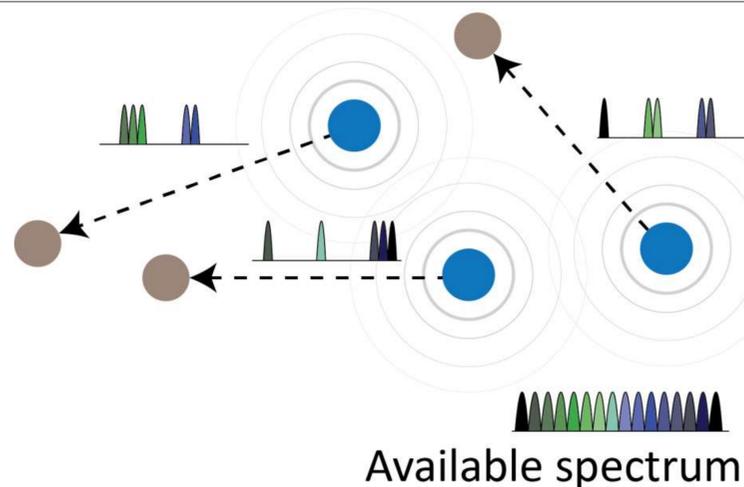


Motivation

- Enable efficient use of non-contiguous spectrum under changing interference/network conditions
- Designing a robust control channel between radios for exchange of information on subcarrier assignment, timing information and control data

Dynamic Spectrum Access using NC-OFDM

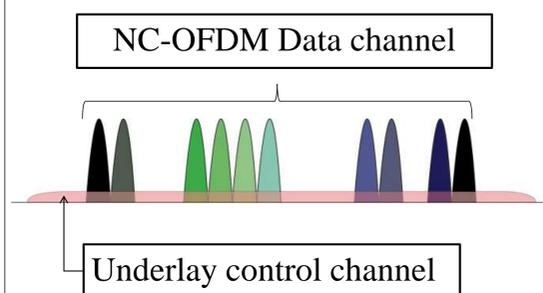
- Non-contiguous OFDM (NC-OFDM) provides reconfigurable access to non-contiguous spectrum in an ad-hoc environment with minimal overhead



Challenges

- Without a strict timing control across multiple links it is not possible to get the correct timing offset for OFDM processing
- Preamble based methods used in traditional OFDM are directly not applicable in an ad-hoc setup due to the asynchronous nature of different transmissions
- A control channel is required to exchange the subcarrier allocation

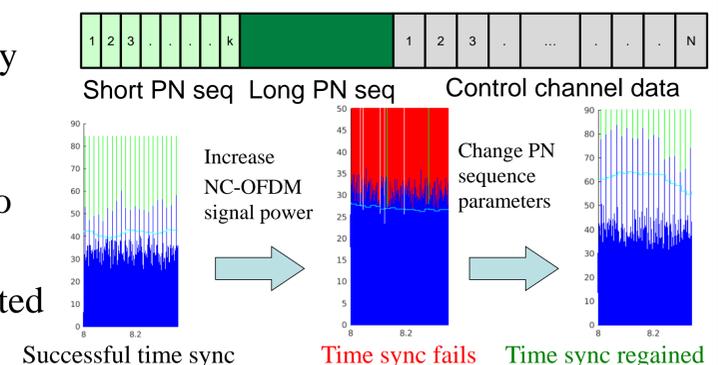
Underlay Control Channel



- Control channel operates at noise floor, therefore does not affect the other links
- CDMA used for sharing this underlay channel among multiple links
- Also used for timing and frequency synchronization of the NC-OFDM signal

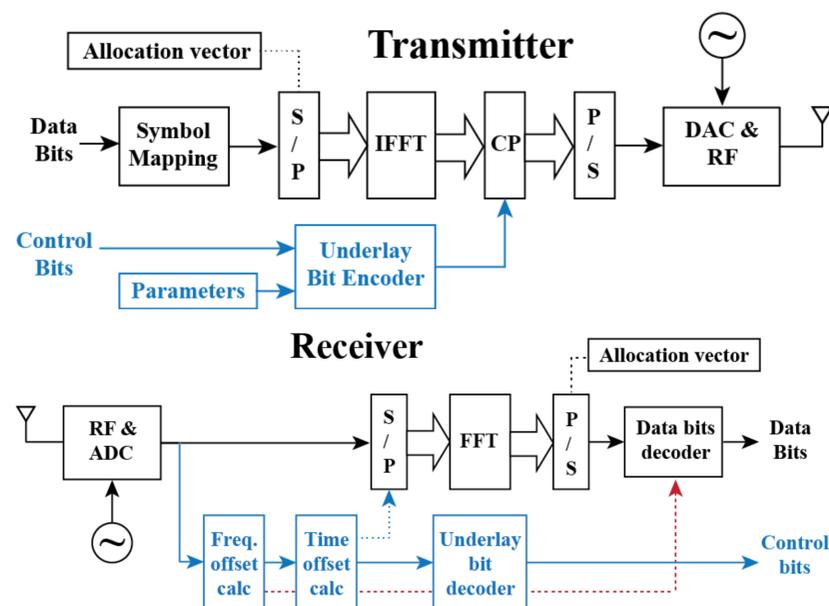
Two Stage Sync and Frequency Offset Calculation

- Use repeated short length PN sequence to calculate frequency offset
- After correcting the frequency offset, use long PN sequence to get correct timing offset
- These parameters can be adjusted based on network conditions



GNU Radio Implementation

- GNU Radio (an open source software radio platform) is used to implement NC-OFDM data and control channel
- GNU Radio is used with USRP N210 radios in the ORBIT testbed to perform experiments
- The source code for this NC-OFDM module for GNU Radio is available on <http://git.io/vRfFP>



Results and Future work

BER calculated for underlay control channel:

Length of PN seq for underlay data	BER	Primary Signal SNR	BER
4	$\sim 2.9 \times 10^{-1}$	3 dB	$< 10^{-3}$
12	$\sim 1.1 \times 10^{-1}$	6 dB	6.3×10^{-3}
24	$\sim 3.7 \times 10^{-2}$	7.7 dB	2.6×10^{-2}
36	$\sim 1.8 \times 10^{-2}$	9.2 dB	9.2×10^{-2}

NC-OFDM to underlay power ratio ≈ 10 dB

Data PN sequence length = 20

Future work:

- Conduct the experiment on bigger scale (up to 8 parallel NC-OFDM links) on ORBIT testbed
- Design a complete SDR-SDN architecture for dynamic spectrum access using NC-OFDM