Multiconnectivity Based Joint Scheduling of URLLC and eMBB Traffic in 5G Networks

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April 18, 2022

Scenario 1: Football Stadium

- There are 100,000 eMBB users watching live
- There are 10 URLLC UAVs capturing footages
- Downlink transmission accounts for eMBB users' streaming and URLLC UAVs' controlling
- Uplink transmission (whose bandwidth is separated from that of downlink) is responsible for uploading UAVs' footages to server for streaming and navigation processing

Scenario 2: Neighborhood

- There are 2,000 households (up to 8,000 eMBB users)
- During work hours and at night, there are only a few URLLC autonomous cars moving around
- Downlink transmission accounts for eMBB users' requests and URLLC autonomous cars' controlling
- Uplink transmission (whose bandwidth is separated from that of downlink) is responsible for uploading cars' data (e.g. camera images, GPS, sensors data, etc.) to server for navigation processing

Scenario 3: Hotel

- There are 10 rooms (up to 40 eMBB users) in a floor
- There are 2 URLLC service robots delivering food and miscellaneous items
- Downlink transmission accounts for eMBB users' requests and URLLC service robots' controlling
- Uplink transmission (whose bandwidth is separated from that of downlink) is responsible for uploading robots' data (i.e. camera images, sensors data, etc.) to server for navigation processing

Problem Statement

- Downlink transmission is considered
- Problems:
  - One base station cannot serve that many eMBB users due to bandwidth limitation
  - eMBB users located at base stations' coverage edges suffer from poor capacity due to path loss, channel fading, and shadowing (especially if mmWave is employed)
- Solution: Multiconnectivity
- Motivation:
- Pros and Cons:
  - (+) Resolves the aforementioned issues
  - (-) Interference among base stations needs to be addressed
  - (-) Requires user equipments to support MIMO (Multiple-Input and Multiple-Output)

Interference Problem of Multiconnectivity

- Solution: W-CDMA (Wideband Code Division Multiple Access)
- Motivation: LEACH (Low-Energy Adaptive Clustering Hierarchy)
- Pros and Cons:
  - (+) Preserves the full spectral resource
  - (+) Fits with the often small number of base stations
  - (+) Simplifies the mathematical model of the system
  - (-) Introduces redundant bits
  - (-) Requires user equipments to support multiple CDMA
- However, the number of redundant bits required is the number of orthogonal basis to assign to each base station i.e. the number of base stations, which is negligible
- On the other hand, it is projected that devices are becoming more and more advanced, so expecting user equipments to support multiple CDMA at the same time is plausible

Spectral Utilization Problem of Dedicated URLLC Channel

- If a bandwidth $\mathfrak{w}$ is dedicated to serve URLLC requests, a total of $\mathfrak{w} \times \mathfrak{b}$ bandwidth is wasted, where $\mathfrak{b}$ is the number of base stations
- Solution: URLLC superposition/puncturing
- Motivation:
- Pros and Cons:

System Model

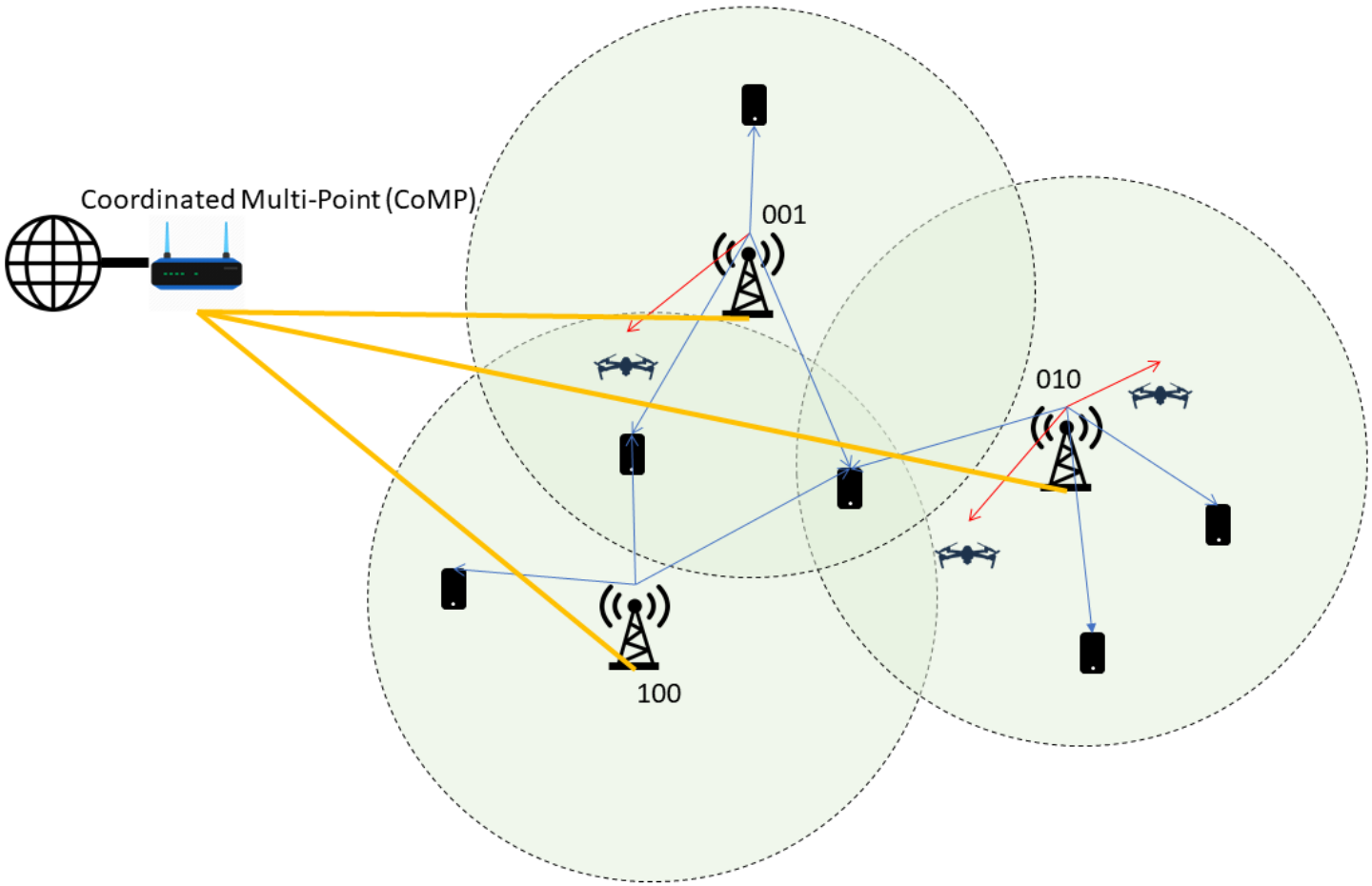

Figure: System model

System Framework

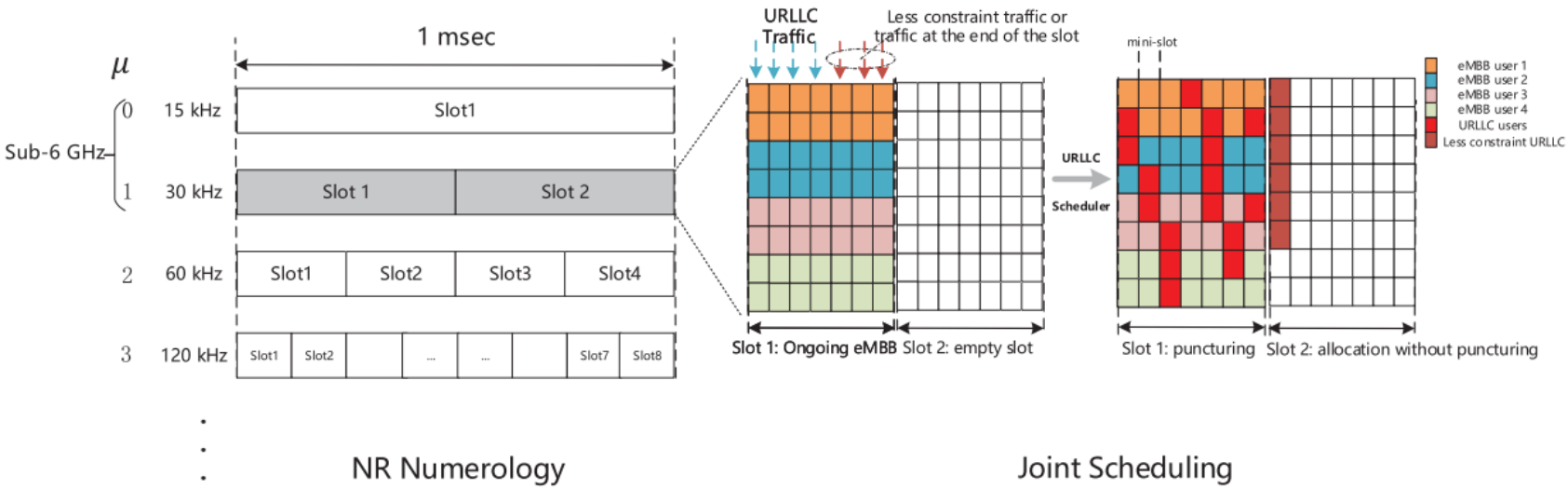

Figure: System framework