Context & Motivation

Thanks to its focusing properties, Time Reversal (TR) [1] has been identified as a promising signal processing technique for green communications and has been evaluated over realistic green scenarios [2][3][4]. However, TR needs several transmit antennas to obtain good performance and, as a closed-loop technique, TR needs channel knowledge and therefore increases Medium Access Control (MAC) layer complexity. This poster presents results of TR Physical (PHY) layer application at 60 GHz with a limited number of transmit antennas and a cross-layer analysis at 5 GHz [5].

Time Reversal Principle [1][4]

- The e-NODE B estimates the CIR
- The CIR is time-reversed and used to prefilter the signal
- Channel Impulse Response

\[ h(t) = h(t) + h(t, r) = h(t, r) + n(t) \]

**Step 1 : Sounding**

**Without Time Reversal:**

**With Time Reversal:**

\[ y(t) = x(t) + n(t) \]

\[ y(t) = x(t) + h(t, r) + n(t) \]

**Step 2 : Focusing**

**TR performance for small cells [6]**

- **5 GHz - IEEE802.11.ac**
  - Large space channel model (indoor/outdoor)
  - 802.11d VHT OFDM PHY MCS1
  - Bandwidth : 80 MHz
  - Datrate : 58.5 Mbps
  - BER performance is enhanced with > 2 transmit antennas
  - @ 5 GHz : 2.9 dB gain (BER = 1E-6)
  - @ 60 GHz : 4.4 dB gain (BER = 1E-4)

**Green Scenarios [2][3]**

**Simple and multi-RAT HetNets**

- Radio Access Technology Heterogeneous Networks
- Multi-RAT Quality Indicator (QCI) metrics combined with a Multiple Interface Management select the most green technology upon each radio link:
  - Green Link Budget Metric (GLB)
  - Multi-RAT radio link set up:
    - Fast Session Transfer (FST)
    - Inter-MAC : L2.5 layer
    - ANDSF (Wi-Fi/LTE)

**LTE-A CoMP**

- Long-Term Evolution Advanced Coordinated MultiPoint
- Coordinated Scheduling / Coordinated Beamforming
- Joint transmission
  - Inter-MAC : L2.5 layer
- Joint Processing
- Green Link Budget Metric (GLB)

- The LTE-A CoMP technique reduce border-cell interference.

- Multi-RAT HetNets are investigated as green scenarios to provide seamless connectivity under QoS constraints
- Multi-RAT Channel Quality Indicator (CQI) metrics combined with a Multiple Interface Management select the most green technology upon each radio link:
  - Green Link Budget Metric (GLB)
  - Wi-Fi @ 2.4/5 GHz switching
  - Inter-MAC : L2.5 layer
  - ANDSF (Wi-Fi/LTE)

Applying TR necessitates channel knowledge at the transmitter, and then induces overhead and additional power consumption. To validate the green nature of TR, it is necessary to evaluate its Energy Efficiency (EE) considering additional control frames generated (sounding).

Simulation parameters:
- Large space channel model (indoor/outdoor)
- 2 transmit antennas
- 802.11ad VHT OFDM PHY
- Bandwidth : 80 MHz
- Datrate of (Data field):
  - MCS1 : 58.5 Mbps (QPSK 16)
  - MCS2 : 87.8 Mbps (QPSK 16)
  - MCS3 : 117.0 Mbps (16-QAM 16)
- Deterministic Access:
  - Transmission duration 16 µs

**TR Cross-layer analysis @5 GHz [5]**

- Reducing the required SNR corresponding to the desired QoS
- Frequent sounding (short data field) (1)
- Using Time-Reversal (2)
- Improving the spectral efficiency
- Increasing modulation (3) or coding scheme
- Increasing the datafield size (4)

- TR with only 2 transmit antennas increases EE