate with the situation in neighboring cells
    - Implementation issue, no specs in the standard.

- Hybrid ARQ with soft combining
  - Very similar to HSDPA
  - Multiple parallel stop-and-wait hybrid ARQ processes
  - Incremental redundancy

Multiple antenna support

- LTE specs from the beginning supports multiple antennas at both terminals and base station
- Multiple antennas: receive diversity
- At base station: transmit diversity and beam-forming.
- Spatial multiplexing: several parallel channels

- Different techniques in different scenarios
  - Beam-forming when terminal at cell edge
  - Spatial multiplexing at high SNR and SIR.

- Base station selects the configuration to be used

Multicast and broadcast support

- Multi-cell broadcast: transmitting same information from several cells
  - Terminal can exploit this information from several cells to get better signal quality
  - WCDMA already had this, where the terminals could soft-combine the signals from multiple cells.
  - LTE goes further, by syncing the transmission timing between the cells
    - Implies the terminal sees that there is a single signal arriving from ONE base station.
    - As if the signal experiences one multipath channel
    - Referred to as Multicast-Broadcast Single Frequency Network (MBSFN)
    - Assumes tight sync and time alignment

Spectrum flexibility

- Highlight of LTE radio access
  - Flexibility in duplex arrangements
  - frequency bands
  - Varying sizes with the spectrum

- Flexibility in duplex arrangement
  - FDD (paired spectrum) and TDD (unpaired spectrum)
  - Support for both paired and unpaired spectrum already in specs since rel99
  - Also supports half-duplex

Spectrum flexibility (2)

- Flexibility in frequency-band-of-operation
  - Frequency-bands different mobile radio technologies operate at:
    - GSM, CDMA200 etc.
  - Also non-mobile radio spectrum: broadcast spectrum
  - Expected to able to operate depending on the availability of spectrum
    - New spectrum for mobile communication: 2.6 to 3.5 GHz
    - Spectrum currently used for LTE
    - present broadcast spectrum
  - LTE should be able to operate between 450MHz to 3.5GHz (at least)

- Bandwidth flexibility
  - Allow other radio access technologies to migrate to LTE
  - High data rates when there is availability in bandwidth
  - Currently, only limited set of transmission bandwidth specified
    - Depending on the migration scenarios that might seem relevant
    - RF specs needs modification to support other bands-of-operation