Fraunhofer
Heinrich Hertz Institute

Spectrum Sharing for LTE-Advanced

Better Services for Mobile Communication

The ever increasing demand for higher data rates in mobile communications has to be met by limited spectrum resources. Many countries, however, have a multiplicity of competing mobile network operators. Researchers from the Fraunhofer Heinrich Hertz Institute HHI have highlighted the benefits of sharing valuable resources among mobile operators in LTE-Advanced. In an over-the-air demo, they show that only a small amount of information exchange is needed between the networks to allow dynamic spectrum sharing tailored to the current traffic situation in each network.

Challenges

A wide range of opportunities exists for sharing resources among mobile operators. Infrastructure sharing is already used in existing networks, in particular in rural areas where sites mounted on prominent structures like church spires are shared. Infrastructure sharing covers joint use of the same sites, same antennas and same backhaul. In LTE-Advanced, the same radio frontends and baseband hardware could be used for multiband operation. Bandwidth can be increased by using carrier aggregation techniques within each RF band while the operator networks are separated logically at the network layer.

Spectrum sharing is more advanced. It requires the dynamic exchange of information between the network operators, such as the instantaneous traffic load in each network and channel quality indicators (CQI) for terminals with high traffic demands. In this way, spectrum access can be dynamically coordinated among mobile operators. By introducing advanced multi-antenna techniques, also spatial reuse of the radio resources becomes possible. Spatial Inter-cell interference cancellation can be enabled by exchange of channel state information inside and/or between the networks. If user data are exchanged in addition, even joint transmission coordinated multipoint techniques can be used. Since operators often use hardware from different vendors, the interfaces required for the information exchange need to be standardized. Common rules for sharing the limited amount of radio resources have to be agreed on.

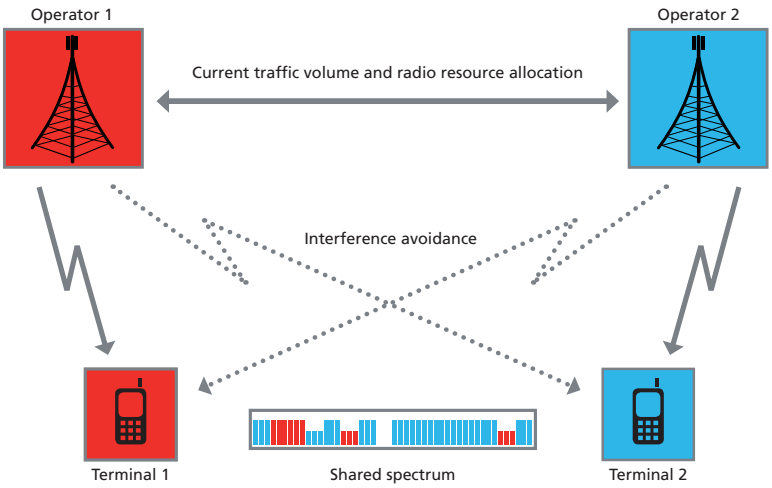
Benefits

Infrastructure sharing

- Sharing of sites, antennas, backhaul networks
- Enhanced coverage, especially in rural areas
- Higher density of base stations
- Higher capacity, especially in urban areas
- Enhanced mobile network availability

Spectrum sharing

- Access to the spectrum of other operators
- In line with the traffic load in each network
- Depending on the channel
- Increased peak throughput
- Increased cell throughput using advanced interference management techniques like inter-cell interference cancellation or coordinated multipoint



Principle of the spectrum sharing experiment explained in the text below.

Technical Background

The experimental setup of the spectrum sharing showcase is described below. The goal is to demonstrate that spectrum sharing can be realized in a distributed manner, using spectrum coordination entities responsible for a certain geographic area. Here base stations can offer unused resources of their operator's spectrum or can request additional resources. Between the networks of the operators, information is exchanged and common rules on spectrum acquisition and release are defined.

Two base stations exemplify two mobile operators. Operator 1 and 2 have 10 MHz bands each. 8 frequency sub-bands can be assigned within each part of the spectrum. The base stations observe the current traffic load (IP-rate) and predict additional need or available radio resources to offer for sharing. Exchanging these information between the base stations within an area using the local spectrum coordinator enables the temporal shift of radio resources from one operator to the other.

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Operators exchange this information on the network layer. If radio resources are shifted for temporal use to the other network one operator is excluding these resources from use while the other operator can allocate these resources for his native users using control mechanisms standardized for carrier aggregation. In practice this means that each operator can use additional resources while the overlapping cell of other operator is at moderate or low load without additional cell handovers or even national roaming.

The following scenarios are showcased in the over-the-air live demo:

- Each operator starts by using its own resources first, as long as traffic is smaller than the capacity limit.
- Unused resources in the shared spectrum mode are assigned by a fixed rule only if an operator's own resources are completely consumed.
- If added resources are no longer used, the worst resource is always released, i.e. sharing is opportunistic and channel-aware.
- Resources are given back to the spectrum owner if he requires additional spectrum for his own users and if no free resources are left in the shared spectrum.
- If the cell load is simultaneously high in both networks, operators will serve their customers within their native spectrum again.