Cognitive Small Cell Deployment for Next Generation Wireless Systems

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Abstract

INTRODUCTION

- Current status of the Cognitive Radio – state of the art includes IEEE standards and LSA. However, does these business models portrays Mitola's vision?
- Spectrum scarcity in the 5G networks, Cognitive Small Cell (CSC) is emerging as a new use case to cognitive radio. Cognitive radio has found its niche in the 5G. The requirements for the 5G have been laid: (i) the areal capacity in bits/m^2 must roughly increase by ($\geq 1000\times$) compare to 4G, (ii) low latency ≈ 1 ms and, (iii) energy and cost efficient small cells [1]. For the demand stated, ultra-densification and spectrum extension can contribute a large portion to the required areal capacity. Cognitive Small Cells can be seen as new use case to the cognitive radio. According to which the deployment leads to densification, and indoor access between the Here we try to motivate the benefits of the deploying Cognitive Small Cell (CSC).
- Deployment Scenario for CSC
  - Do we really have spectrum scarcity or its inefficient use is making it scare. This debate will depict the future of next generation wireless systems. Spectrum usage for the CSC (< 6 Hz and > 6 Hz). Beyond 6 GHz, penetration is reduced, thus to sustain coverage CSC has to operated at higher power. This issue is resolved for spectrum below 6 GHz,
  - Different Entities: Cognitive Relay, Indoor Devices
  - Indoor and outdoor antenna
  - Access link considered for shared access and wireless Fronthaul link as licensed shared access.
  - The cost of connecting the base station and the small cell is incredibly high, So, it is major concern for the mobile operators.
- Cognitive Small Cell (CSC) as interweave system
  - Frame Structure

  - Constraints and performance parameters
  - Performance analysis – Sensing throughput tradeoff
  - CSC deployed for indoor scenarios favours the performance of the CSC. As indoor scenarios are prone to high path loss exponent between the CSC and the primary systems – demonstrate based on the numerical analysis (If possible!)
  - Multiple CSC (Nice to have!)
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- How software defined architecture could harness the future of cognitive radio?
- Research Challenges
  - Frequency translation capability – Wireless backhaul link works on a different frequency compared to the frequency of channels serving indoor devices.
  - Considering massive MIMO at the CR to improve energy efficiency and reduce co-tier .

Since the invention of a smart phone in 2007, the mobile data traffic rate has proliferated tremendously. As depicted by the market analysts [2], this trend is likely to persist in the future. Given the state of the technologies in the existent standards, it is not possible to catch-up these demands. Considering this situation, the requirements for the next generation wireless systems are conceptualized. Some of these include: (i) the areal capacity in bits/m^2 must roughly increase by ($\geq 1000\times$) compare to 4G, (ii) low latency $\approx 1\,$ms and, (iii) energy and cost efficient deployment [1].

Recently, Small Cell (SC) deployment has evolved as a potential solution for coverage and capacity enhancements in a network. An SC corresponds to a low power station that ranges from $10\,$m to $100\,$m, comparable to size of a femtocell. SC is particularly deployed in a indoor or outdoor environments, these include enterprise, shopping complex and residential [3]. Thus, ultra-densification via SCs is envisaged as an absolute paramount for 5G systems. Given the deployment scalability, it is not possible for the mobile vendors to sustain the cost of the backhaul and energy consumed by these SCs. Due to limited spectrum available, even with ultra-desification, it is difficult to accomplish the capacity demands. Certainly, an extension in the available spectrum is necessary. The potential contenders for the spectrum extension constitute: (i) $\geq 6\,$Hz, it largely entails the millimeter Wave (mmW) technology and (ii) $\leq 6\,$GHz, it necessitate secondary access to the spectrum below $6\,$Hz.

In order to fulfill the spectrum demand, we propose a Cognitive Small Cell (CSC) deployment

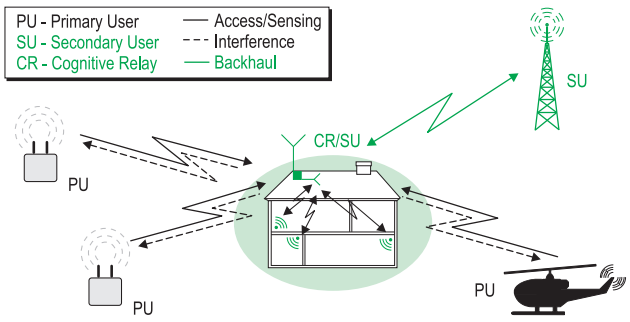

Fig. 1. A scenario demonstrating the cognitive small cell deployment.

Deployment Scenario

In this section, we illustrate the deployment scenario for CSC. Explain the use case

- From the mobile operators perspective, Backhaul supply mount to capital expenditure (CAPEX) is a major limitation for ultra-densification. Fronthaul: A highly directive link between the CR and BS, it capable to bring the down CAPEX.
- The CR possess the cell ID and provides provides the signalling to the IDs.
- Understanding the traffic demand, it is important to not only just deploy cells, most important is to deploy small cells where demand exists. Indoor scenarios and hot spots are typical use cases.
- If the CAPEX and OPEX goes down, then the mobile operators are willing to spend money

CSC as Interweave System

CSC as Underlay System

Research Challenges

- Background noise
- Perfect knowledge of the noise power
- In order to accomplish low latency with the CSC, a frequency translation represents a viable solution.
- OPEX: Who will bear the operation expenditure (OPEX): premises owner or mobile operator.

References

[1] J. Andrews *et al.*, "What Will 5G Be?" *IEEE Journal on Selected Areas in Communications*, vol. 32, no. 6, pp. 1065–1082, June 2014.

[2] CISCO, "Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013–2018," *White Paper*, February 2014.

[3] "Small cells – big ideas: How small cells left home – and where they're going next," *White Paper, Small Cell Forum*, February 2014.