MATLAB Based Femtocell Network Simulation

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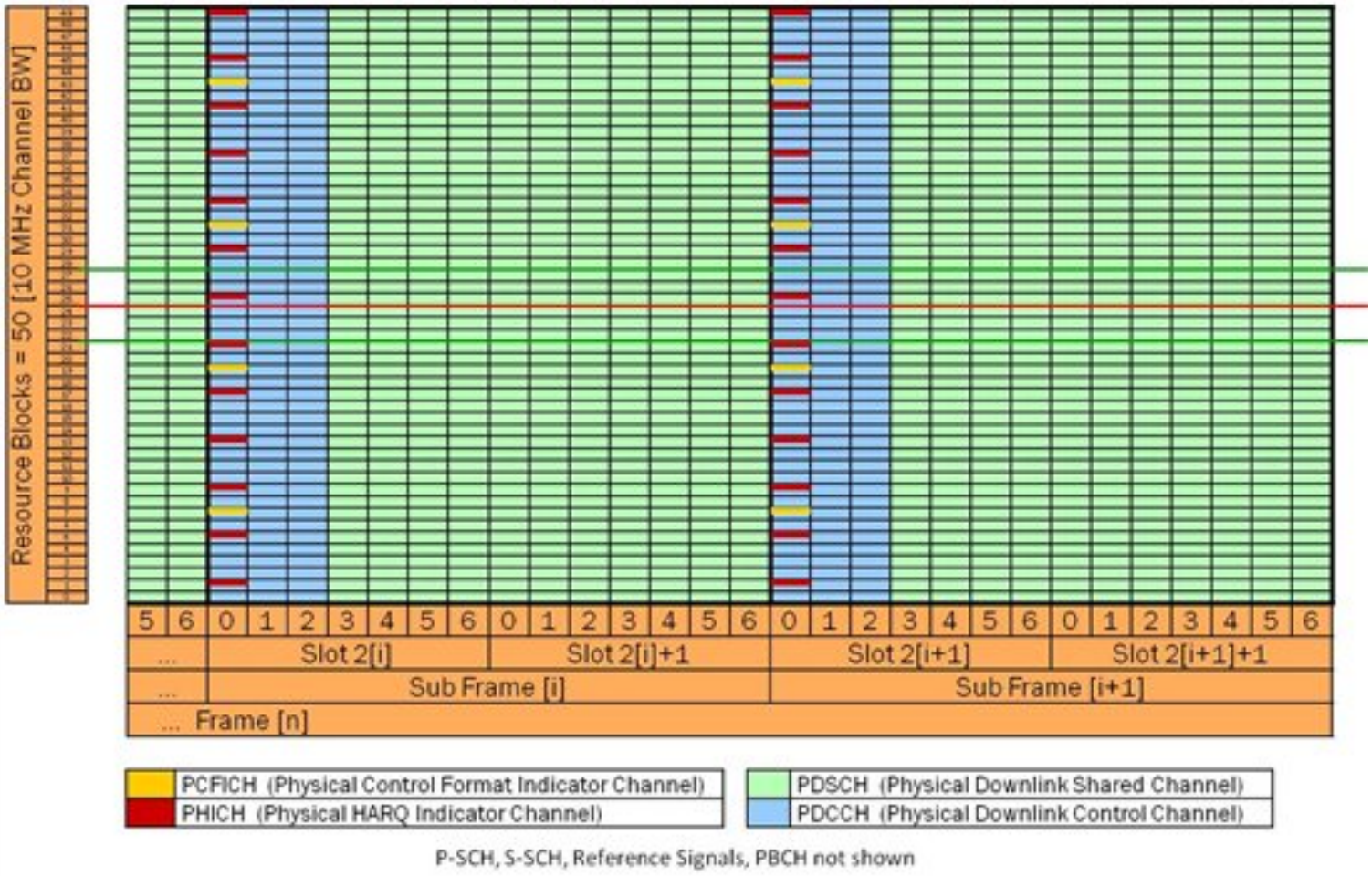
Overview

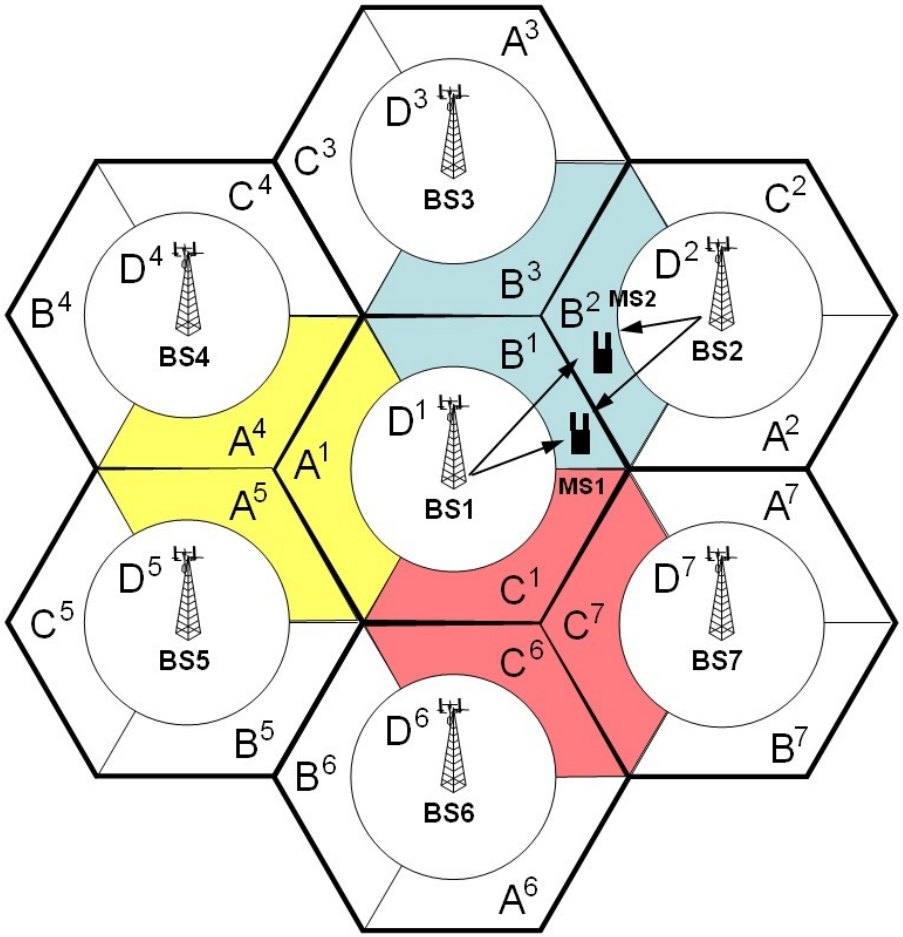
LTE Attributes/Features

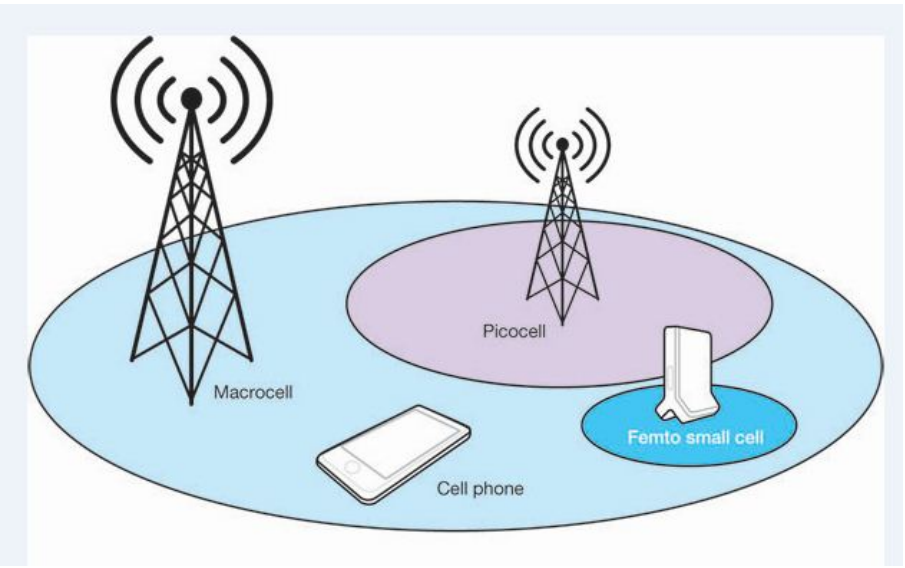
- LTE uses a fully scheduled MAC Layer (except for RACH)
- LTE comes in flavors of both TDD and FDD (FDD will be focused on since it can be simplier to evaluate and explain)
- Bandwidths from 1.4MHz to 20MHz
- Resource Blocks can be QPSK, 16QAM, 64QAM
- Turbocoding rates from 1/2 to 948/1024 (Puncturing when necessary)

Basic LTE Resource Allocation

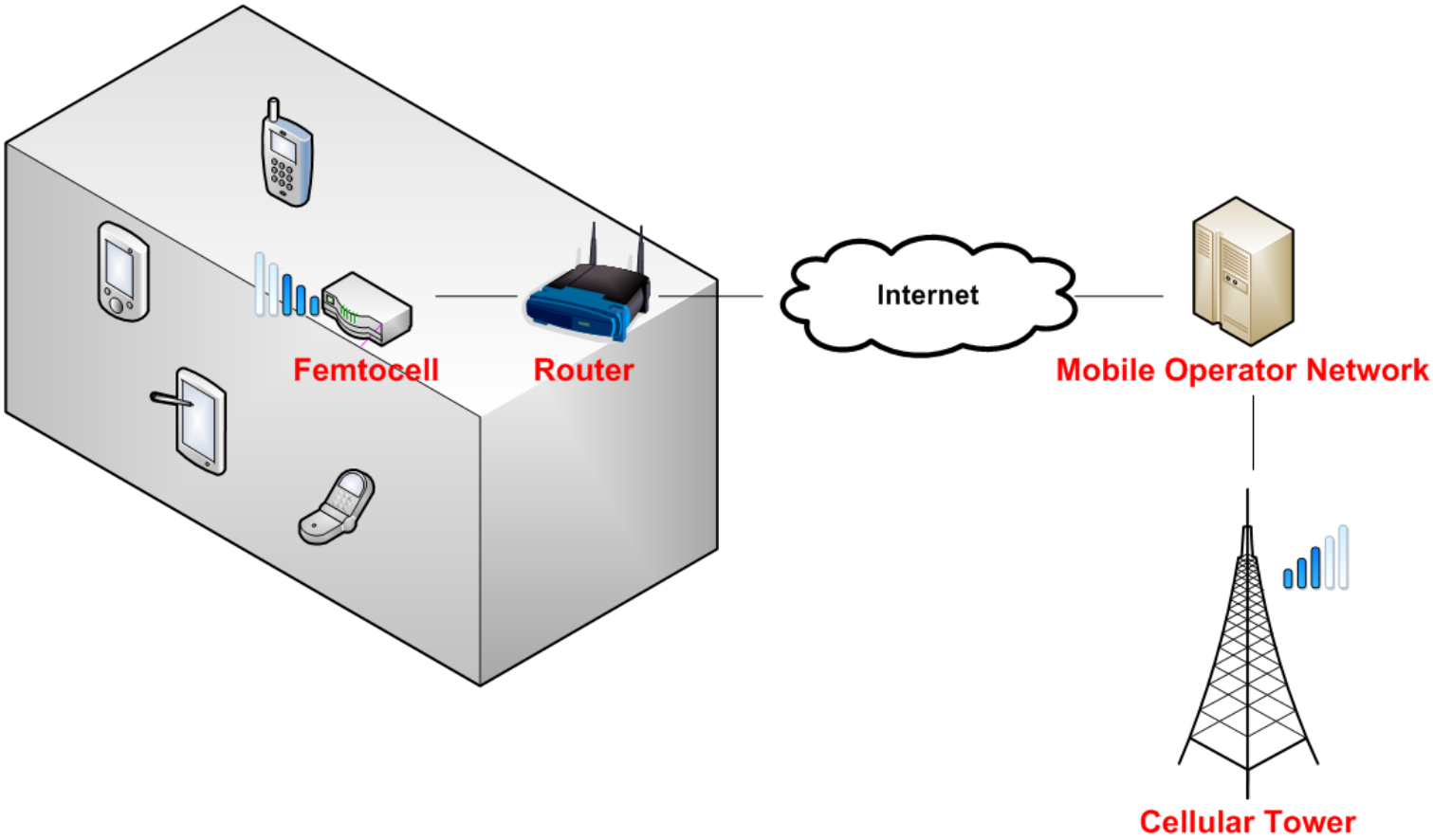


Cell Topologies





Femtocells



- Cheap with small transmission range
- Reduce load on Macrocells
- Provide service to residential dead zones

Interference Problems

Inter-cell (Among)

- ICIC (inter-cell interference coordination) is used to resource interference among overlapping edge users
- Uses coordination over X2 interface between eNodeB's to enforce scheduling rules

Intra-cell (Within)

- eICIC is still under development and only methods for Pico-cells have been standardized
- Femtocell interference is still an area of debate, but will most likely adopt strategies similar to ICIC
- Interference among Femtocells is still up for grabs

Current Approaches for Femtocell Interference

Split Bands

- Macro users get bands A-C and Femto users get bands D-E
- **Pros**: Simple to implement and no co-channel interference
- **Cos**: Spectrally inefficient

Shared Bands

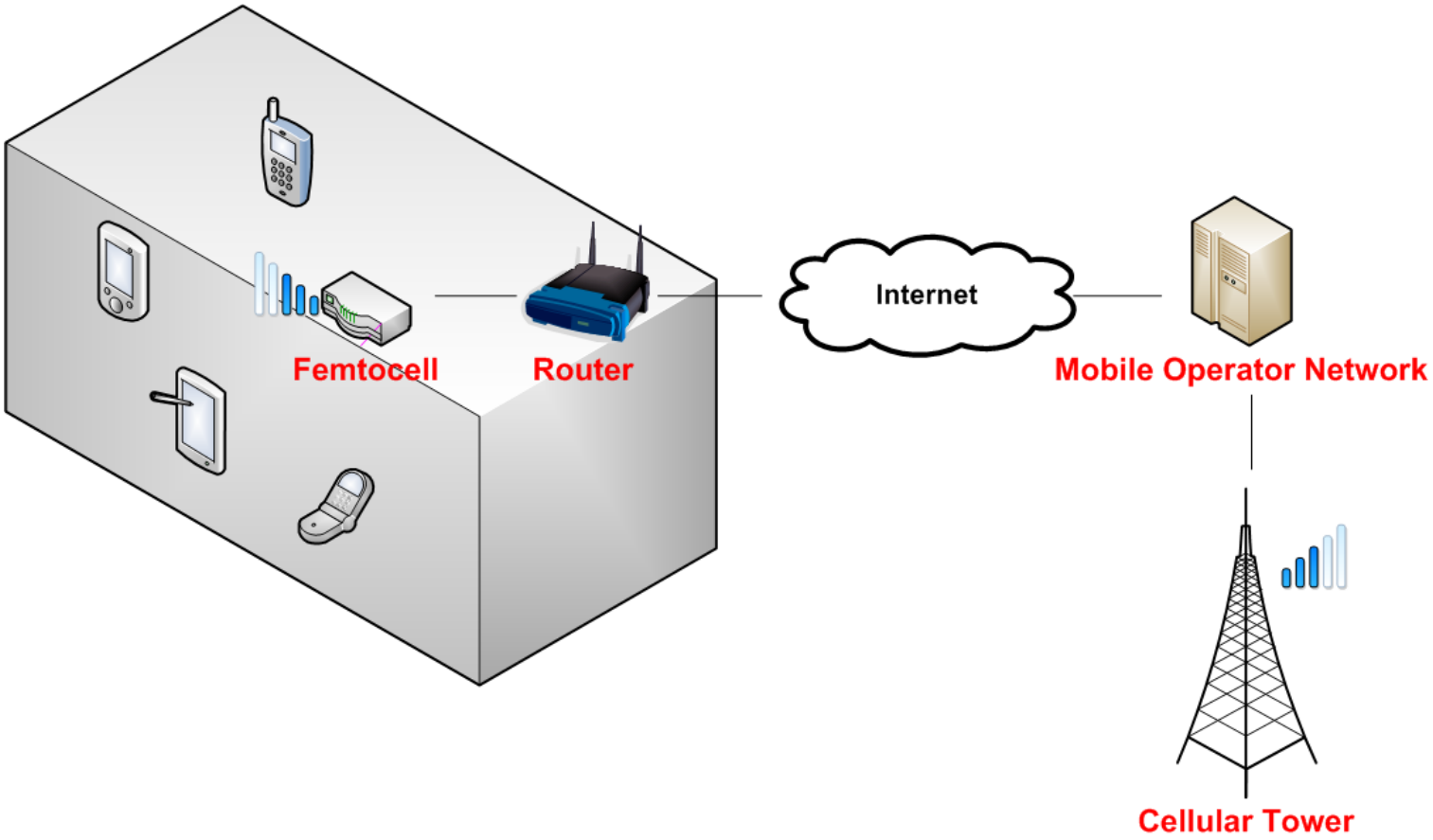
- Both share all bands, Macro transmits deterministic ABS to lower cell edge transmissions
- **Pros**: All users can use all bands
- **Cos**: Co-channel interference, coordination required

Overview

Goal

- Model interference between Femtocells
- Impacts of interference on network
- Avoidance with minimal changes to network operation

Scenarios of Interest



Working and Tobe Changed

Working

- Can simulate N Femtocells with M UE's associate with each cell
- Pathloss is based off WINNER Model (Current using indoor only models without walls)
- Resource blocks utilization is monitored simulation wide
- AP's can have custom positions
- Nodes can have customized tasks (aka VOIP, Web, etc...)
- Scheduler is Round Robin based (first come first serve)

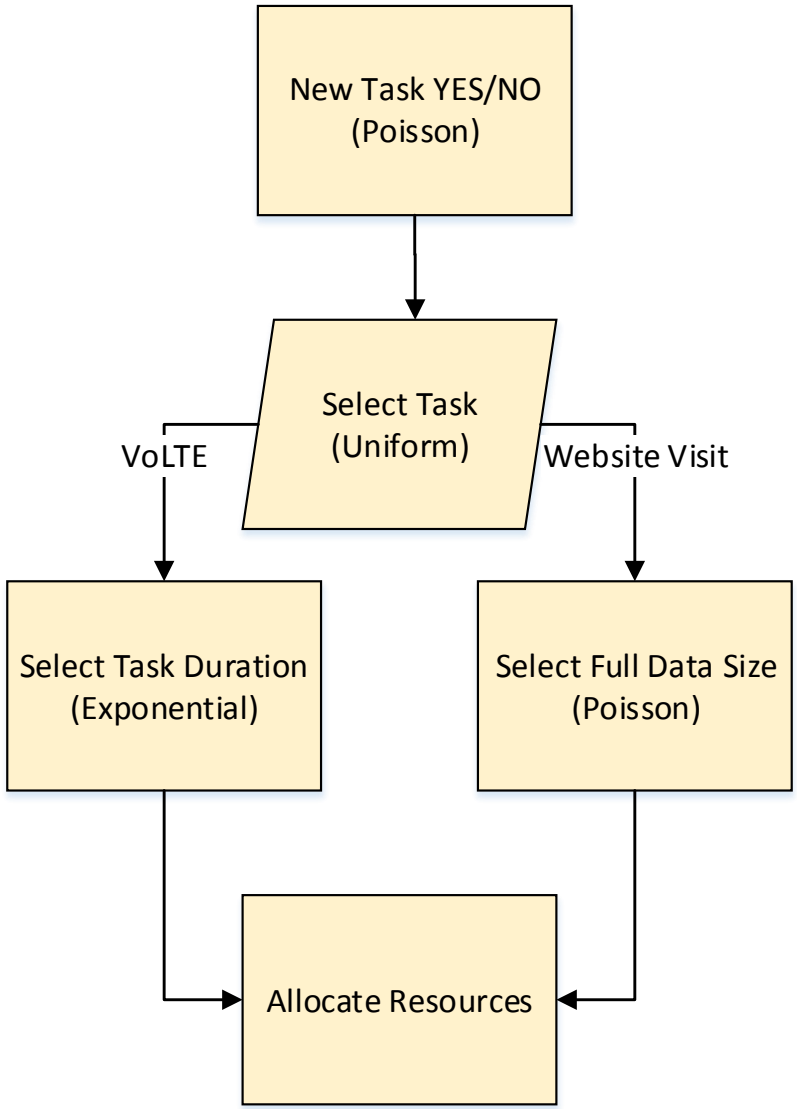
In progress Work

- Sensing is non-realistic (Not traditional to LTE)
- AP's are assumed synchronized, not realistic

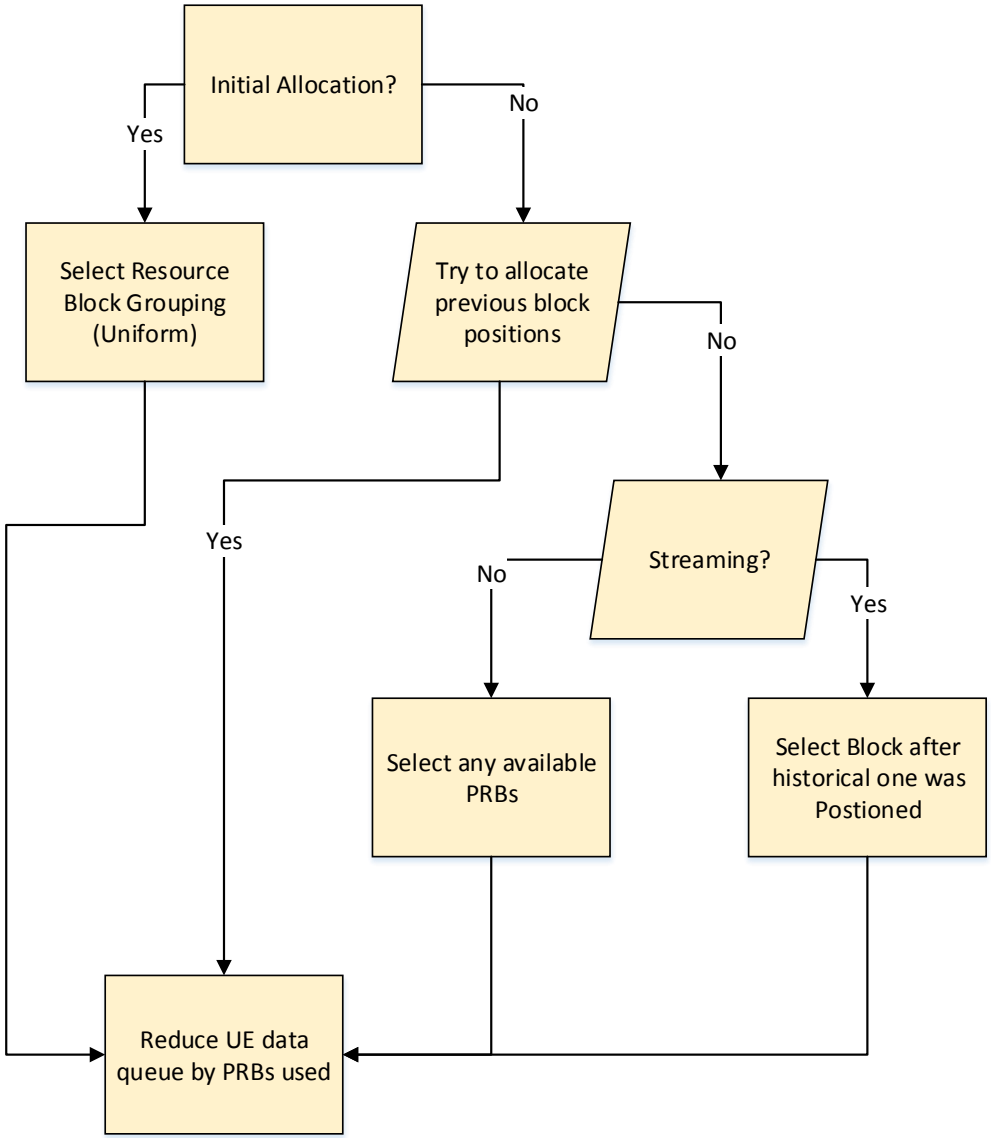
Modeling Work

- Overall network throughput as nodes increase
- Interference characteristics
- User statistics
- Resource allocation modeling
- Smart scheduling
- Can sensing be done? Does it provide any advantage?

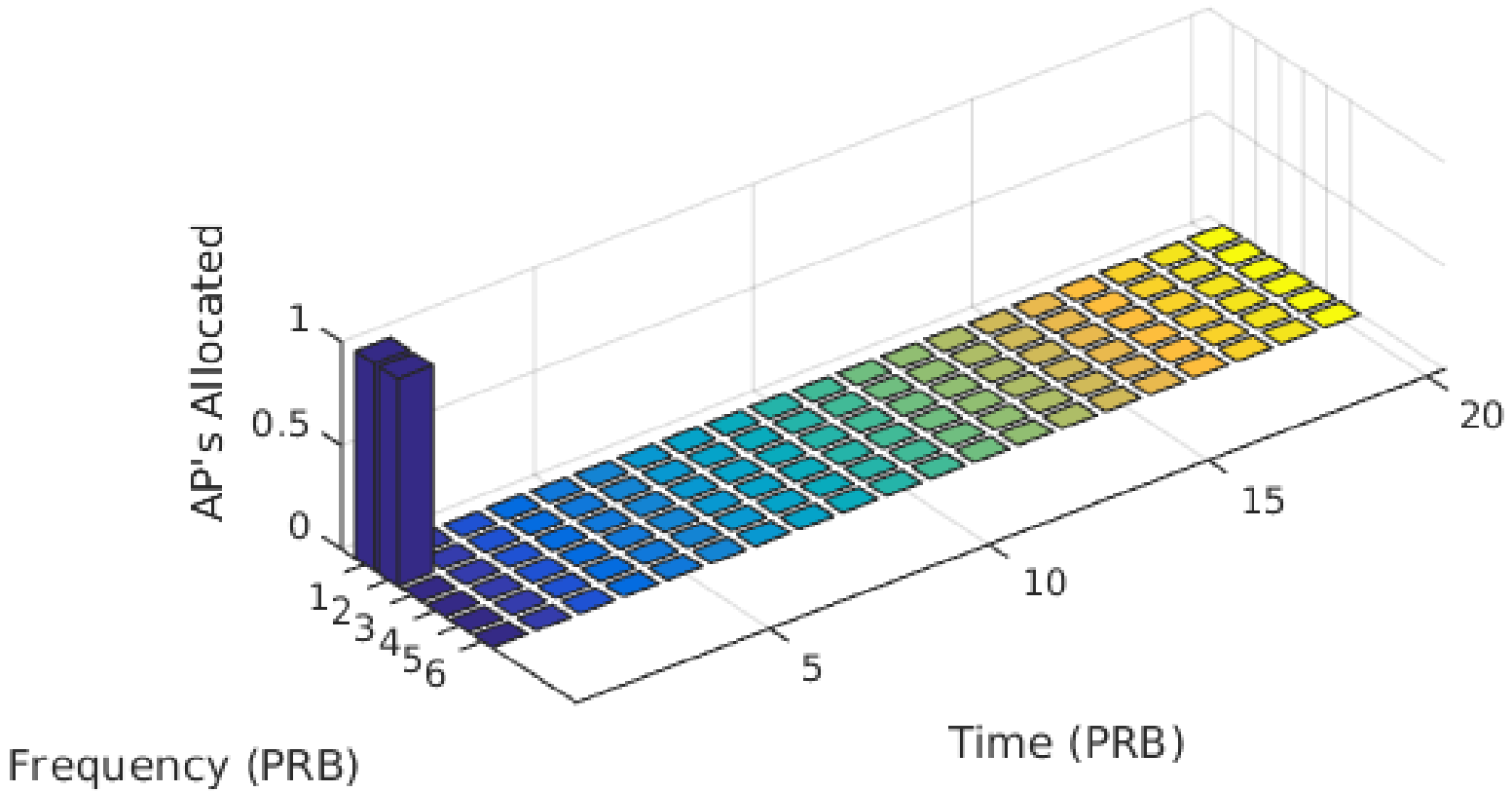
Scheduler Operation



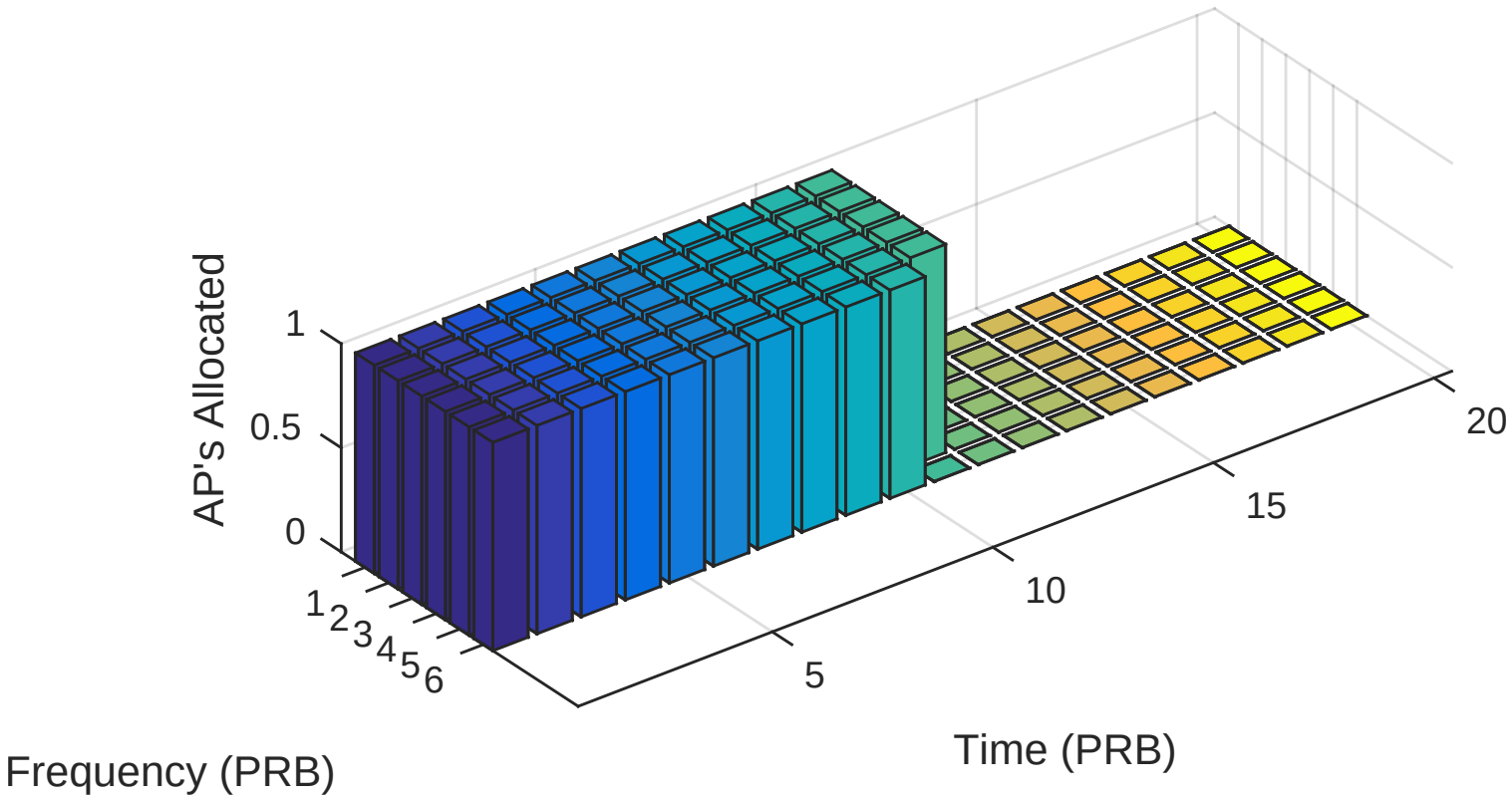
Scheduler Operation



VoLTE Allocation



Web Download Allocation



Modeling of Grid/Resource Usage

- Users allocate a group of resources with a probability $p(x) = \frac{e^{-\lambda}\lambda^x}{x!}$
  - $\lambda = \sum \lambda_{event}$
  - λ is dependent on the number of users connected to each Femtocell
- The probability of network saturation is $P(x) = 1 - \frac{\Gamma(x+1,\lambda)}{k!}$
  - The index x is determined by the bandwidth and channel conditions
- This only discribes the density of the grid, not the individual PRBs
- If PRBs are scheduled without channel information $P(x)$ should be a good estimate of their allocation probability with x being that PRBs location

Demo

References

- http://lteuniversity.com/get_trained/expert_opinion1/b/dhar/archive/2010/08/27/one-millisecond-in-the-life-of-an-lte-ue.aspx
- http://mwrf.com/site-files/mwrf.com/files/uploads/2012/08/2_1.JPG
- http://www.citi.sinica.edu.tw/~rchang/BSC.bmp