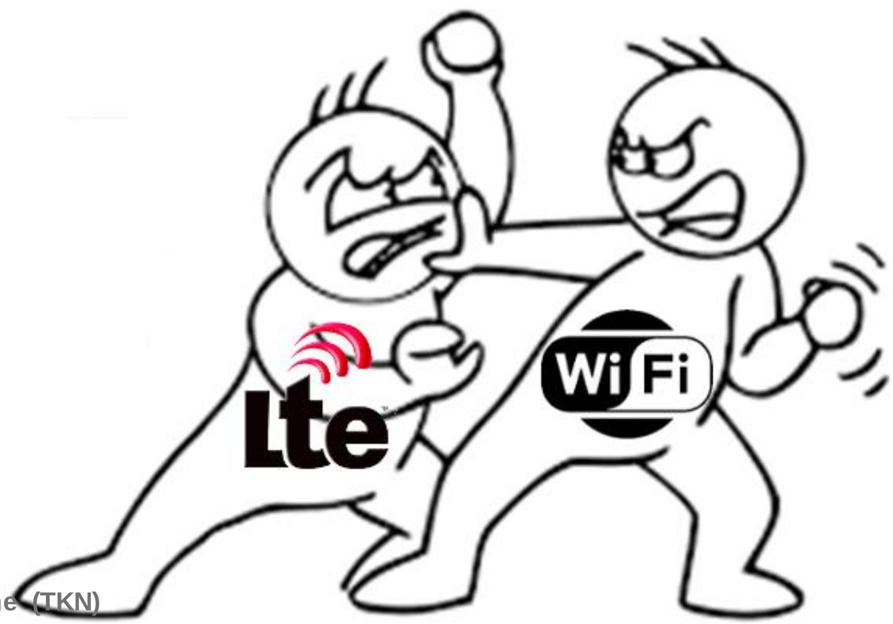
Technische Universität Berlin

Demo Abstract: Cross-Technology Communication between LTE-U/LAA and WiFi

Piotr Gawłowicz, Anatolij Zubow, Suzan Bayhan

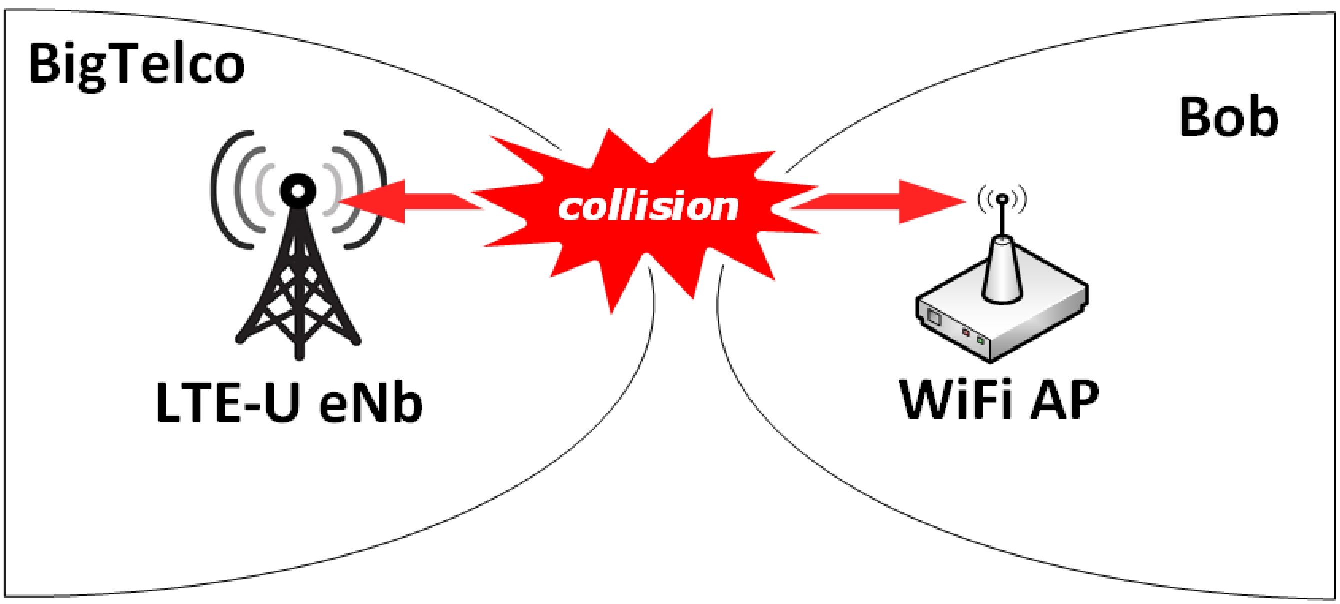
Motivation

- WiFi dominated 5GHz band
- LTE started moving to 5GHz band (**LTE-U**)
- Advanced technologies
  - data rates in order of Gbps
- Performance degradation
  - Increased contention
  - Mutual interferences

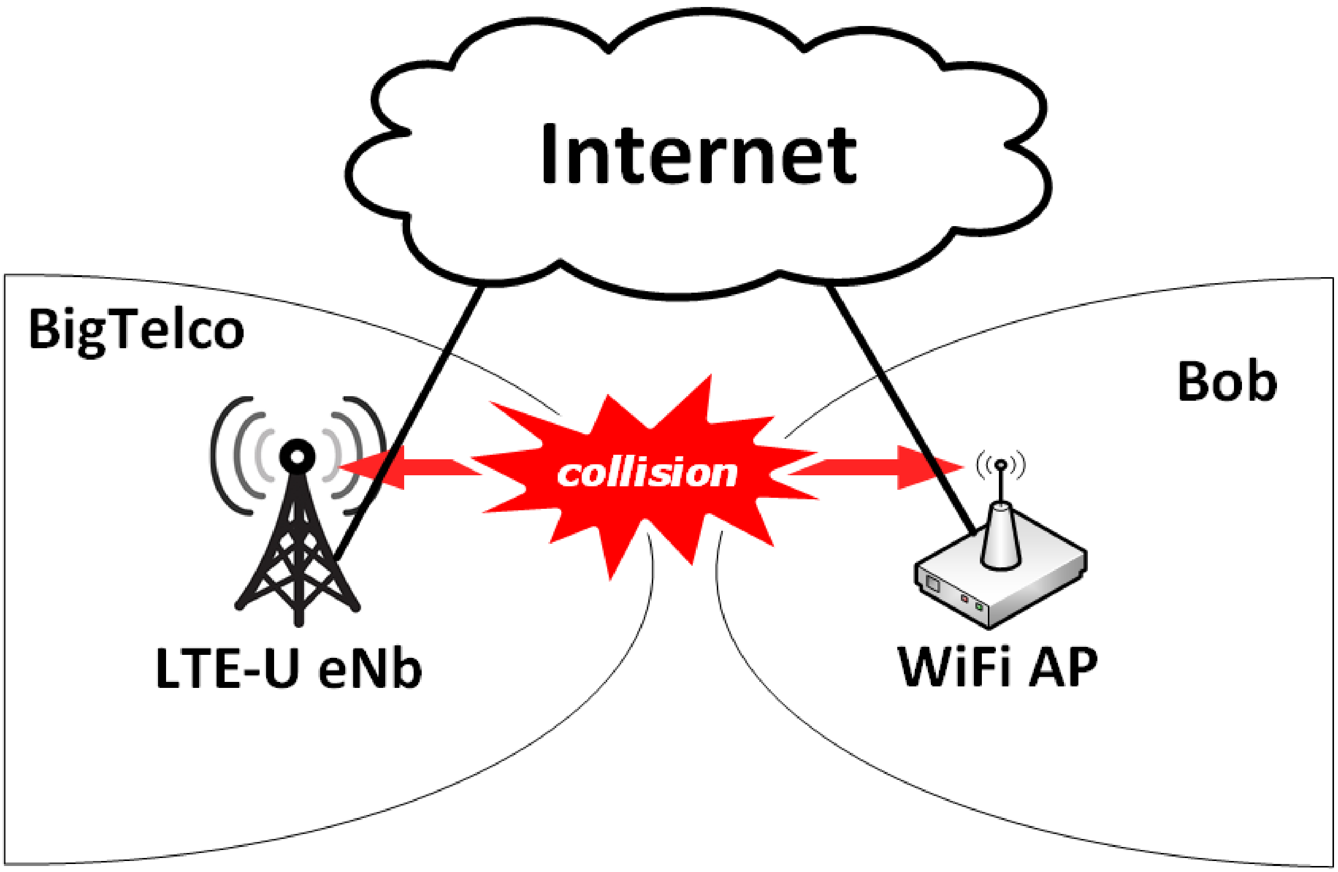


Coexistence Issues

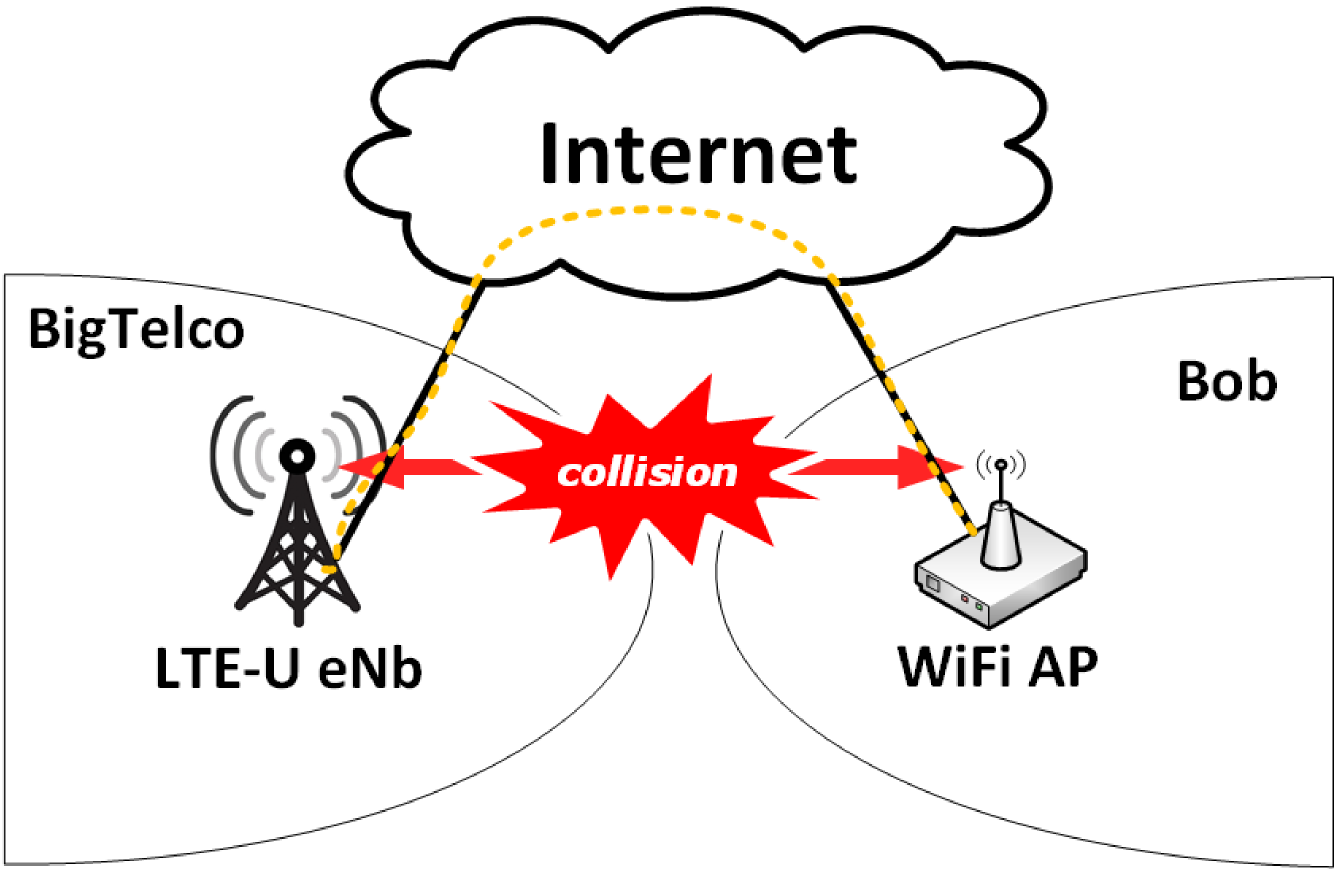
Coexistence Issues



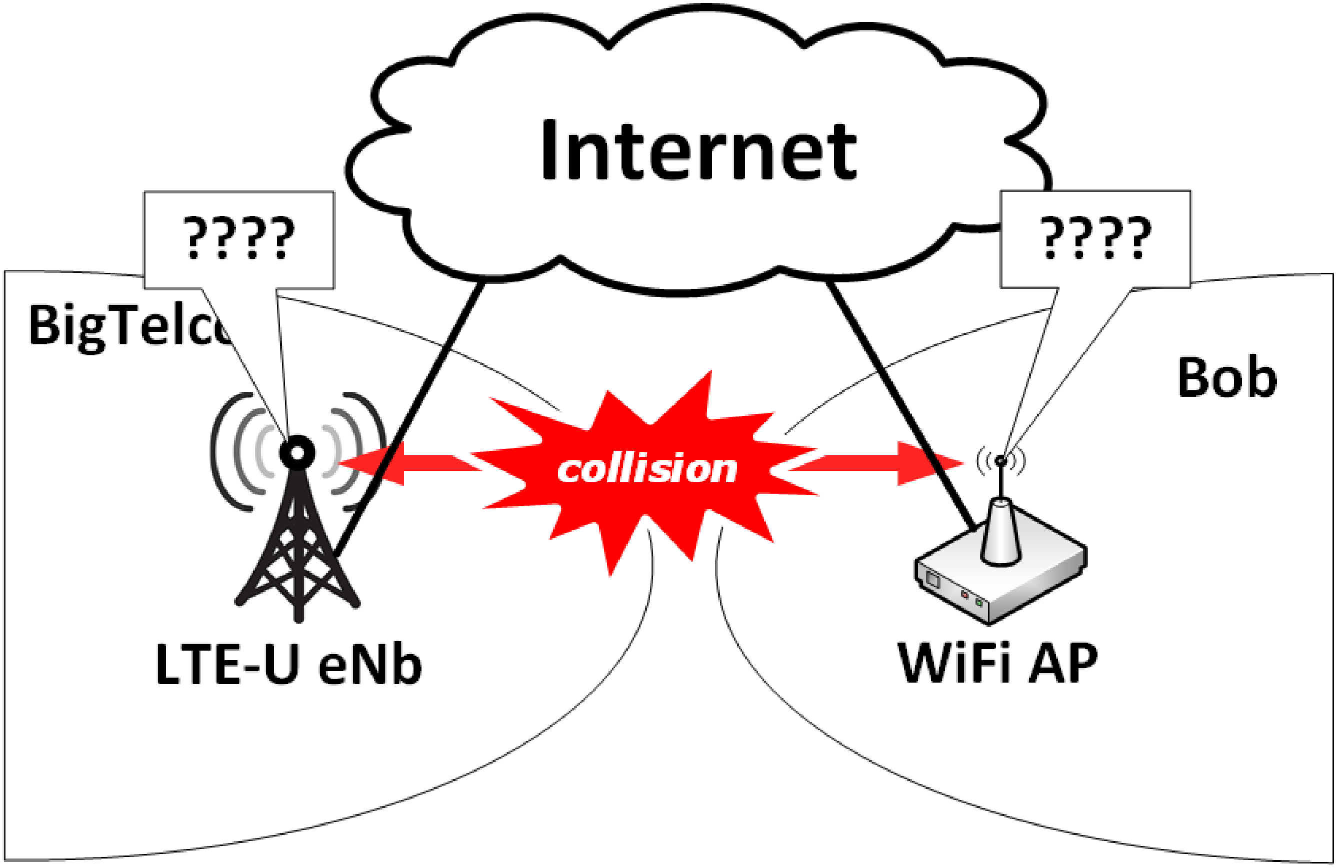
We are connected!



Let’s setup a control channel

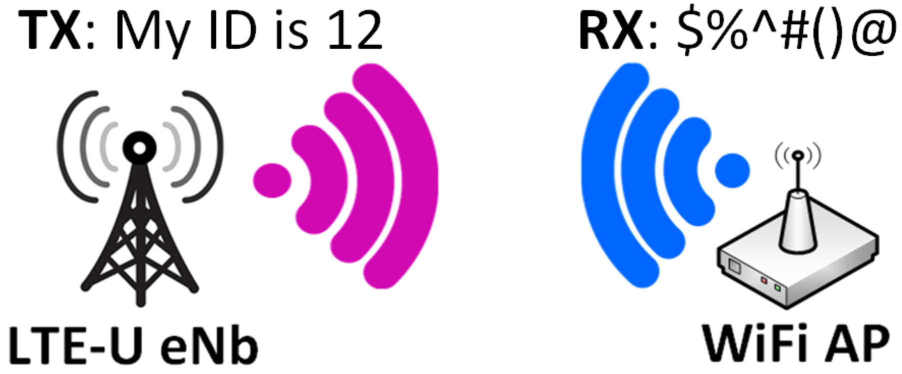


But how?



Over-the-air Neighbor Discovery

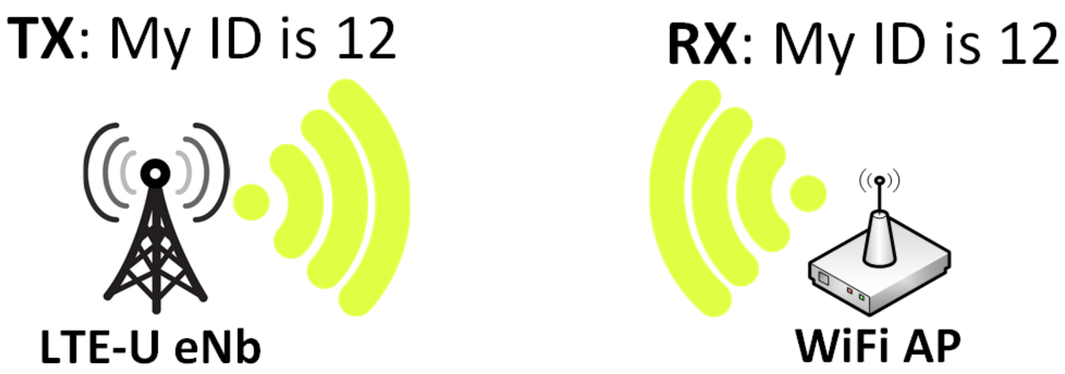
- How to perform neighbor discovery between nodes of heterogeneous technologies?
  - Common belief: heterogeneities cannot talk with each other



Cross-technology Communication (CTC)

- CTC enables heterogeneous devices to talk directly
  - Simple side-channel on top of normal transmissions
    - e.g. CTC data encoded in frame duration

- We design CTC scheme for WiFi and LTE-U



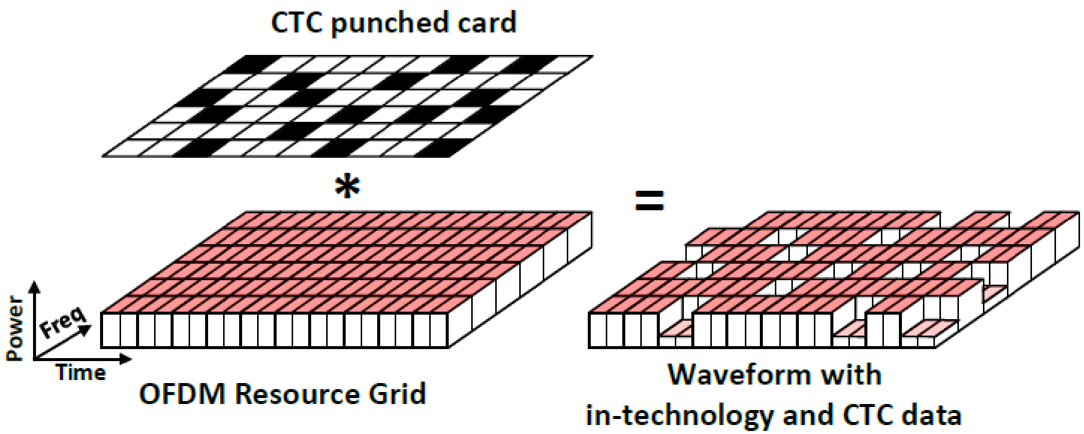
LTE and WiFi are both OFDM

- Both use OFDM in PHY layer, but with different grid parameters
  - WiFi – symbol time 4us, subcarrier spacing 312.5kHz
    FFT 64, used subcarriers 56
  - LTE – symbol time 71.4us, subcarrier spacing 15kHz
    FFT 2048, used subcarriers 1200

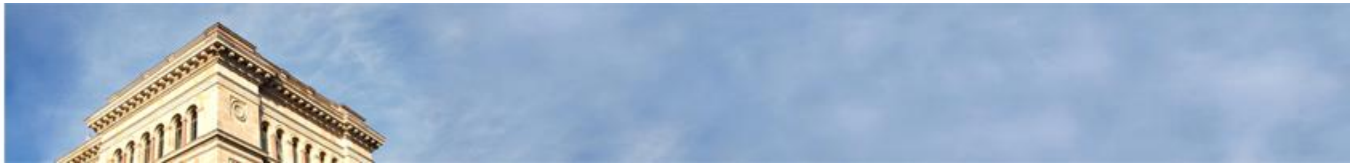
- They can use their FFT blocks to perform spectrum scanning
  - modern WiFi cards supports it (ath9k, ath10k)
  - they can measure each other signals in frequency domain!

- **CTC idea**: modulate CTC message into 2D power pattern

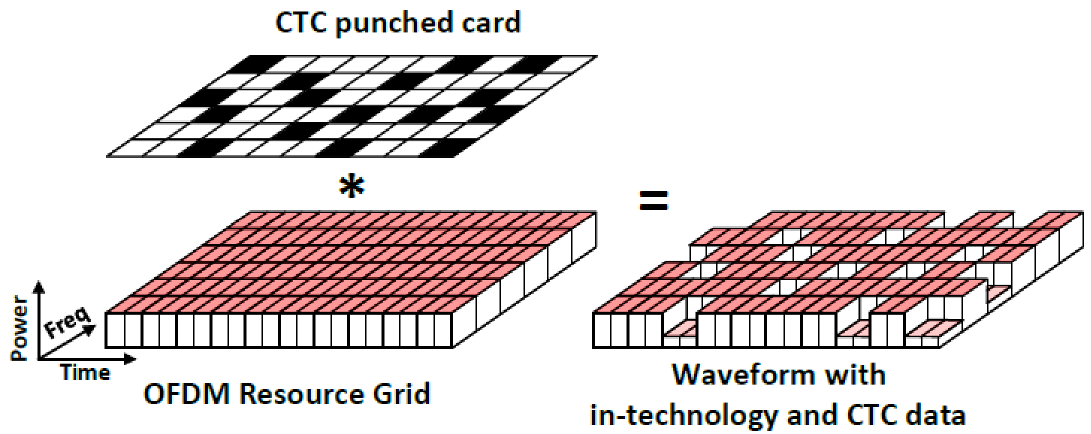
Punched Cards: the Message-bearing Power Patterns



Superposition Coding - communicate two message simultaneously by encoding them into a single signal in two layers



Punched Cards: the Message-bearing Power Patterns



2D Nyquist sampling:

$$\Delta T_{\mathrm{CORB}} = a \cdot \Delta T_{\mathrm{TX}} + \epsilon_a \geqslant b \cdot \Delta T_{\mathrm{RX}} + \epsilon_b$$

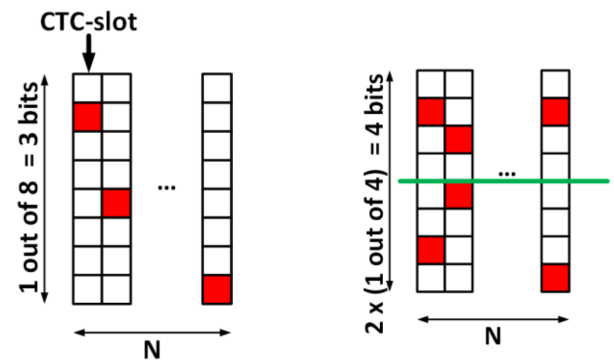
$$a \geqslant 1, b \geqslant 2 \quad \text{where } a, b \in \mathbb{N}, \quad \epsilon_a \to 0, \epsilon_b \to 0$$

$$\Delta f_{\mathrm{CORB}} = n \cdot \Delta f_{\mathrm{TX}} + \epsilon_n \geqslant m \cdot \Delta f_{\mathrm{RX}} + \epsilon_m$$

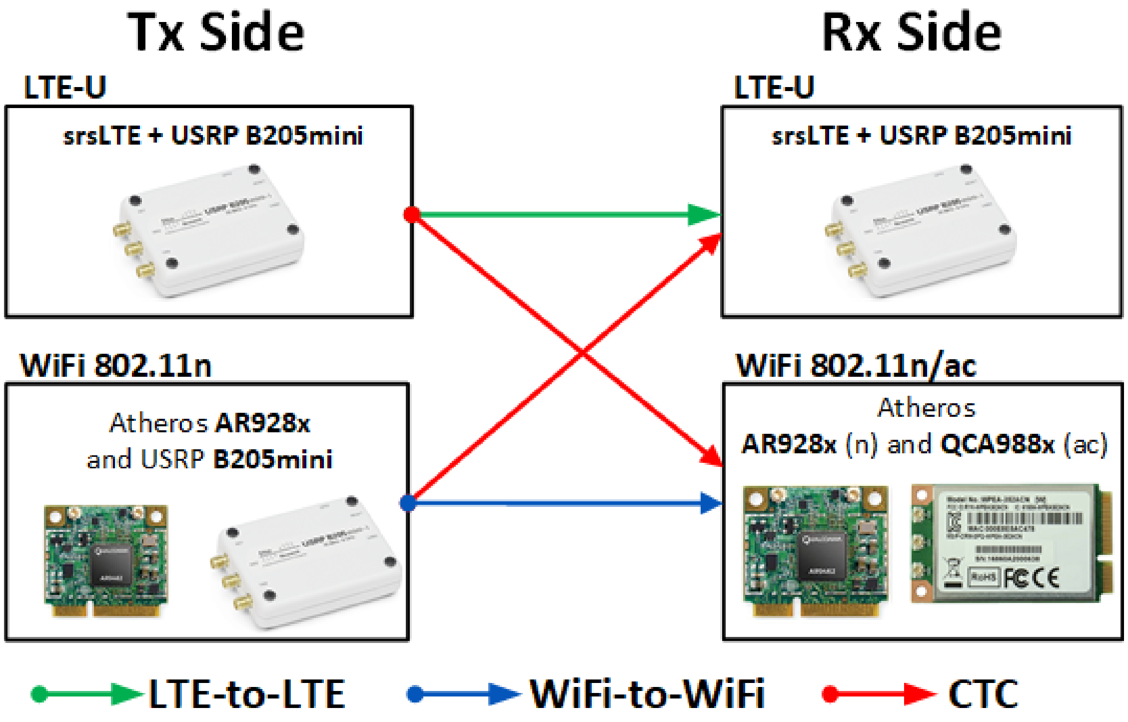
$$n \geqslant 1, m \geqslant 2 \quad \text{where } n, m \in \mathbb{N}, \quad \epsilon_n \to 0, \epsilon_m \to 0$$

$$\Delta B_{\mathrm{PP}} = (F_{\mathrm{TX}}^{\mathrm{start}}, F_{\mathrm{TX}}^{\mathrm{end}}) \cap (F_{\mathrm{RX}}^{\mathrm{start}}, F_{\mathrm{RX}}^{\mathrm{end}})$$

1 out of N encoding

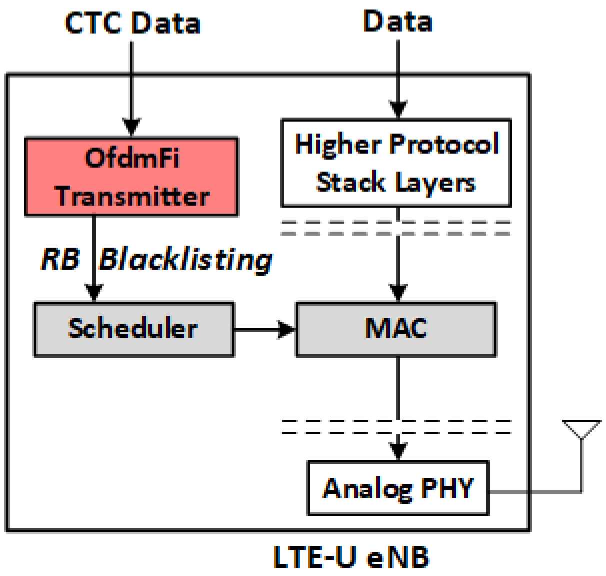


Prototype Implementation



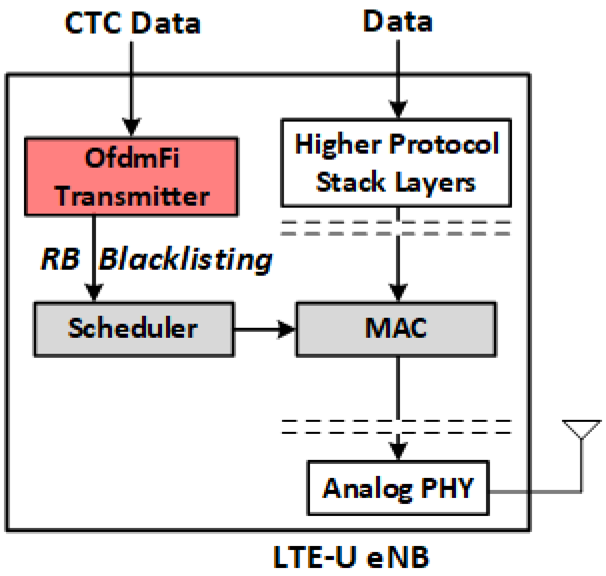
Punched Cards in LTE-U

- **RB Blacklisting:** a scheduler do not allocate blacklisted RBs



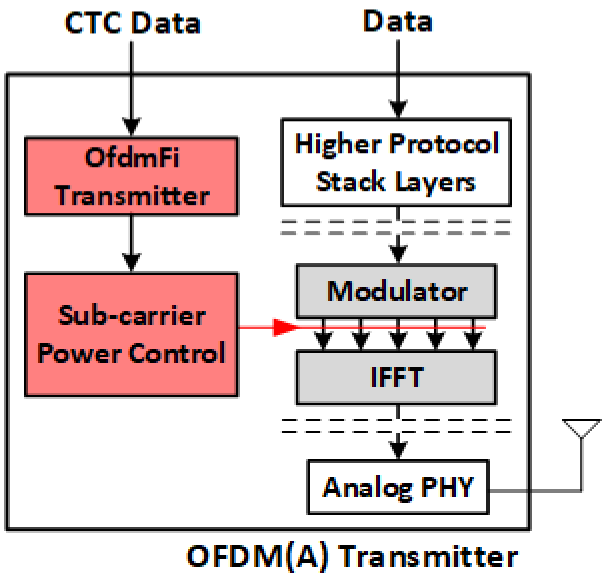
Punched Cards in LTE-U

- RB Blacklisting**:** a scheduler do not allocate blacklisted RBs
- **Problem**: *srsLTE* does not support RB blacklisting



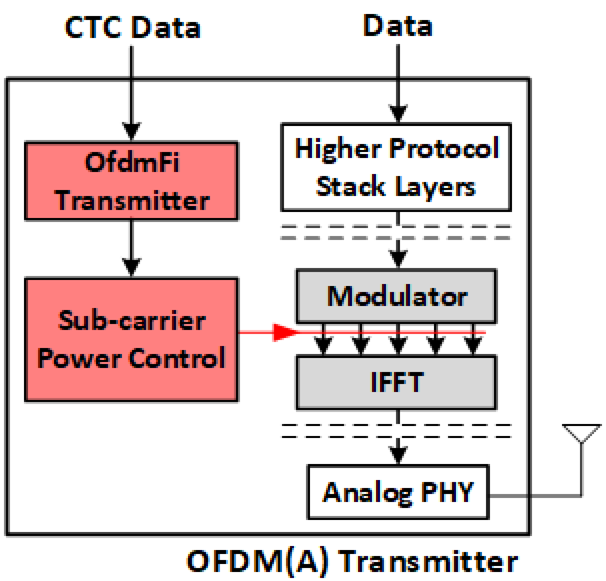
Punched Cards in LTE-U

- RB Blacklisting**:** a scheduler do not allocate blacklisted RBs
- Problem: *srsLTE* does not support RB blacklisting
- **Prototype Implementation**: Modulate power of sub-carriers

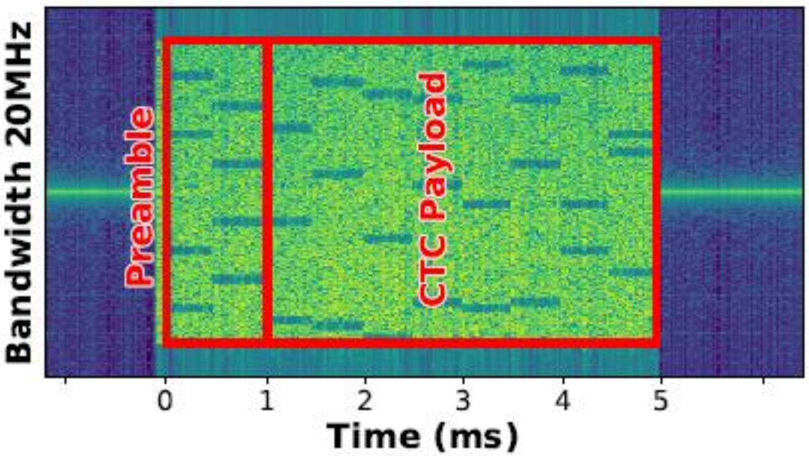


Punched Cards in LTE-U

- RB Blacklisting**:** a scheduler do not allocate blacklisted RBs
- Problem: *srsLTE* does not support RB blacklisting
- **Prototype Implementation**: Modulate power of sub-carriers

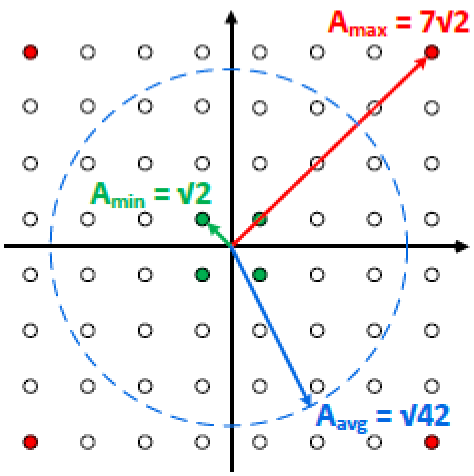


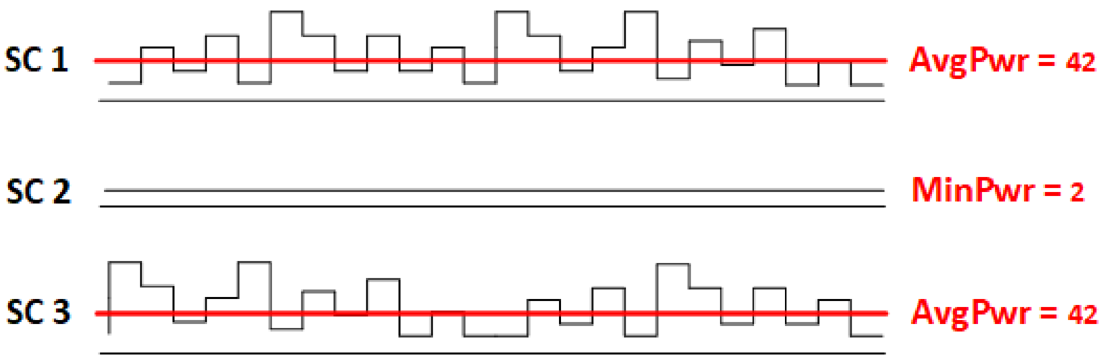
LTE-U -> WiFi Data Rate: 24kbps



Punched Cards in WiFi

- How to generate power pattern in WiFi?
- 64-QAM – different phase and **power** levels
- 1 LTE symbol equals 18 WiFi symbols in time -> power **averaging**

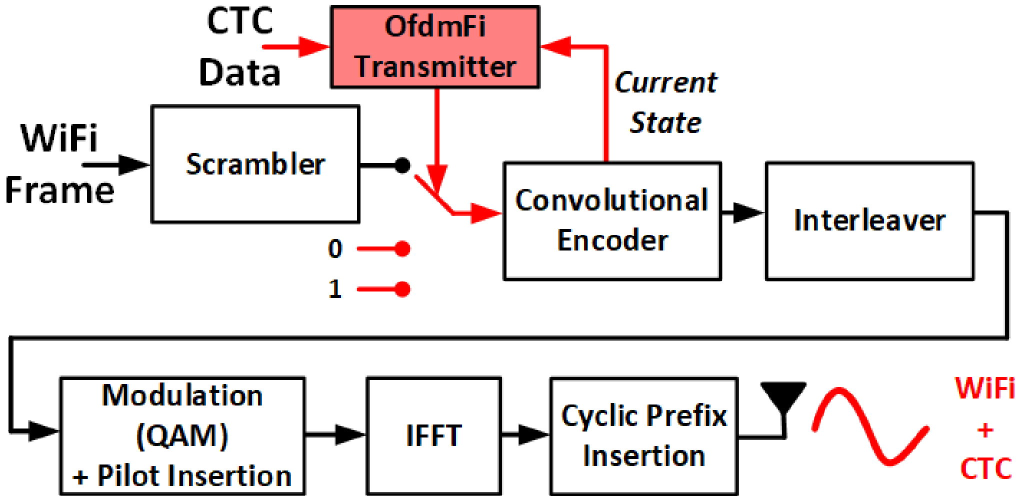




AvgPwr/MinPwr = 10log10(42/2) = 13.2 dB !!!

Punched Cards in WiFi

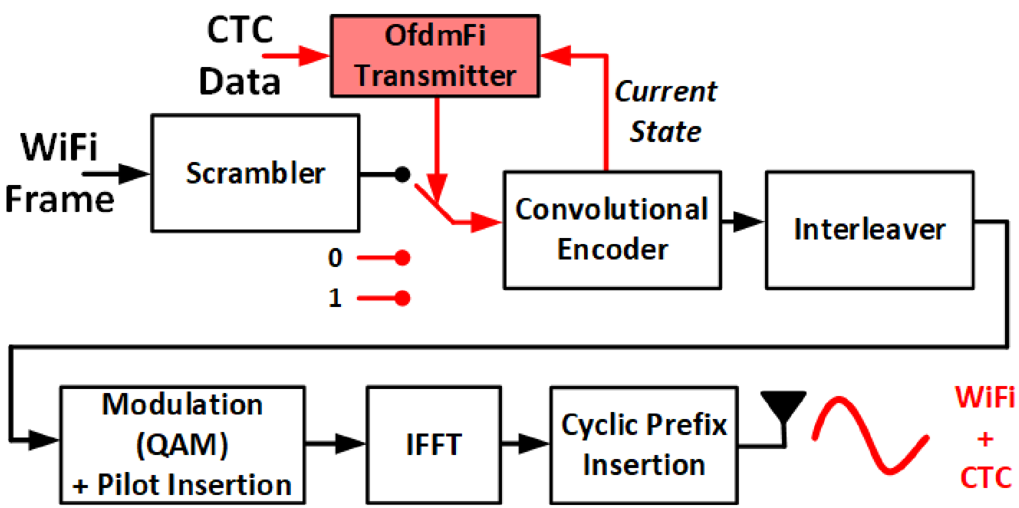
- Add only few bits in proper places, i.e. *pattern generating bit sequence to* force usage of min power constellation points at proper places in OFDM grid

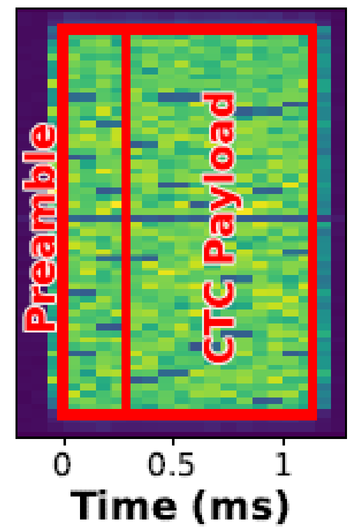


Punched Cards in WiFi

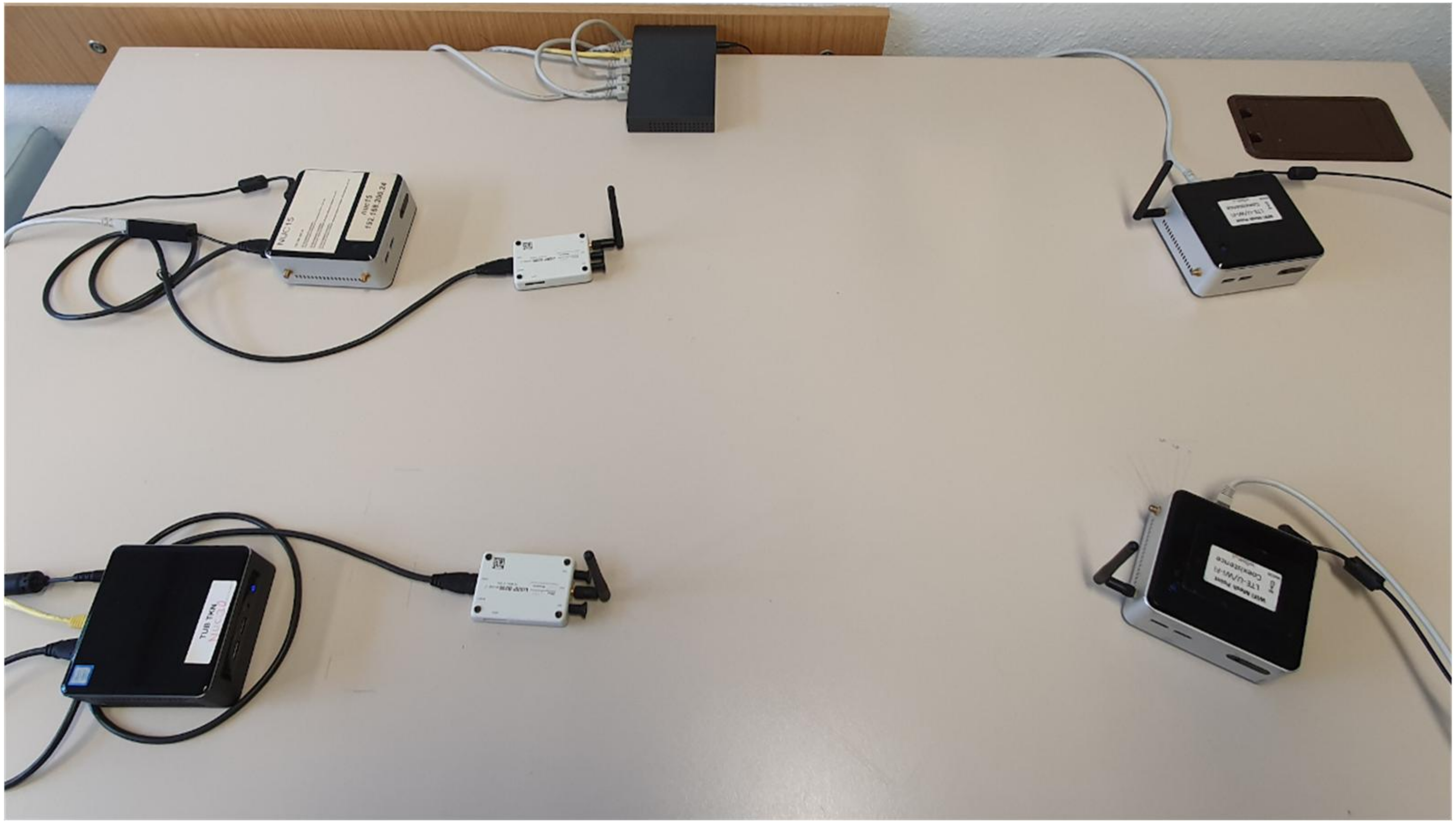
- Add only few bits in proper places, i.e. *pattern generating bit sequence to* force usage of min power constellation points at proper places in OFDM grid

WiFi-> LTE-U Data Rate: 84kbps

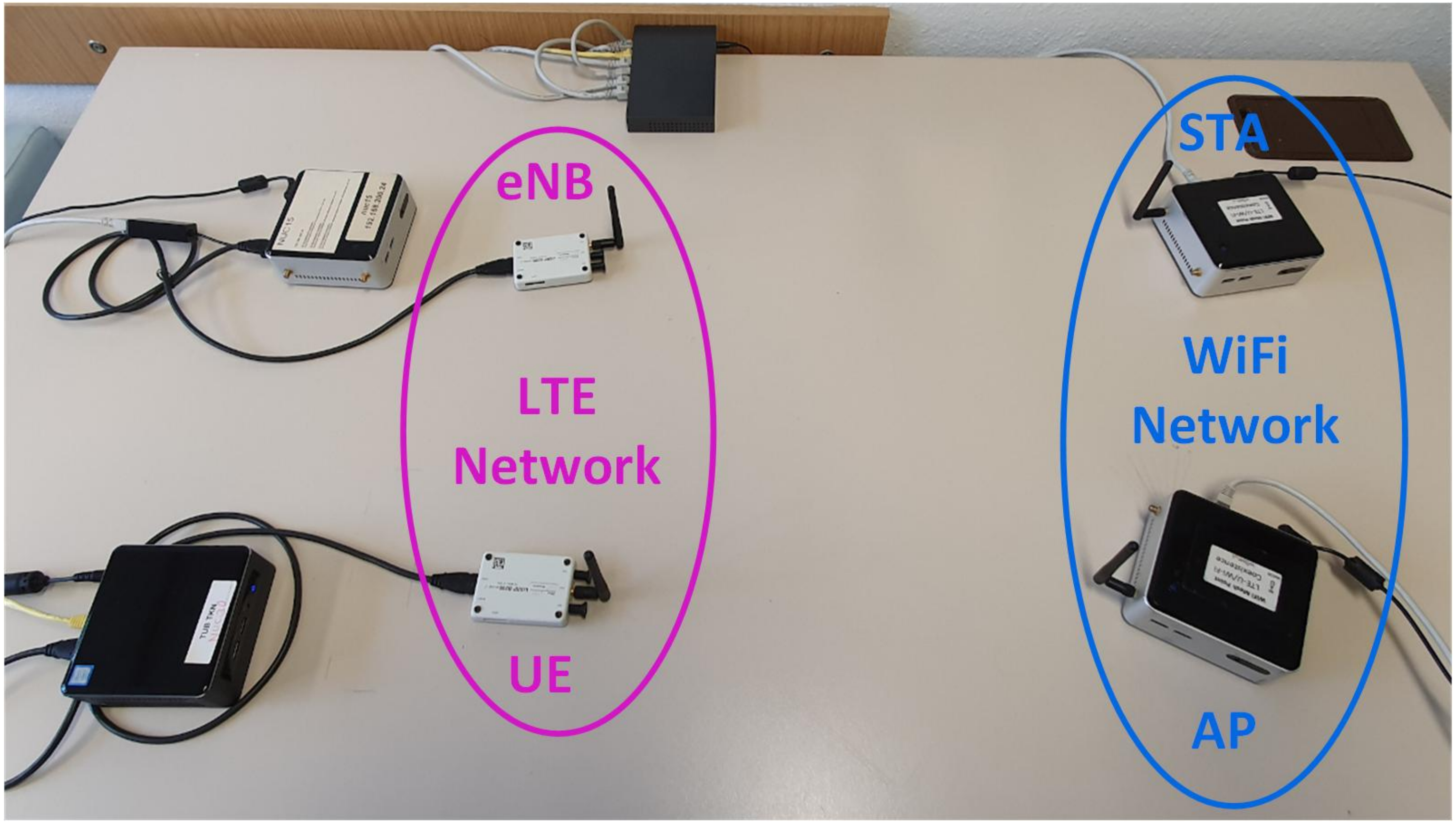




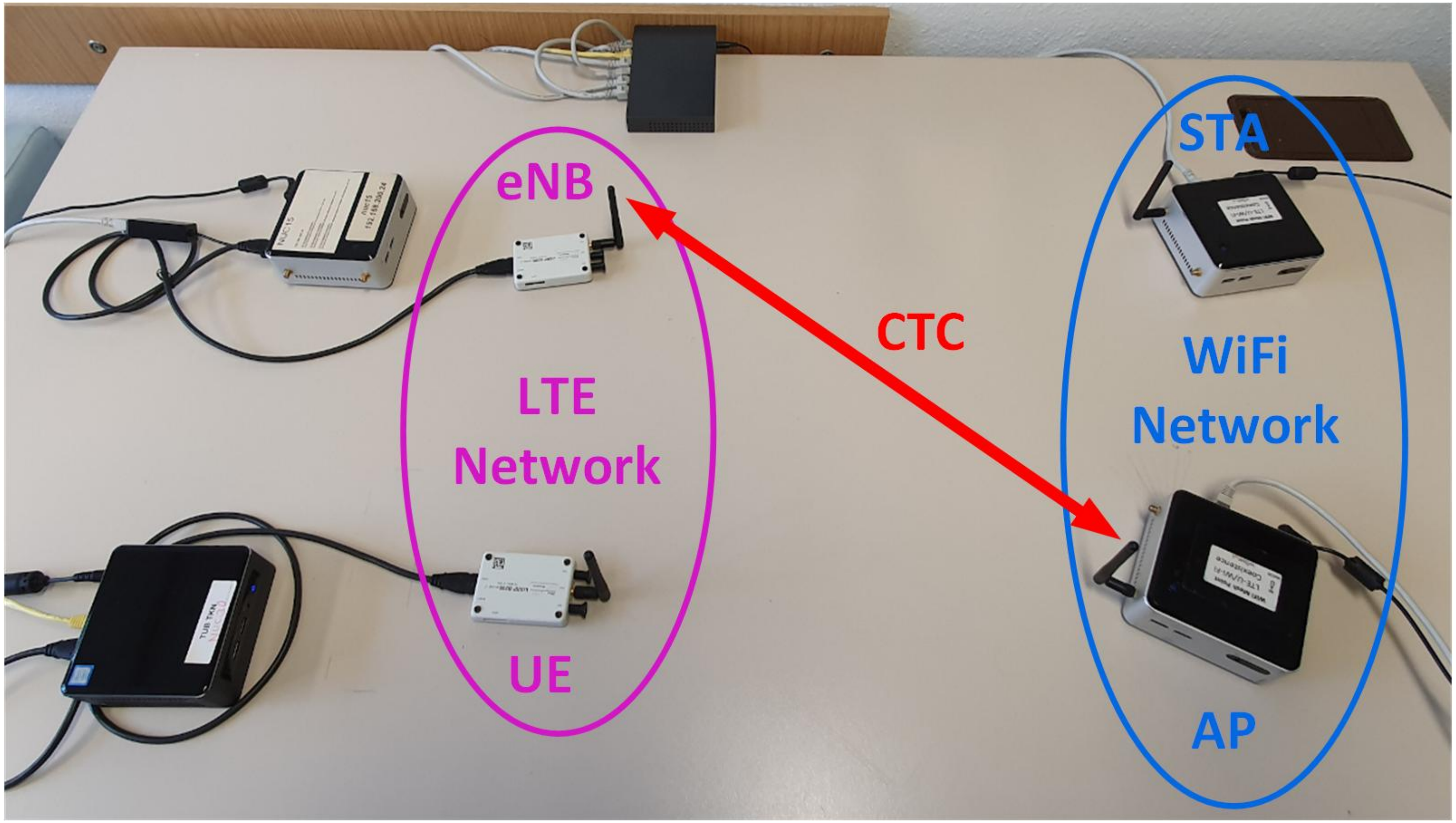
Demo Setup



Demo Setup

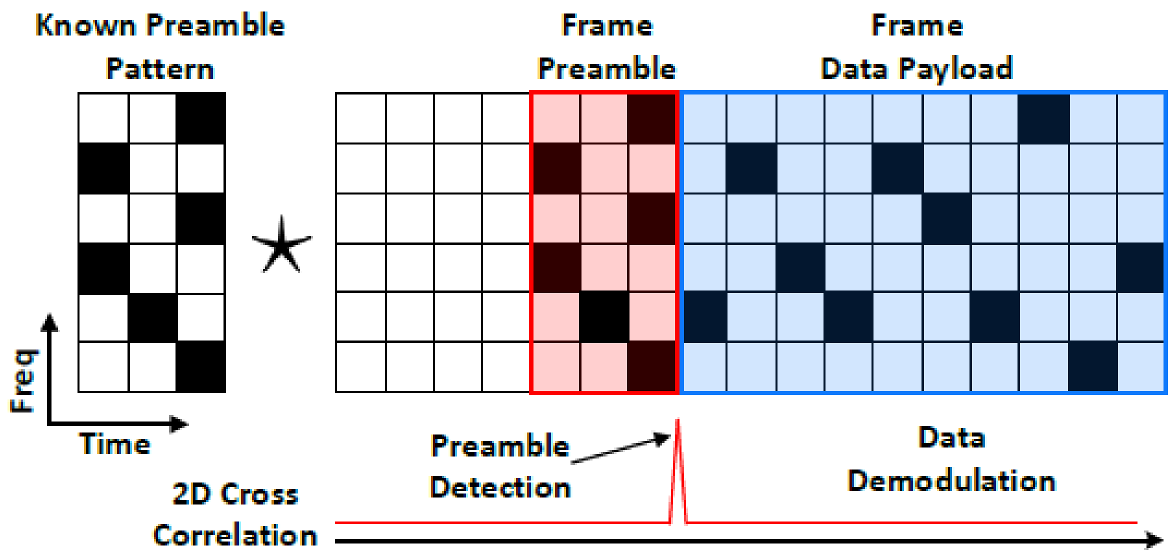


Part I: LTE-U -> WiFi

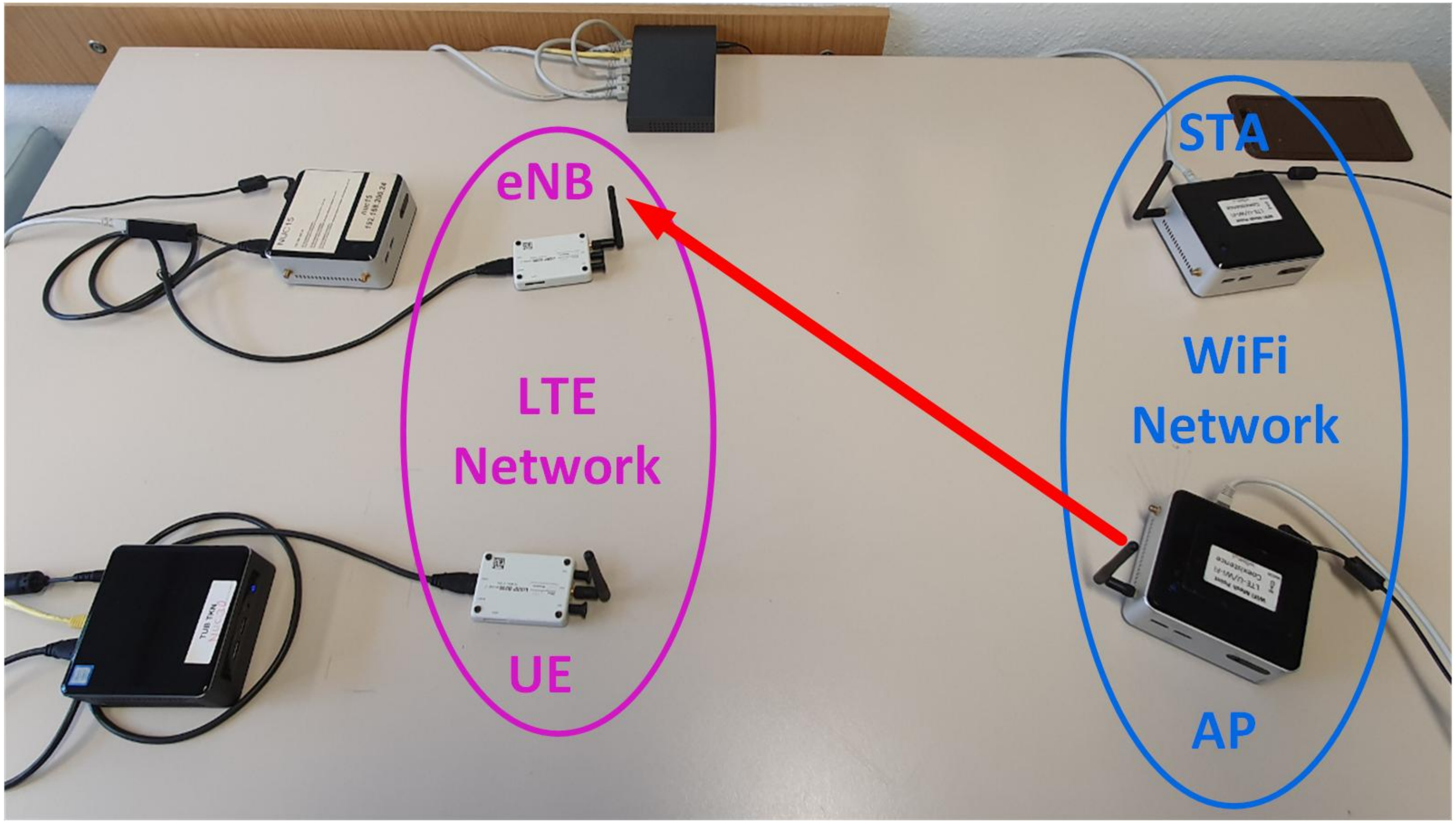


Part II: Partial CSI Measurements

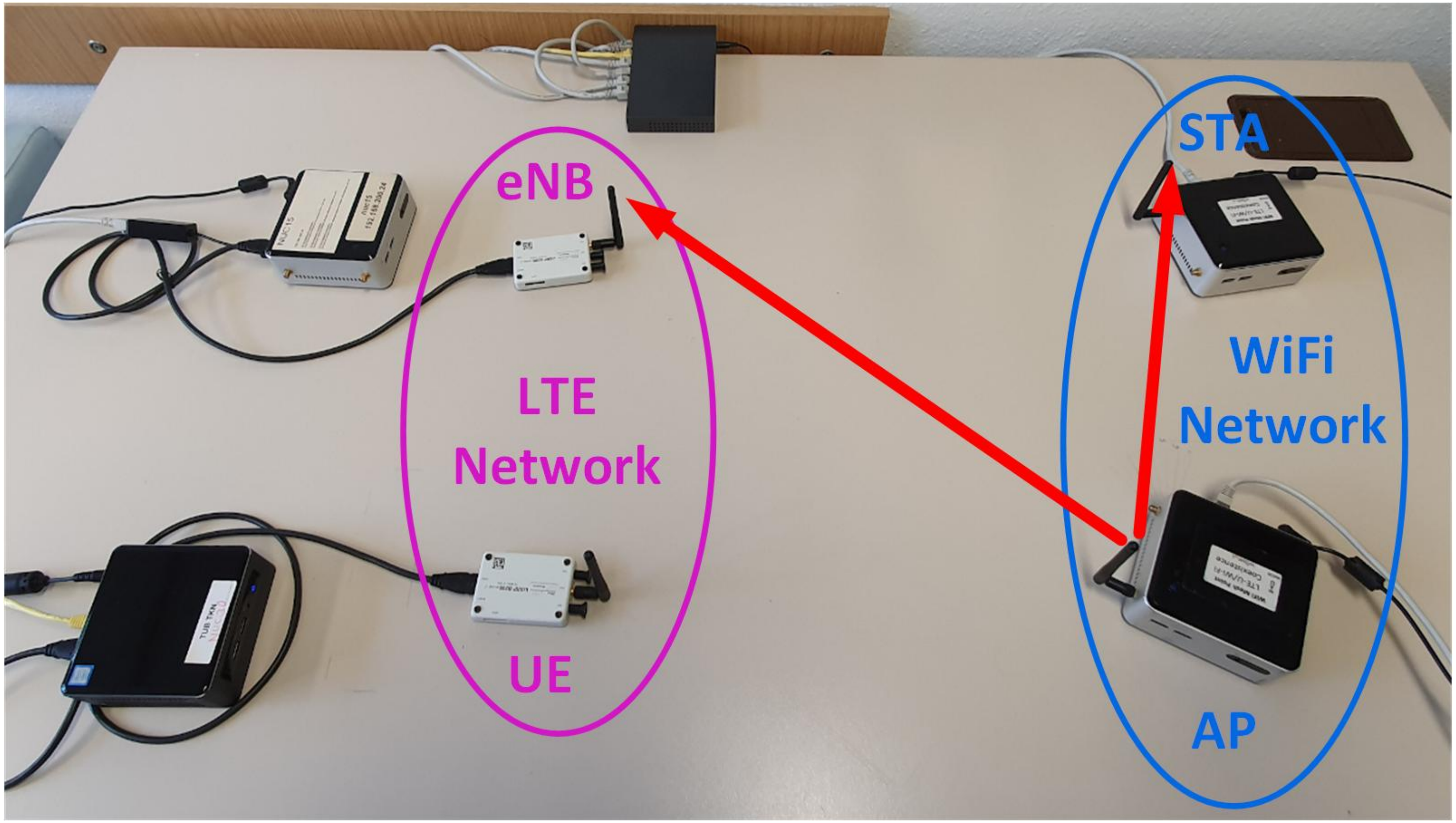
- Frame detection and synchronization based on 2D cross-correlation
- Channel estimation during preamble detection

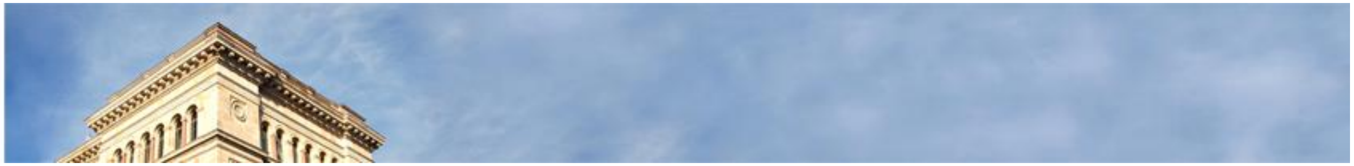


Part III: WiFi -> LTE-U



Part IV: Cross-technology Broadcast Channel





Conclusions

Thank you!

Contact: gawlowicz@tu-berlin.de