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Key Physical Layer Technologies to address
the LTE-Advanced Requirements

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Key technology implications for:

- Requirement for backwards compatibility
- Spectrum-related requirements
- Peak-rate requirements
- Spectral efficiency requirements

Technology aspects of Requirement for Backwards Compatibility

- LTE-A must be able to provide the **same common channels as LTE**
 - PSS / SSS
 - Common RS
 - PBCH
 - PDCCH / PHICH
- **Modified PDCCH may be provided for LTE-A-capable UEs**
 - Optimisations to reduce control signalling overhead (currently 7-21%)
 - Need to provide efficient support for larger numbers of active users
 - Resource allocation signalling will need extension to handle wider bandwidths and non-contiguous carriers
 - Need to avoid resource allocation signalling growing exponentially with bandwidth
- **New PDSCH formats may be used in RBs allocated to LTE-A-capable UEs**

Technology aspects of Spectrum-related Requirements

- LTE physical layer already supports deployment with a wide range of system bandwidths
 - The range of supported bandwidths will need to be increased:
 - Primarily a RAN4 issue, but also relax the hard constraint in L1 specs
- Need to decide **how to handle aggregated spectrum**. Some possibilities:
 - Handled by RAN4? – as separate carriers requiring multi-carrier support from the UE, assuming implementation with separate RF chain and demodulator;
 - Which level does aggregation occur at – L1 or L2/3 (or higher)?
- **Not all LTE-A terminals should have to be capable of 100MHz bandwidth**
- **Frequency agility** considerations:
 - System design should facilitate fast switching between different carriers
 - RAN1: provision of sufficient signalling information
 - Carrier-switching should be fast enough to reap the benefits of fast multi-user scheduling gain
 - RAN4: Definition of UE requirements on switching time
- Provide support for **flexible UL/DL bandwidth asymmetry**

Technology aspects of Peak-Rate Requirements

- Per-user peak rate is not the most important consideration for delivering enhanced user experience and enabling LTE-A to be a success in the market
- Downlink:
 - Peak rate >1Gbps can be achieved by increased BW (without large numbers of antennas)
- Uplink:
 - UL peak rate enhancement is necessitated by changing usage patterns
 - Peak Rate >500Mbps would require enhancements beyond simply increasing BW, e.g.:
 - UL SU-MIMO (limited to max 2 transmit antennas)

Technology aspects of Spectral Efficiency Requirements (1)

- System spectral efficiency is vital to support high user densities in limited spectrum
- Downlink:
 - **Multi User MIMO** aims to maximise system throughput, not peak per-user throughput
 - Gives an additional degree of freedom to the scheduler for improved total system performance
 - Possible improvements for LTE-A:
 - Improved availability and use of channel knowledge at eNB
 - Interference estimation at UE and signalling to eNB
 - Use of UE-specific RS to facilitate multi-user beamforming techniques
 - Non-unitary precoding
 - Combination of SU-MIMO and MU-MIMO
 - Signalling to support interference cancellation...
 - **Interference management / mitigation**
 - Both intra-cell and inter-cell
 - Move from interference randomisation to **interference co-ordination and cancellation**
 - Optimise for **synchronised networks**
 - Network should provide useful information to the terminal to improve feasibility of cancellation
 - Signalling overhead may be justified by improved performance
 - Advanced receiver techniques at UE
 - Facilitate by network synchronisation and suitable signalling provision
 - Implementation cost and complexity can be justifiable by the performance improvement
 - New performance requirements in RAN4
 - Code-division multiplexing may increase total capacity when combined with OFDM

Technology aspects of Spectral Efficiency Requirements (2)

- Uplink:
 - Macro-diversity
 - UL transmit diversity
- Control signalling design:
 - Already mentioned need to support:
 - wider bandwidths / non-contiguous bands
 - high densities of active users
 - Need to ensure control signalling design / overhead is not the limiting factor for cell size or system capacity
(as opposed to traditional limitations such as range/power or interference)
- New definitions of spectral efficiency are required for new network topologies, e.g.
 - relaying
 - multi-cell cooperation
- Self-Optimising Networks can benefit spectral efficiency
 - Planning of cell parameters (IDs, hopping sequences, etc)

Summary

- Requirement for backwards compatibility
 - Same common channels as LTE
 - Modified PDCCH may be provided for LTE-A-capable UEs
 - New PDSCH formats may be used in RBs allocated to LTE-A-capable UEs
- Spectrum-related requirements
 - Wider range of system bandwidths – relax the hard constraint in L1 specs
 - Spectrum aggregation: at L1, L2/3 or higher?
 - Not all LTE-A terminals capable of 100MHz bandwidth
 - Frequency agility: facilitate fast switching between different carriers
 - Support flexible UL/DL bandwidth asymmetry
- Peak-rate requirements
 - Downlink peak rate >1Gbps can be achieved by increased BW (without large numbers of antennas)
 - Uplink requires more than simply increasing BW, e.g.: UL SU-MIMO (limited to max 2 tx antennas)
- Spectral efficiency requirements
 - Downlink Multi-User MIMO
 - Interference management / mitigation
 - Move from interference randomisation to interference co-ordination and cancellation
 - Optimise for synchronised networks
 - Signalling provided to the terminal to improve feasibility of cancellation
 - Advanced receiver techniques at UE
 - Code-division multiplexing combined with OFDM
 - Uplink macro-diversity
 - Efficient control signalling design
- New definitions of spectral efficiency are required for new network topologies

