lec 2.03: Mobile architectures: LTE, LTE-A, LTE-A-PRO

LTE: Long Term Evolution

Motivations for LTE

- Exponential increase in demand
- Support for higher data rates
- Need for lower latency
- Inter-networking with legacy network
- Flexibility in spectrum use
- Lower capital and operating expenses for network operator
- Smooth transition to 4G

LTE performance objectives

- 100Mbps Down, 50 up
- Reduced latency to 10ms
- Scalable bandwidth up to 20MHz
- Backwards compatibility with GSM/EDGE/UMTS
- Can make use of existing spectrum allocation
- FDD and TDD operation
- Mobility up to 350km/h
- wide range of terminals e.g phone, smartphone, camera etc

LTE features

- OFDM/OFDMA
  - Increased spectral efficiency
- All IP-Architecture
- Spectrum flexibility
- Operating in various bands, with variable bandwidth
- resource aggregation

Spectrum flexibility

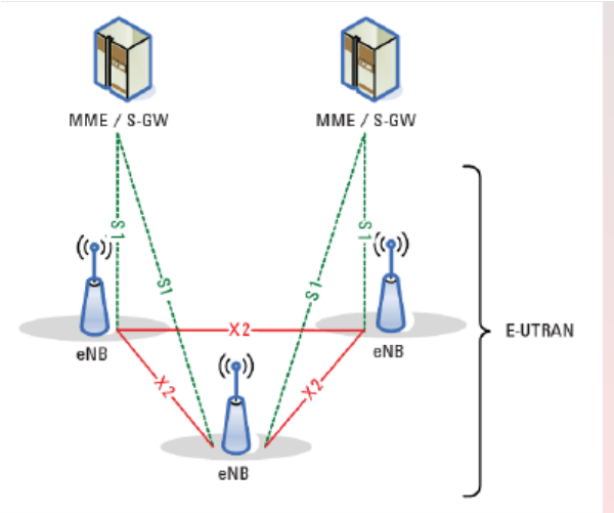
operates in a wide range of spectrum

- Current and future 3G spectrum
- Migration of 2G spectrum (e.g 900MHz)
- Refarming of spectrum (e.g UHF)

Can operate in different-sized bands

- Up to 20MHz to support high data rates
- Less than 5MHz to enable smooth spectrum migration

Architecture



MME = Mobility Management Entity

S-GW = Serving Gateway

eNB = Evolved Node B

E-UTRAN = Evolved Universal Terrestrial Radio Access Network

Protocol layers

Packet Data Convergence Protocol (PDCP)

- IP Header compression
- Cyphering and integrity protection

Radio Link Control (RLC)

- Segmentation and concatenation
- Retransmission handling
- In-order delivery to higher layers

Medium Access Control (MAC)

- Uplink and downlink scheduling at eNB
- Hybrid Automatic Repeat ReQuest (HARQ)

Physical Layer (PHY)

- Coding/decoding
- Modulation/demodulation (OFDM)
- Multiple-antenna use

PHY Layer

- OFDMA with cyclic prefix in DL, SC-FDMA with cyclic prefix in UL
- Duplexing: FDD and TDD
- 10ms radio frames, containing 20 slots of 0.5 ms duration
- Supported modulation schemes: QPSK, 16-QAM, 64-QAM
  - Broadcast channel uses QPSK

Note: Duplexing means that communication can occur in both- directions at the same time.

Scheduling

- Scheduler in eNB allocates resource blocks to users for pre determined amounts of time.
- Slots consist of either 6 (long cyclic prefix)or 7 (short cyclic prefix) OFDM symbols
- Number of available sub-carriers changes depending on transmission bandwidth
  - sub-carrier spacing is fixed.

OFDMA

- OFDM uses a large number of narrow sub-carriers for multi-carrier transmission
- The basic LTE downlink physical resource can be seen as a time-frequency grid
  - Frequency domain, spacing between the subcarriers is $\Delta f = 15kHz$
  - Symbol duration time: $1/\Delta f$ + cyclic prefix
  - cyclic prefix is user to avoid inter-symbol interference and allows for the use of simpler receiver architectures
- one resource elements carries QPSK, 16QAM or 64QAM

OFDM symbols are grouped into resource blocks

- A resource block has 180kHz in the frequency domain and 0.5 ms in the time domain

MIMO

- Multiple antennas on transmitter and receiver
- Beamforming for signal reliability
  - transmitter should know the wireless channel
- Multiplexing for higher data rate

LTE Advanced (LTE+)

Goals of LTE+

- 1Gbps down, 500Mpbs up
- 3 times greater spectrum efficiency than LTE
- Peak spectrum efficiency: DL - 30 bps/HZ; UL - 15 bps/Hz
- Spectrum use: the ability to support scalable bandwidth use and spectrum aggregation
- Latency less than 5ms
- More advanced MIMO

- Twice the user throughput at the cell edge
- Average user throughput 3 times greater than that of LTE
- Same mobility as in LTE
- Backwards compatibility

LTE+ Pro

- Aggregating more carriers, spectrums and cell types
- Making use of unlicensed spectrum
- Lower latency
- Massive MIMO, 3D beamforming (FD-MIMO)
- more interconnectivity with industry, services, users etc.

Acronyms

- LTE: Long Term Evolution
- FDD: Frequency division duplexing
- TDD: Time division duplexing
- OFDM: Orthogonal Frequency Division Multiplexing
- OFDMA: Orthogonal Frequency Division Multiple Access
- MME: Mobility Management Entity
- S-GW: serving gateway
- eNB: evolved node B
- E-UTRAN: Evolved Universal Terrestrial Radio Access Network
- PDCP: Packet Data Convergence Protocol
- RLC: Radio Link Control
- MAC: Medium Access Control
- HARQ: Hybrid Automatic Repeat Request
- SC-FDMA: Single Carrier Frequency Division Multiple Access
- MIMO: Multiple Input Multiple Output
- FD-MIMO: Full dimension Multiple Input Multiple Output