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Motivation for new WI proposal: Advanced Carrier Aggregation Techniques for LTE

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Advanced CA Techniques: overview

- **Fast Carrier switching at UE (esp. for UEs supporting fewer CCs than eNB)**
  - Reduce UE baseband/RF complexity and power consumption (compared to CA), while allowing UE to access the entire available eNB spectrum over time
  - Improve network interference coordination and load balancing
  - Take full advantage of multi-carrier LBT for LAA
  - UE follows eNB carrier selection decision
- **CRS reduction**
  - Light-weighted carriers with minimum interference from common channels and improved energy efficiency
  - Significant gain showed in Small Cell Enhancement SI (see TR36.872)
  - It has already been done for LAA LBT
- **SCell coverage enhancement**
  - e.g. by beamforming of signals used for UE synchronization

Motivations for fast carrier switching

- Motivations
  - Allow UE with limited CA capability/complexity/energy to access more carriers in UL & DL
    - Slow standard development (esp. RAN4 RF related) for CA with many carriers
    - Leverage currently standardized CA capability (e.g., up to 3 CCs) for access of more carriers
  - Take full advantage of multi-carrier LBT for LAA
  - Improve network interference coordination / load balancing
  - Power / complexity reduction for UE operating on many carriers
- Solution: FCS
  - SCell configuration/activation: #CCs configured/activated to a UE ≥ #CCs for simultaneous data reception/transmission
  - Carrier selection: eNB-level selection out of a number of carriers
  - Carrier switching: switching from one CC to another, per eNB instruction
- Performance
  - 2x ~ >5x edge UPT gains than slow carrier switch, in licensed and/or unlicensed

FCS feasibility and comparison to alternatives

- Related RAN4 studies/conclusions related to UE switching
  - RF retuning for SRS switching: [<100] us, [100] us, 200 us, 300 us, 500 us, 900 us (R4-164974)
  - RF retuning for eMTC: 200~300 us (R4-152889)
  - AGC setting for D2D: < 1 OFDM symbol duration (R4-140973)
  - RF/AGC for eMTC: 200~300 us (R4-141235 (R1-141109))
  - Switching for measurement gap: < 0.5 ms (Total: 6 ms; measurements: 5 ms; one way switching: < 0.5 ms)
- Tracking
  - Generally not needed for intra-band co-located CCs that are not far from each other
- RRM/CSI measurement
  - via DRS and detected CRS
  - Conservative transmission can be used before more accurate CSI report is available
  - One-shot measurement may be used (similar to LAA/FD-MIMO)
- FCS vs SCell addition/removal via RRC
  - RRC cannot respond fast enough to interference/load changes
  - High overhead/complexity due to frequent reconfiguration
- FCS vs SCell activation/deactivation via MAC
  - MAC signaling is not fast enough (8~24 ms; ~50 ms from some field data)
  - Unless it can be shortened to about 1 ms, it may not benefit LAA
  - Cannot respond fast enough to interference/load changes, esp. for small packets
- FCS vs CA approach (UE monitoring all CCs all the time)
  - High UE capability requirement/complexity/power consumption
  - Slow standard development in specifying CA RF requirements ➔ CA with many CCs will not be usable in a few years

CRS reduction

- General motivations
  - Reduce interference; Increased opportunities for 256 QAM
  - Energy saving for eNB (PA may be turned off)
  - Energy saving and complexity reduction for UE
- Motivations from R12
  - SCE/NCT concluded CRS reduction is beneficial
  - SCE introduced semi-static on/off for CRS reduction; concluded dynamic on/off can lead to even higher gains (but did not have enough time to complete the support)
- Motivations from R13
  - LAA operates with CRS reduction, creating much less interference
- Solutions
  - CRS reduction in time/frequency domain; support UE meas./sync/demod
- Performance
  - 10% ~ 30% (or even >50%) gains per TR 36.872

SCell coverage enhancements

- **Motivations**
  - MIMO beamforming used for **data/control/UE specific RS,** but not PSS/SSS/CRS/DRS
  - Signals used for UE synchronization may have smaller coverage than data/control/UE specific RS
  - For high-frequency SCells, UE needs to synchronize the Scells with the aid of synchronization signal, which coverage is smaller than those in low-frequency
- **Solution**
  - Beamformed signals for UE **synchronization** on Scell
    - e.g. PSS/SSS/DRS/CSI-RS/DMRS

Standards impacts

- FCS
  - SCell configuration/activation: #CCs configured/activated to a UE ≥ #CCs for simultaneous data reception/transmission
  - Dynamic indication: unified design for fast switching and dynamic on/off
  - RRM/CSI measurements and synchronization
    - Rely on DRS and alternative measurements (e.g., similar to RSSI-like in LAA) for RRM
    - Rely on DRS/preamble for CSI measurements; allow one-shot measurement (similar to LAA)
    - Extension of quasi co-location concept to across co-located intra-band carriers
  - Preamble (plus DRS) designed to achieve fine synchronization
- CRS reduction
  - Time-domain reduction: similar to FCS
  - Frequency-domain reduction: PCell assisting
- SCell coverage enhancements
  - Beamforming of signals used by UE synchronization

Backward compatibility

- **FCS**
  - No impact on backward compatibility
- **CRS reduction**
  - Time-domain reduction
    - No backward compatibility problem for R12+ semi-static on/off-capable (i.e., DRS-capable) UE if the fast on/off carrier is deactivated for the UE
    - No backward compatibility problem for other legacy UE if the UE is not connected to the fast on/off carrier
  - Frequency-domain reduction: no impact
- **SCell coverage enhancements**
  - No or minor impact on backward compatibility

Conclusions

- **Further enhancement of CA is crucial for future networks**
- **Multiple related advanced technologies for further CA enhancements:**
  - Carrier switching in DL/UL is beneficial
  - CRS reduction can be integrated into this framework
  - SCell coverage enhancement
- **Approve a WI for Rel-14**