Xzero: Cross-Technology Interference Nulling for Improved LTE-U/WiFi Coexistence

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1. Motivation

- Cellular network operators strive for additional capacity,
- Direct usage of unlicensed spectrum at 5 GHz where WiFi (IEEE 802.11n/ac/ax) also operates,
- **Coexistence** of unlicensed LTE (LTE-U) and WiFi is a big challenge,
- Traditional approach: separation of transmissions in frequency, time, space,
- Our proposal: **Co-existence gaps in space** = separation in space domain via **Cross-Technology Interference Nulling (CTIN) from LTE-BS towards** WiFi [1,2].
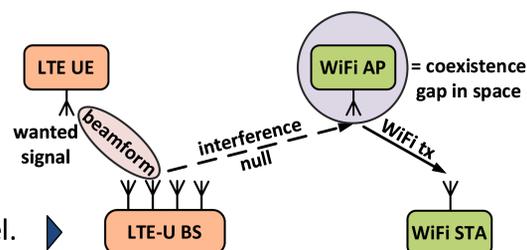

Fig. 1 – System model.

2. Prerequisite - Establishing Cross-technology Communication

- CTIN requires explicit cooperation between co-located nodes of heterogenious technologies (LTE-U & WiFi),
- Cross-technology Communication (CTC) enables heterogeneous devices to talk directly,
- Our approach uses **LtFi** [4] which consists of two interfaces:
  - **Air-Interface**
    - Over-the-air CTC broadcast channel from LTE to WiFi,
    - Simple side-channel on top of normal transmission,
    - Low data rates enough for transmission of control data,
    - On WiFi side the receive power of CTC (LTE) signal can be estimated per WiFi OFDM subcarrier.
  - **X2-Interface**
    - Over-the-wire bidirectional channel (Internet)
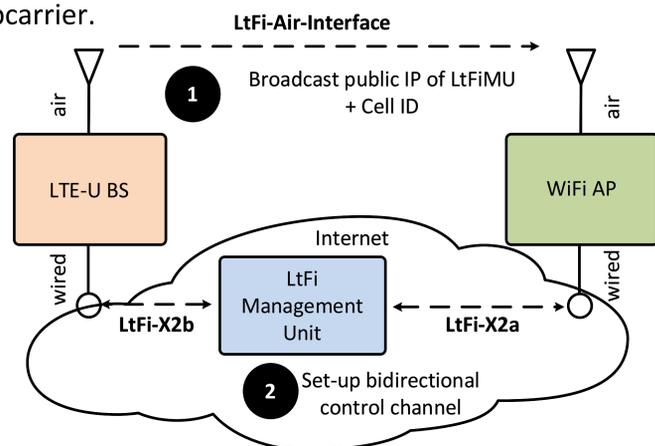   - Used for collaboration

Fig. 2 – LtFi system architecture.

3. Xzero in a Nutshell

- Key challenge in cross-technology interference nulling: **LTE BS lacks the channel State information** (CSI) towards the WiFi node to be nulled,
- Existing works aim at CT CSI estimation, e.g., [5],
- **Xzero** works differently:
  - **Testing** different **nulling configurations** by measuring effective LTE interference at WiFi side on a per OFDM subcarrier basis,
  - **Feedback** of results towards LTE-BS using CT control channel,
  - Fast **tree-based search**:
    - Start testing a wide null region, e.g., 60°, and later decreases the region width by focusing on the best configuration at each step,
    - WiFi node reports the nulling configuration providing the lowest interference-to-noise-ratio (INR) and LTE-U BS continues its search by further decreasing the null region, e.g., 20°, only in the reported angular space.
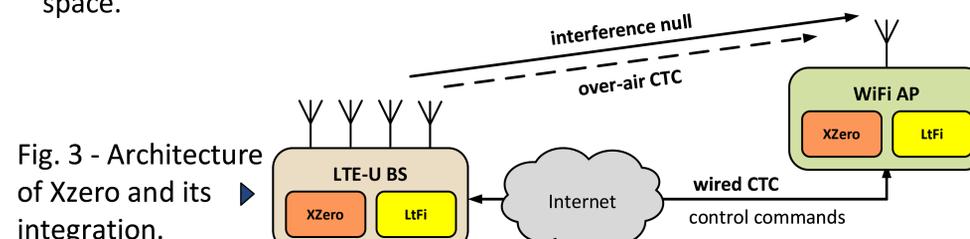

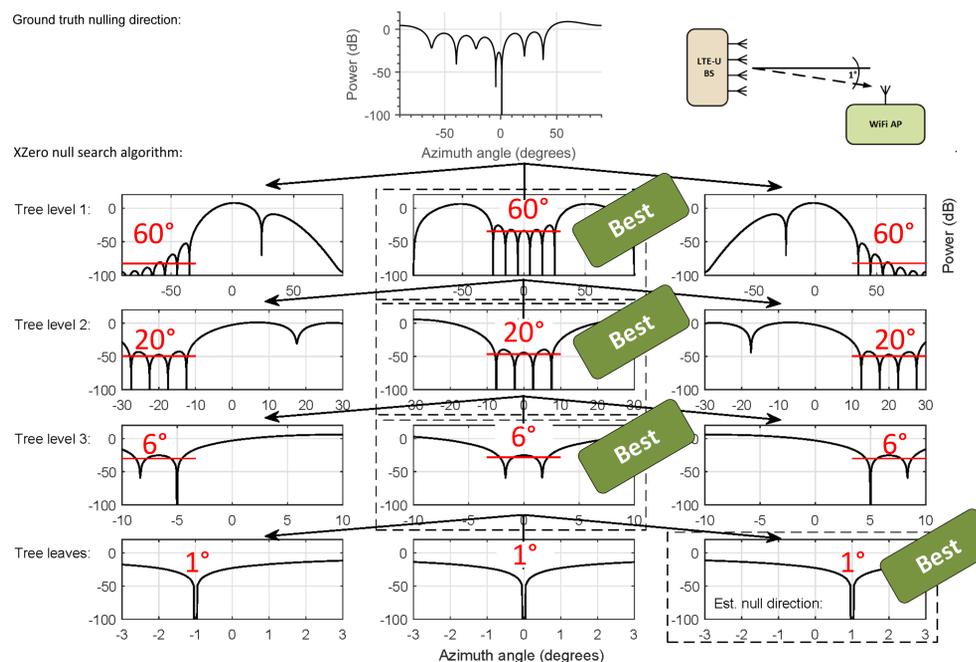Fig. 3 - Architecture of Xzero and its integration.

Fig. 4 - Illustrative example of XZero null search algorithm (8 antennas).
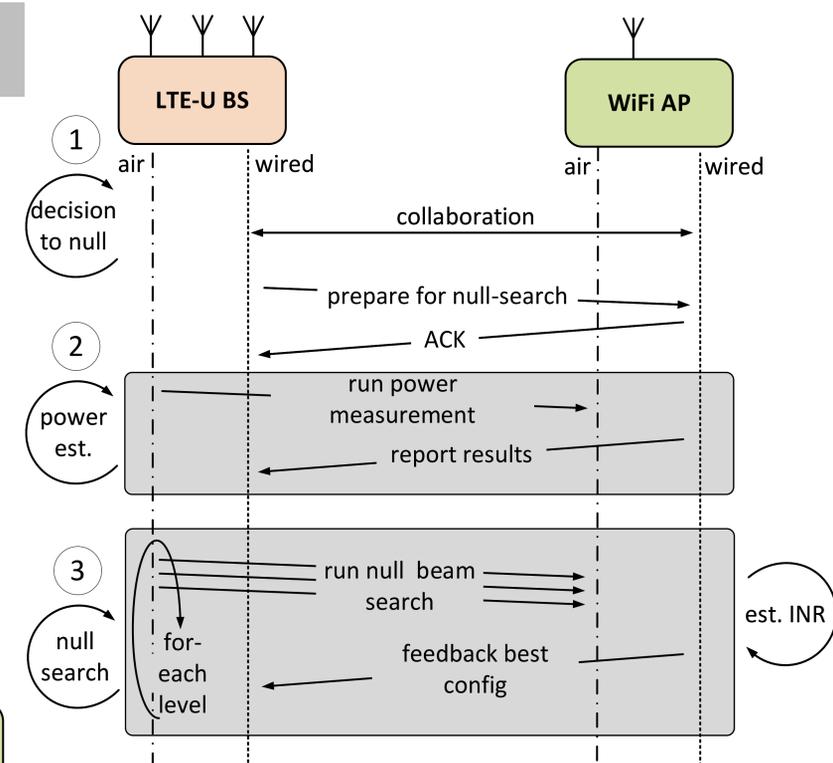

Fig. 5 - Collaboration between LTE and WiFi.

4. XZero Prototype

- Prototype based on SDR-USRP (LTE) and COTS (WiFi)
- Usage of open-source software-based LTE stack (srsLTE) & WiFi driver (ATH9k),
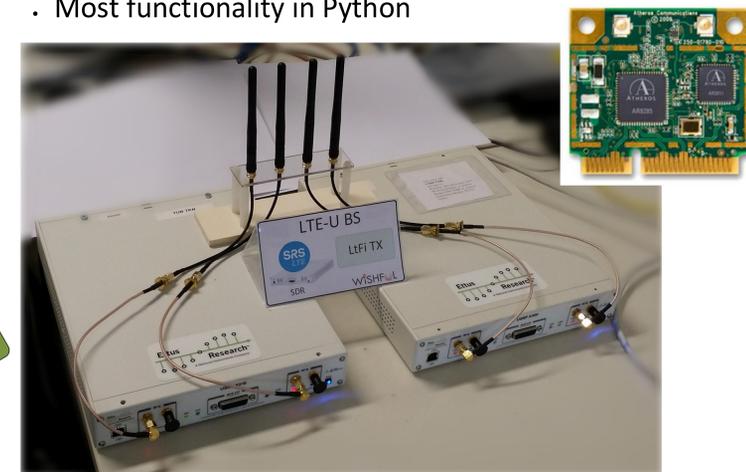- Most functionality in Python

Fig. 6 – LTE BS (left) & COTS WiFi NIC (right).

[1] "LTE-U Forum.", http://www.lteuforum.org
[2] A.Zubow, P. Gawłowicz, S.Bayhan, On Practical Coexistence Gaps in Space for LTE-U/WiFi Coexistence, European Wireless 2018
[3] S. Bayhan, A. Zubow, and A. Wolisz, "Coexistence gaps in space: Crosstechnology interference-nulling for improving lte-u/wifi coexistence," IEEE WoWMoM 2018
[4] P. Gawłowicz, A. Zubow, and A. Wolisz, "Enabling Cross-technology Communication between LTE Unlicensed and WiFi," in INFOCOM 2018.
[5] Geraci, Giovanni, et al. "Operating massive MIMO in unlicensed bands for enhanced coexistence and spatial reuse." IEEE JSAC 2017