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Dynamic Spectral Sensing and Resource Allocation in Optical-Wireless Networks

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WOCA
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Wireless and Optical Convergent Access

NovaGenesis

Outline

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- Radio Over Fiber
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- Experiments
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Introduction

- The ever growing number of always connected devices, the desire for high data rates and low power consumption, the demand for flexibility and cost reduction (CAPEX and OPEX), the spectrum scarcity, the quest for network resources optimization, etc, are constantly challenging access network design.
- There is a strong demand for convergent and integrative proposals, able to explore unthinkable synergies in access networks, covering not only the physical layer, but also the other network layers.
- Among various research areas, two of them have been particularly successful in the last years: Radio over Fiber (RoF) and Cognitive Radio (CR).
- They make possible the emergence what could be called as a Cognitive Radio over Fiber Network (CRoFN).

Introduction

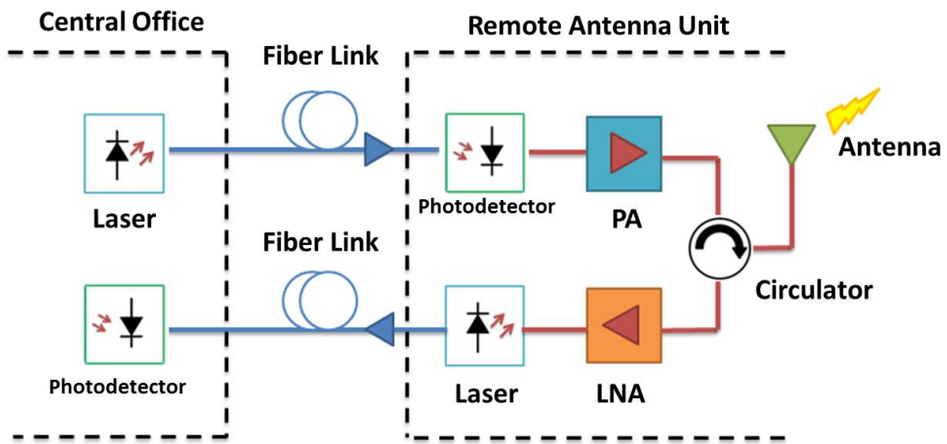
- We propose the concept and reports the implementation of an innovative, adaptive, and Cognitive Optical-Wireless Network.
- It is able to perform Spectral Sensing (SS) and Dynamic Resource Allocation (DRA) in order to dynamically adapt the frequency band and/or antenna radiation pattern as a function of the radio environment situation.

Cognitive Radio

- A radio:
  - That is aimed at better frequency spectrum usage.
  - Capable to self-manage, self-optimize, and self-configure.
  - That is self-aware, environment-aware, and regulation-aware.
  - That can estimate the spectrum occupancy through the use of an SS technique, therefore determining opportunities in a frequency range of interest, based on the occupation or not of the channels by licensed users (also known as primary users).
  - That can learn from the radio environment and decide whether or not to transmit at a certain frequency white spaces.
  - That considers its internal capabilities (self-awareness), as well as regulations and etiquettes.

Radio over Fiber

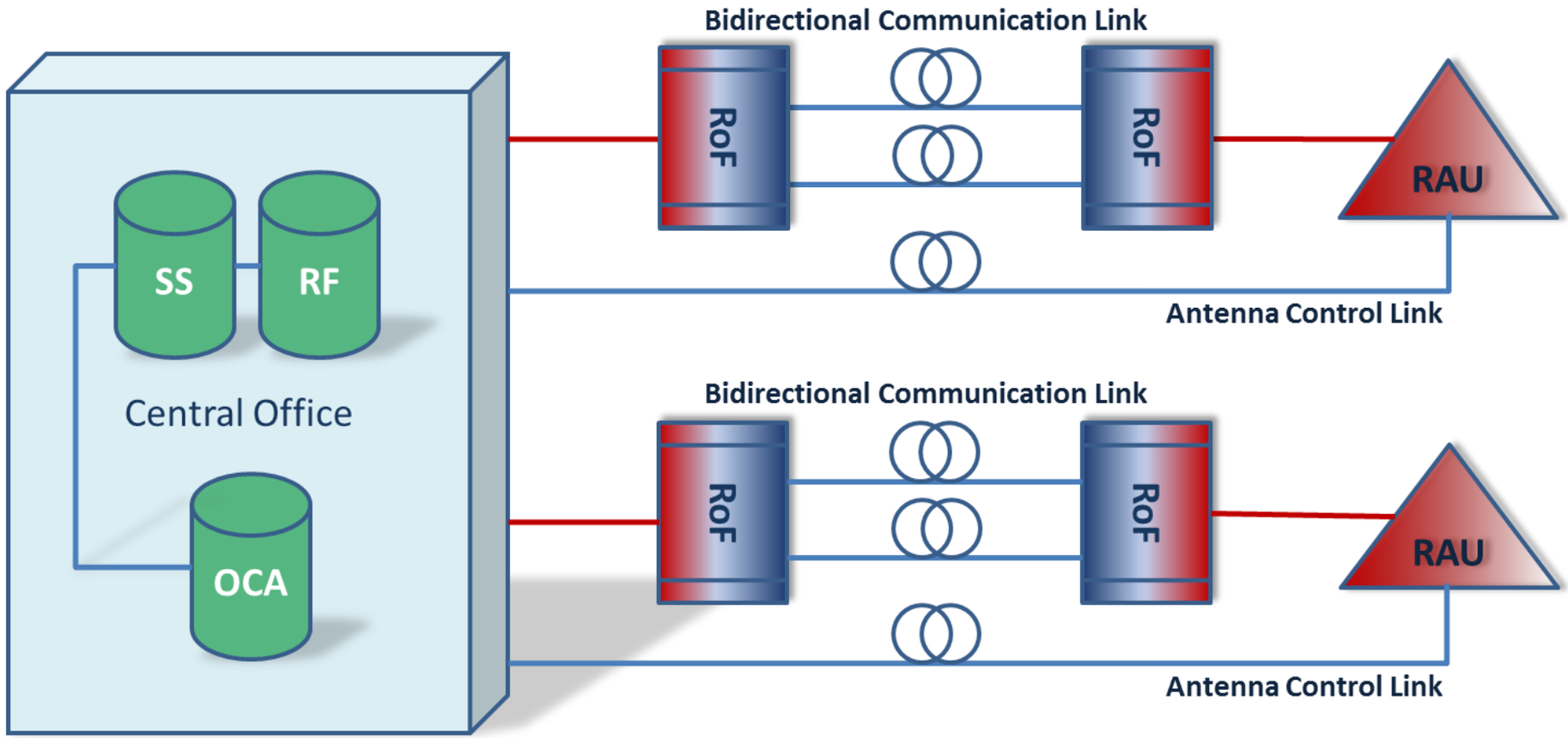
- The idea involves the transmission of RF signals via an optical fiber between a Central Office (CO) and a given number of Remote Antenna Units (RAUs).
- The final users are commonly considered as mobile devices connected to RAUs through a wireless link.



- RoF leads to a significant simplification and cost reduction of base stations since all routing, switching, and processing are performed at the CO.

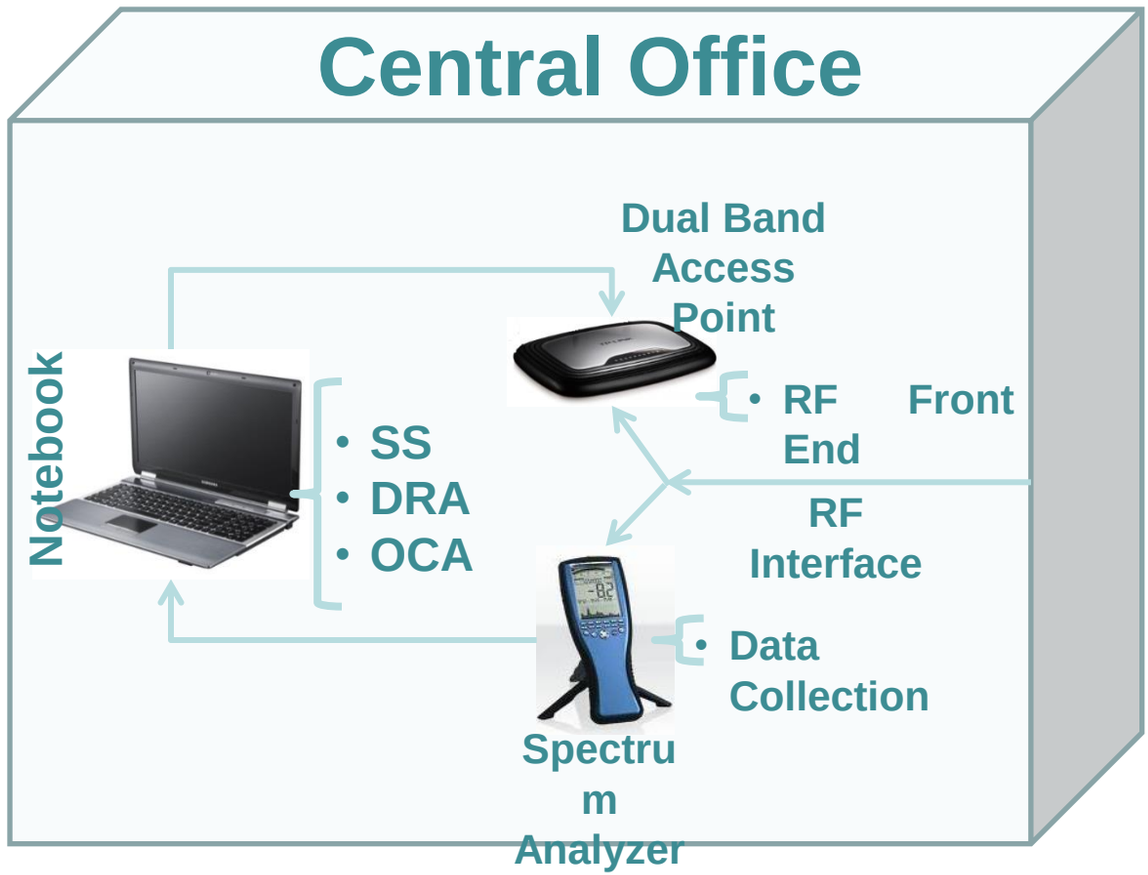
The Proposed Cognitive Radio over Fiber System

- Complete System Overview
  - Optically Controlled Antenna (OCA), Spectrum Sensing (SS), Dynamic Resource Allocation (DRA), and RF modules.



The Proposed Cognitive Radio over Fiber System

- Central Office Overview

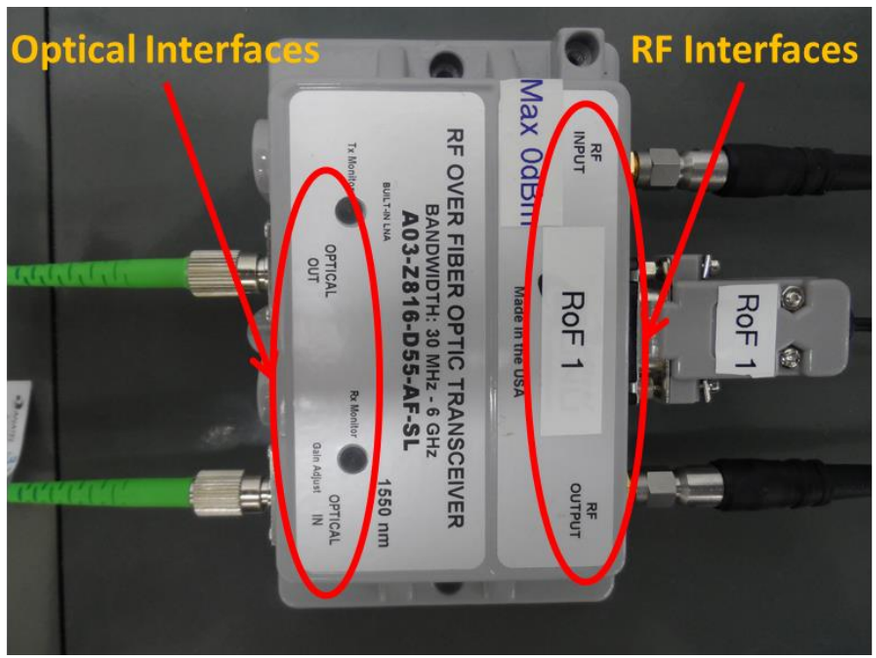


The Proposed Cognitive Radio over Fiber System

- Functioning overview:
  - The spectrum is sensed by RAU and the raw samples of the spectrum environment are received by the CO through the RoF link.
  - The information contained on the spectrum samples are processed using an algorithm based on the energy detection technique, and the best channel and/or band to transmit is chosen.
  - Finally, the DRA is performed setting the RF parameters (number of the selected channel and the antenna operation band: 2.4GHz or 5GHz).
  - The system operates in the new channel until the next estimation is performed.

The Proposed Cognitive Radio over Fiber System

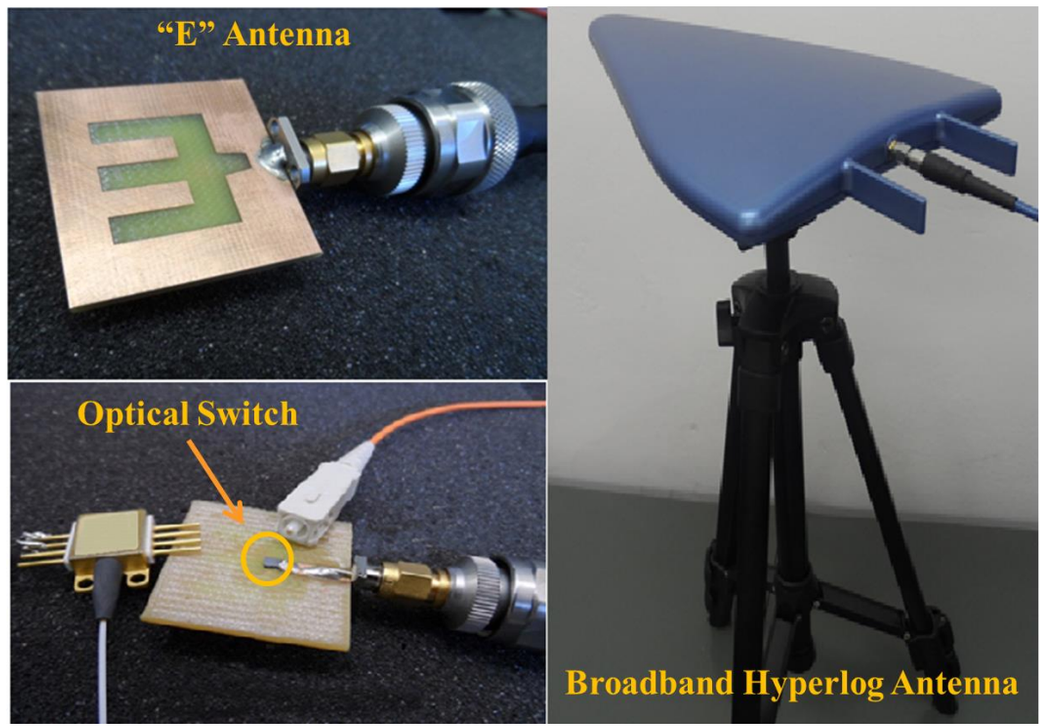
- The input RF signal is composed by uplink data and raw sensed spectrum data, which is received by CO through a RF interface.



- The uplink data is sent to the dual band Access Point (AP) and the sensed spectrum data is forwarded to a portable Spectrum Analyzer to generate sensed spectrum information.

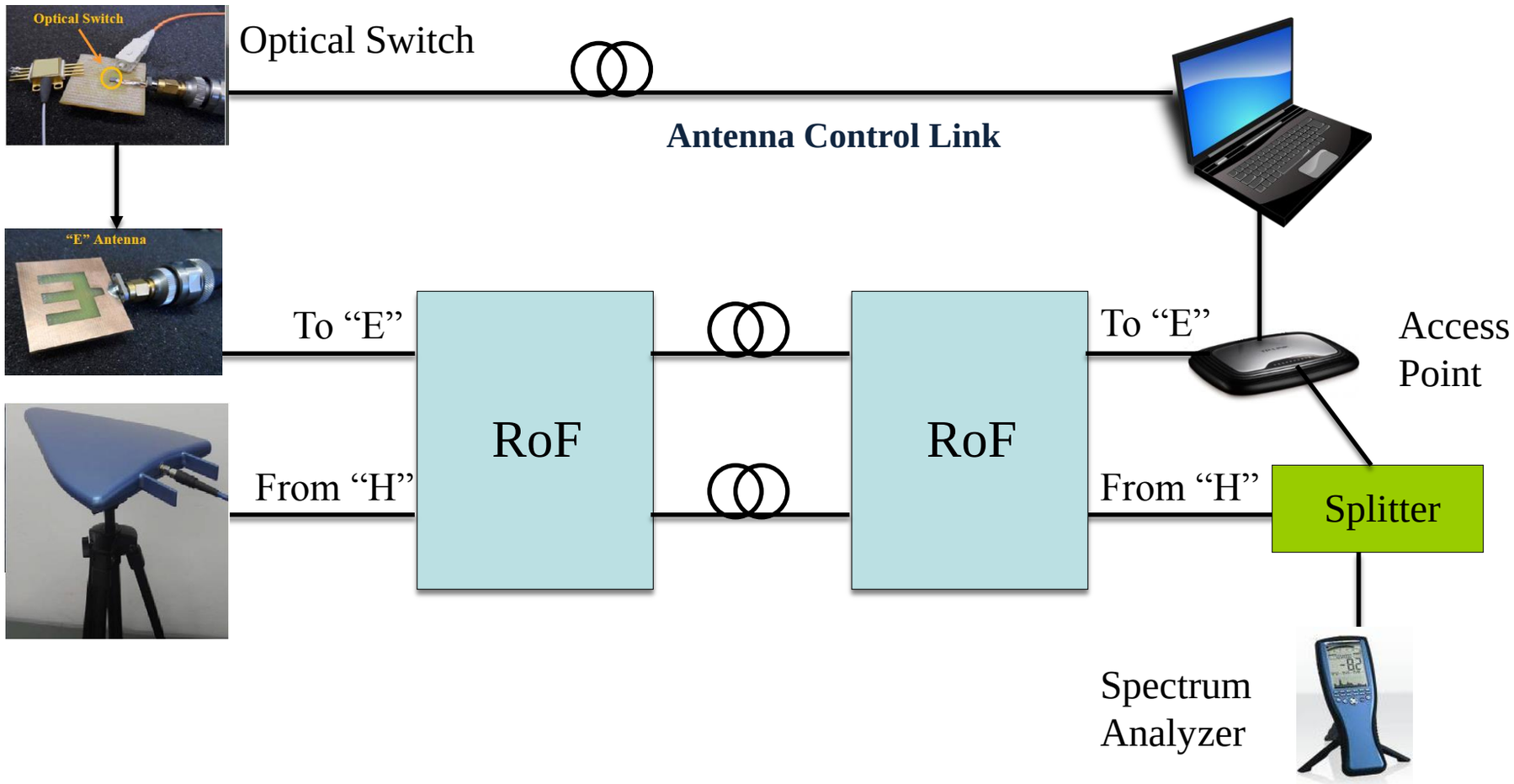
The Proposed Cognitive Radio over Fiber System

- The RAU consists of two antennas:
  - A broadband *hyperlog* commercial antenna to do the spectrum sensing (from 680MHz up to 10GHz)
  - Dual band optically reconfigurable slot "E" antenna to transmit and receive data (two different bands (2.4GHz and 5GHz) depending on the CO decision).



Experiments

- Setup

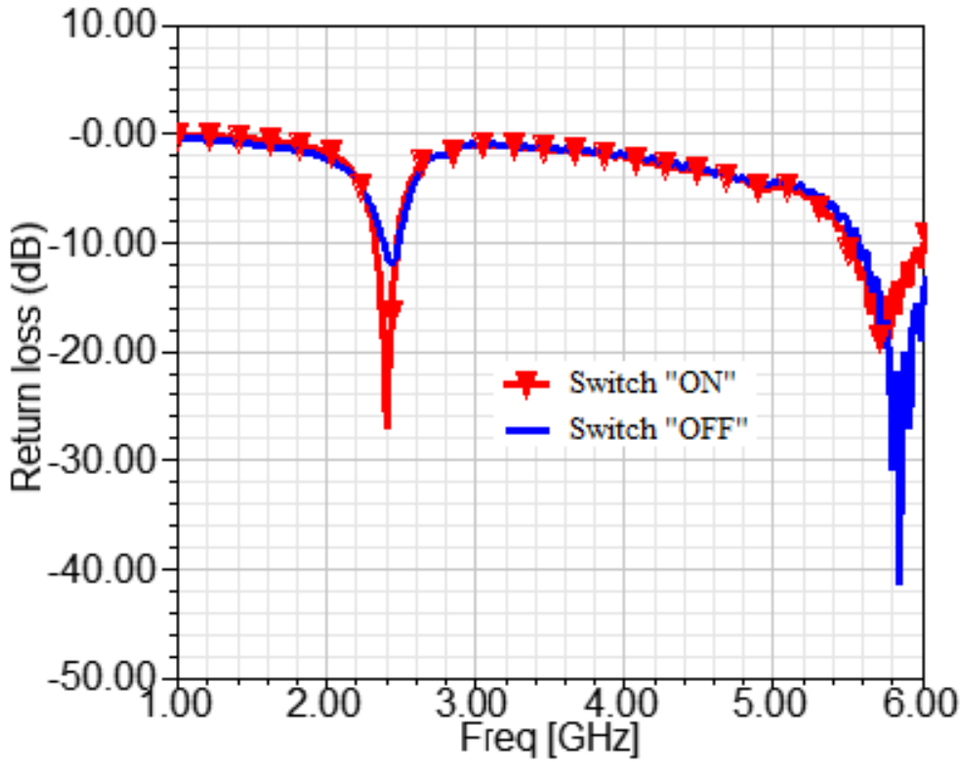


Experiments

- Setup
  - The optical link has 2 monomode fibers with 325 meters each.
  - The CO is located at WOCA Laboratory and the RAU is located at the second floor of Building V, with LOS to the downtown and neighborhood.

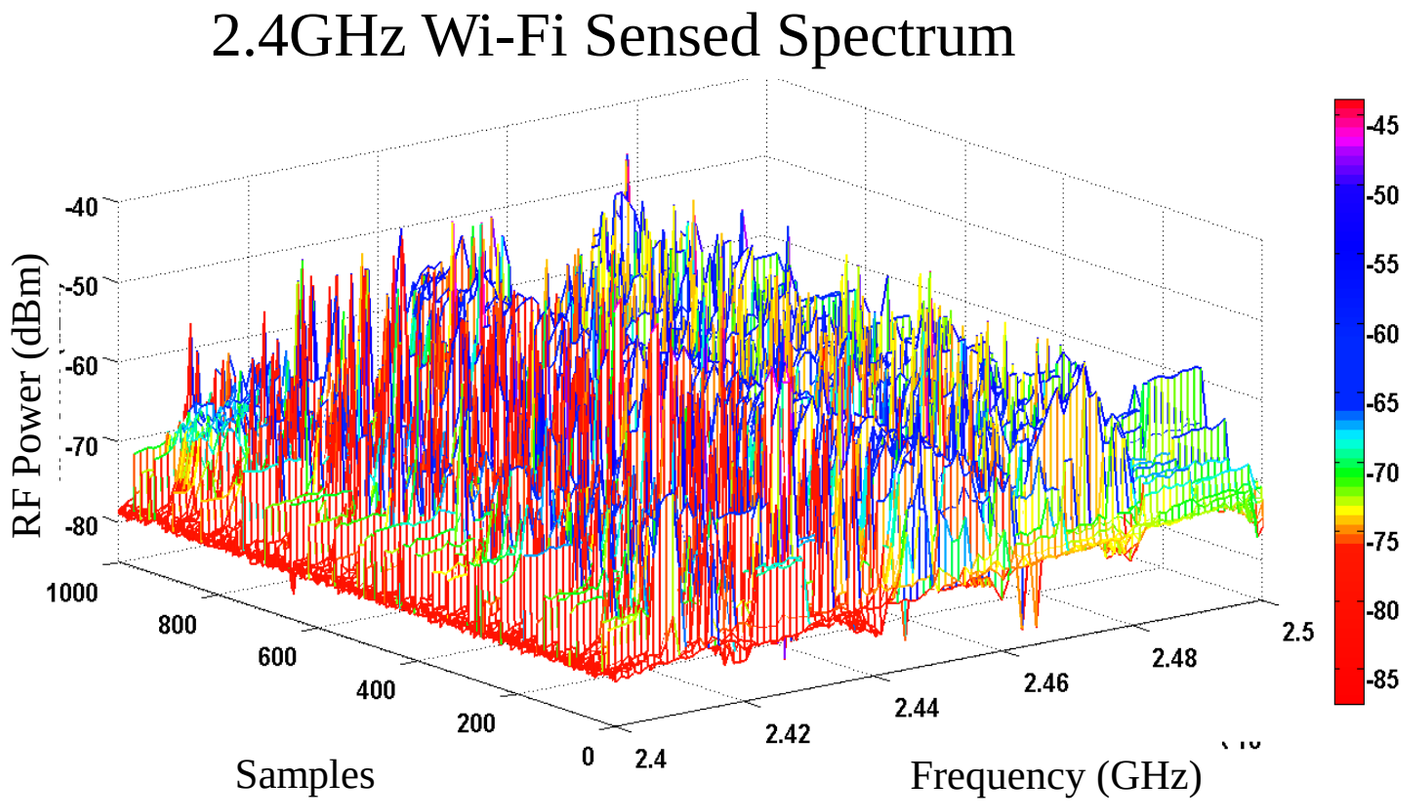
Experiments

- Optical Switching at the “E” Antenna
  - Testing operation at 5GHz band (when the optical switch is in mode "on“) and 2,4GHz (when the optical switch is in mode "off“).



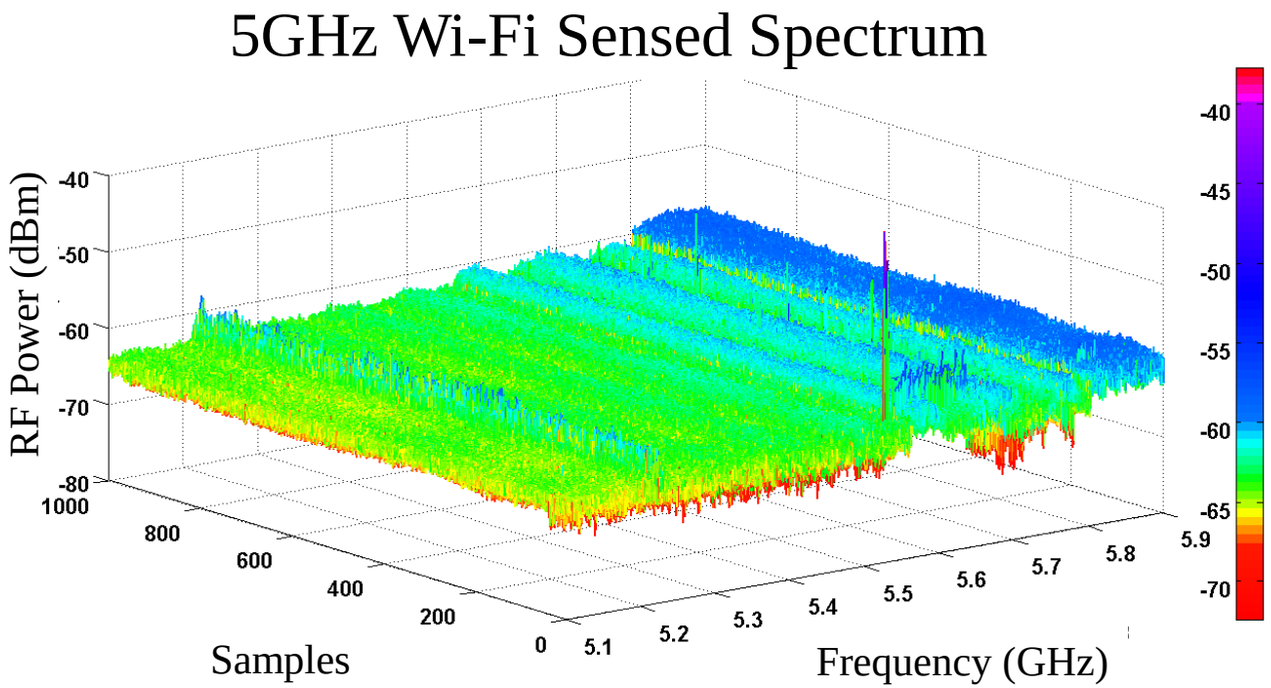
Experiments

- Sensing at 2.4 GHz
  - The frequency range sensed: 2400MHz to 2500MHz, with dS=1MHz.
  - The channel bandwidth of 22MHz.



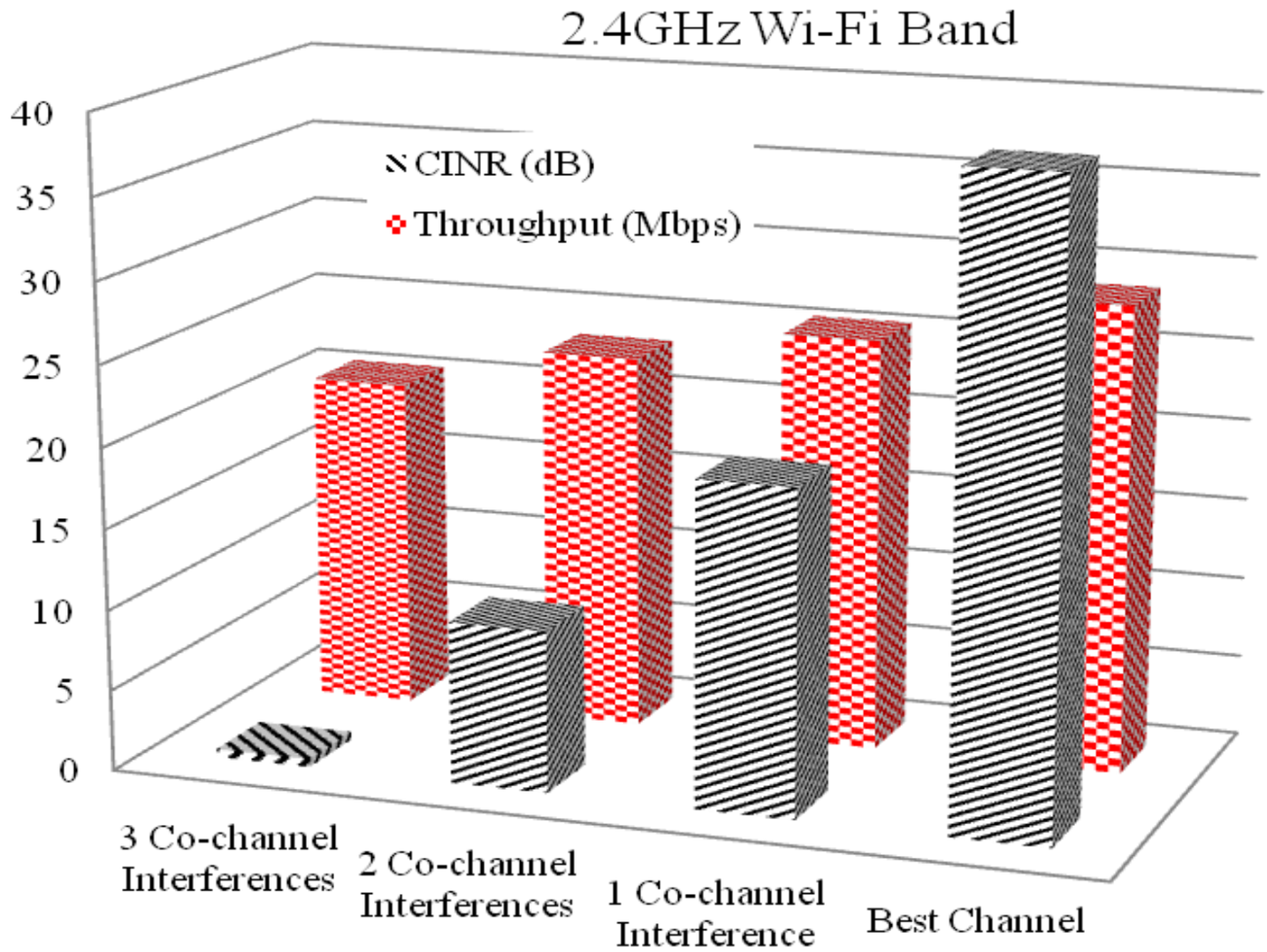
Experiments

- Sensing at 5 GHz
  - The frequency range sensed: 5100MHz to 5900MHz, with dS=1MHz.
  - The channel bandwidth of 22MHz.



Experiments

- Co-channel interference and Throughput in Wi-Fi networks



CINR - Carrier to Interference plus Noise Ratio

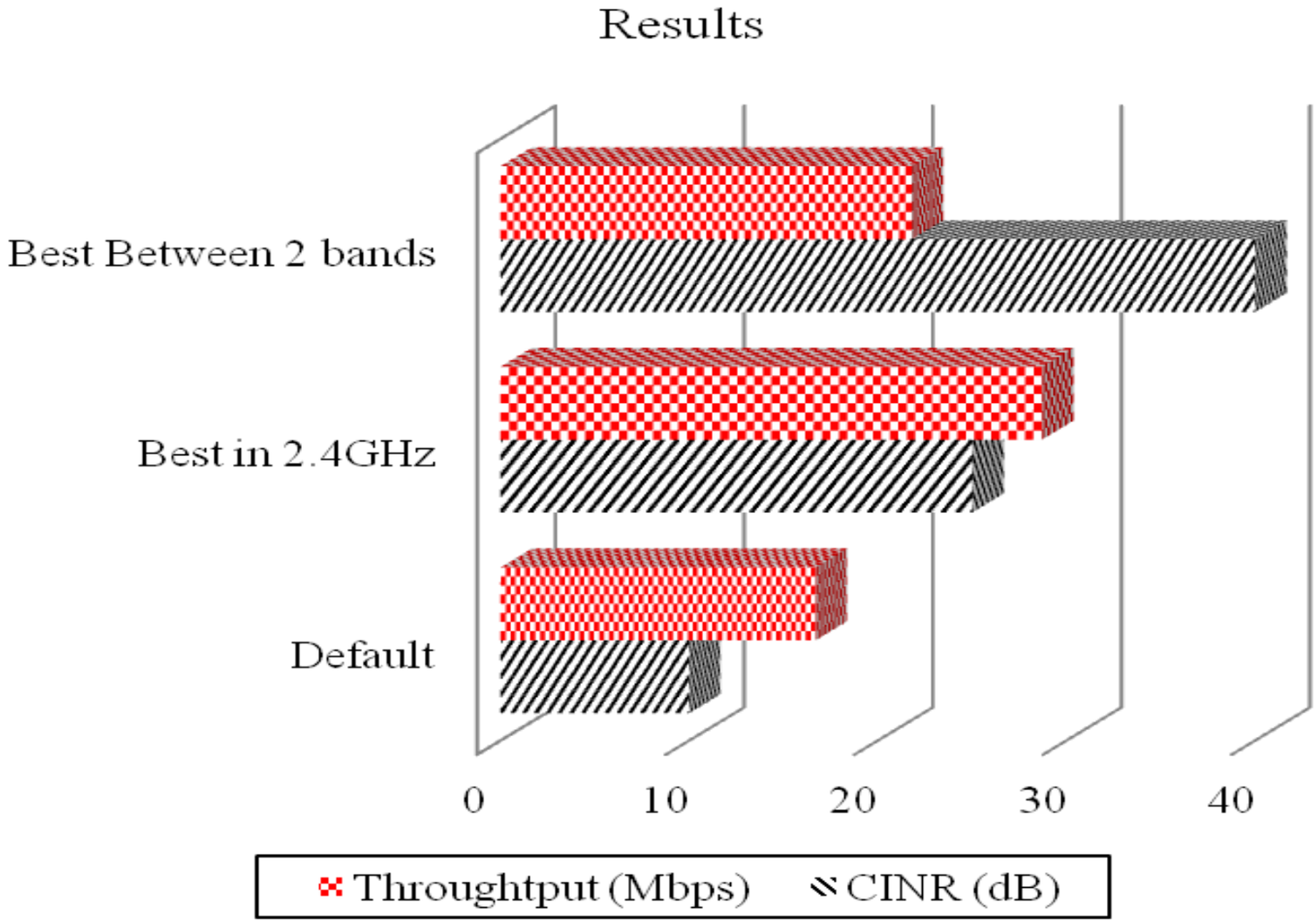
Experiments

- To improve the system performance, the proposed algorithm was tested and the results was compared in the following situations:

1. Transmission on channel 6 (2.437GHz) which is considered the default channel when an AP starts.
2. The best channel at the 2.4GHz band determined by the proposed algorithm, channel 11 specific in this case (2.462GHz).
3. The best transmission channel between the 2.4GHz and 5.8GHz bands determined by the proposed algorithm.

Experiments

- Co-channel interference and Throughput in Wi-Fi networks using the proposed algorithm



Conclusions

- We designed, implemented, and successfully demonstrated the benefits of our CRoF network.
- The results shown that the network performance in terms of CINR and throughput can be improved by using SS and spectral DRA.
- Future works include:
  - The use of optically controlled antenna arrays.
  - Implementation of all CO functionalities in FPGA.
  - Testing at two or more geographic regions.
  - The integration with NovaGenesis “Future Internet” architecture project.

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Thank you!

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