

# Light Cognitive Radio Enabled Inter Operator Flexible Spectrum Usage for IMT-Advanced

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# INTRODUCTION

## IMT-Advanced

- ❑ 4G systems with new capabilities
- ❑ Provide access to wide range of telecommunication services
- ❑ Target peak data rates **1 Gbps** in DL and **500 Mbps** in UL
- ❑ Support low to high mobility application
- ❑ To be operational around the year 2015

## Minimum Targets

- |                              |  |
|------------------------------|--|
| ❑ Cell Spectral Efficiency   | DL : 2.1 b/s/Hz/cell [4 x 2 Tx-Rx antenna] |
|                              | UL: 1.5 b/s/Hz/cell [2x4 Tx-Rx antenna]    |
| ❑ Peak Spectral Efficiency:  | DL : 7/10 b/s/Hz [4x4 antenna]             |
|                              | UL : 2.5 / 5 b/s/Hz [2 x 4 antenna]        |
| ❑ Cell edge user throughput: | DL : 0.06 b/s/Hz/user [4x2 antenna]        |
|                              | UL : 0.03 b/s/Hz/user [2x4 antenna]        |

3GPP LTE-Advanced aims to meet /exceed IMT-Advanced targets

# Required Enhancements and Solution Components

## Required Technological Enhancement

Enhanced coverage  
Increased user data rate and cell capacity  
Increase traffic volume handling  
Reduced cost per bit  
Lower latency  
Backward compatibility with legacy systems.  
Efficient operation with unequal cell loading  
Decentralized Nomadic /Local Area Solution

## Solution Components

Relay Nodes  
Support of Larger Bandwidth  
Cognitive Radio Concepts  
Flexible Spectrum Usage

Also

ICIC Refinements  
Advanced Receivers  
SU-MIMO  
Further Advanced AMC

# Local Area Deployment Scenario (1)

- ❑ IMT-A has increased focus on nomadic/ local area deployment
- ❑ Deployment : Decentralized and Uncoordinated
- ❑ Required
  - Autonomous Network Configuration and Operation
  - Support of higher bandwidth

## HeNB [HBS or Femto Cells]

- ❑ High data rate and high quality indoor coverage
- ❑ Large scale deployment
- ❑ Plug and play device with typical base station functionality
- ❑ User deployed : Random and Uncoordinated deployment
- ❑ Prior network planning not feasible
- ❑ Share Spectrum from Common Pool

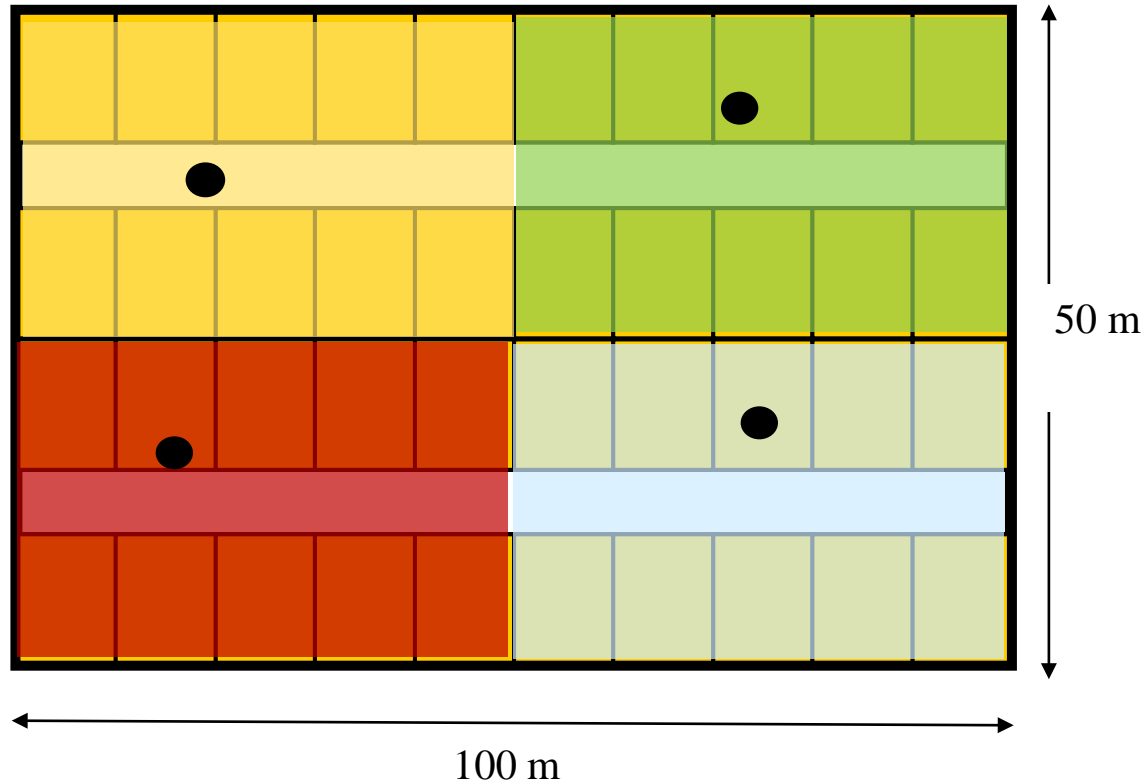
# Local Area Deployment Scenario (2)

## Critical Issues involving HeNB Deployment

- Mutual interference
- Co-existence
- Efficient spectrum utilization
- Fairness among operators

# Modeling Assumptions (1)

Assumed : No  
RAN Sharing



Decentralized uncoordinated deployment  
scenario with 4 HeNBs

# Modeling Assumptions (2)

## The Simulation Assumptions

- Deployment scenario : Indoor Corporate
- UE mobility : Nomadic
- Carrier frequency : 3.5 GHz
- System bandwidth : 100 MHz
- HeNB Total TX power : 24 dBm
- TDD with equal downlink –uplink ratio
- Frame duration 10 ms
- .....



# Algorithm : Policy Assisted Light Cognitive Radio

## Policy

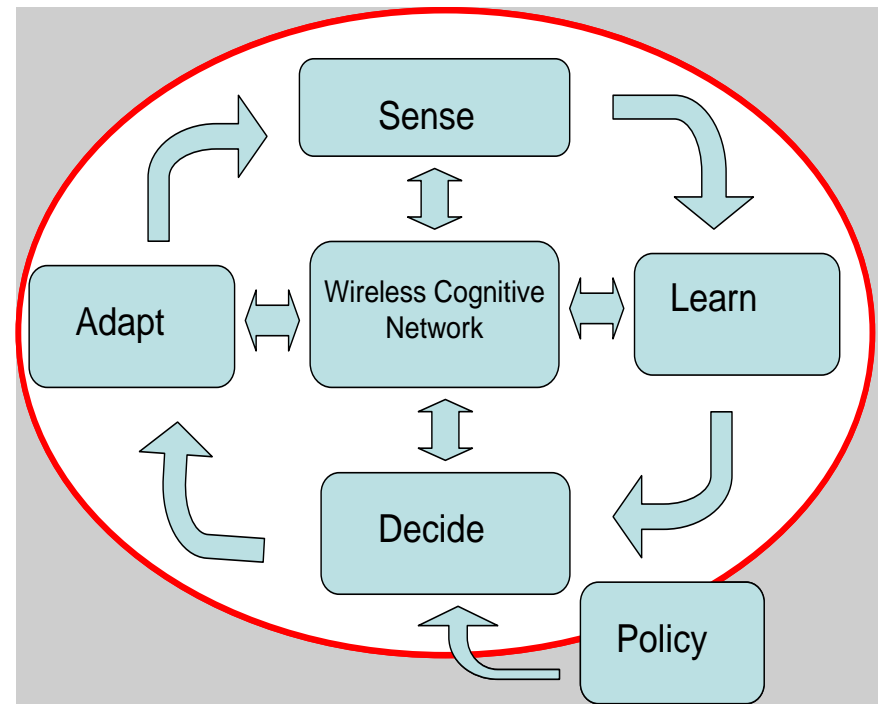
- ❑ A set of rules agreed among the operators

## Cognitive Radio

- ❑ An intelligent wireless system
- ❑ Aware of its surroundings
- ❑ Learn from the environment and
- ❑ Adapts statistical variations
- ❑ Able to reconfigure using SDR

## Light Cognitive Radio

- ❑ Makes use of the cognitive radio cycle,
- ❑ Does not involve SDR for reconfigurability



Decision Making is assisted by policy

# Algorithm : Description

Step 1

- ❑ HeNB is powered on
- ❑ Random PRB Allocation

Sensing  
(starts )

Step 2

- ❑ Interference Threshold based PRB Allocation
- ❑ Policy specifies initial, Min. and Max. # PRB allocation
- ❑ Increase #PRBs per user in subsequent turns
- ❑ Calculate pay off using utility function

Learning  
Phase

$$UF = \frac{TP^\alpha}{B}$$

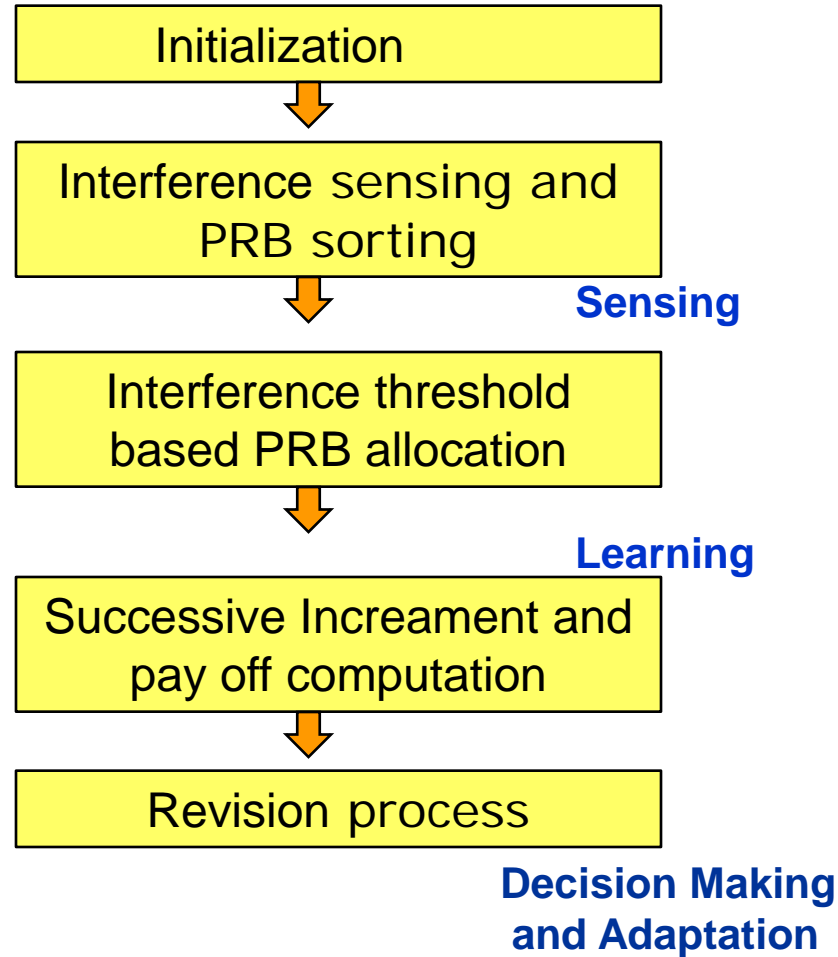
Step 3

- ❑ Compare pay off : current and previous
- ❑ Select allocation with highest pay off
- ❑ Change when an alternative pay off exceeds the current

Decision and  
Adaptation

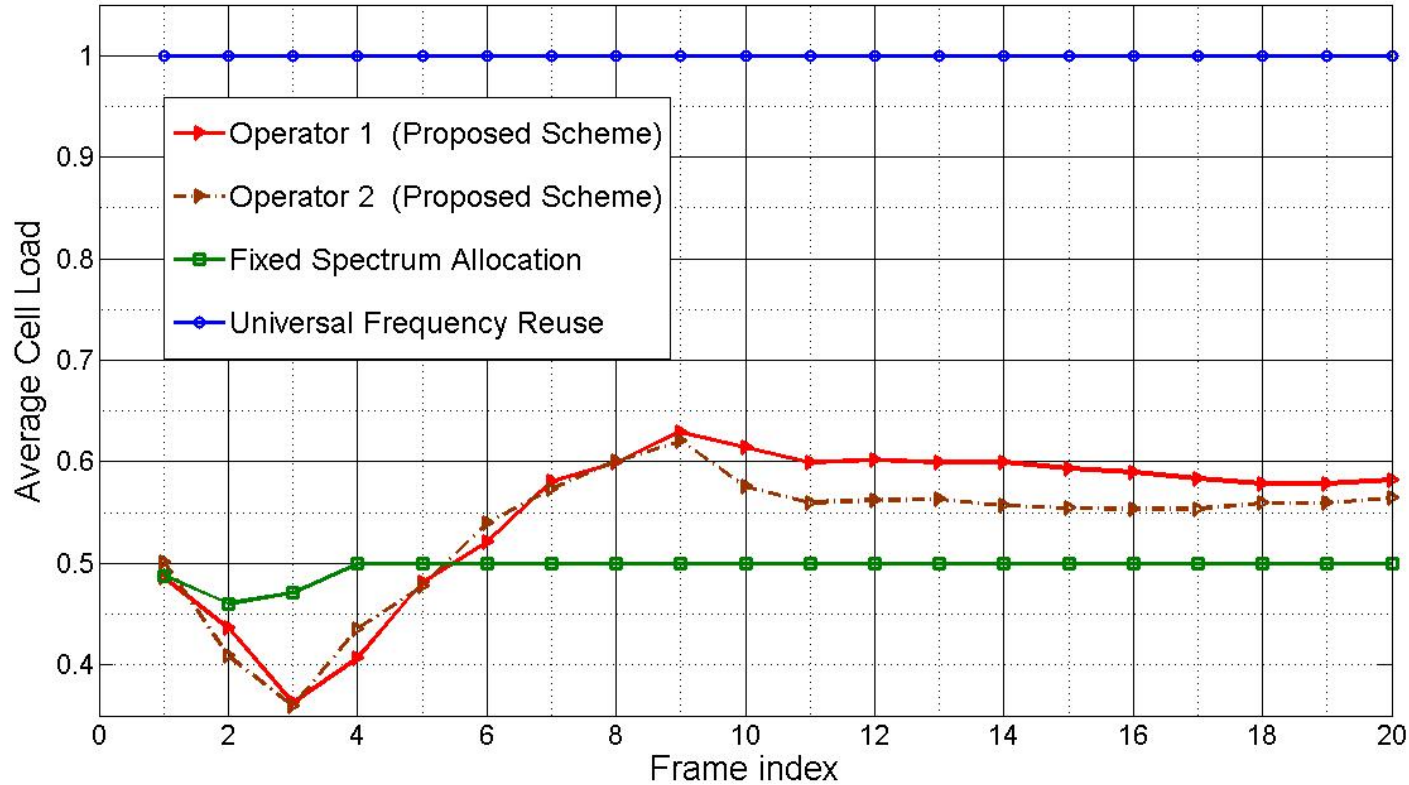
# Algorithm : Steps

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# Performance Evaluation (1)

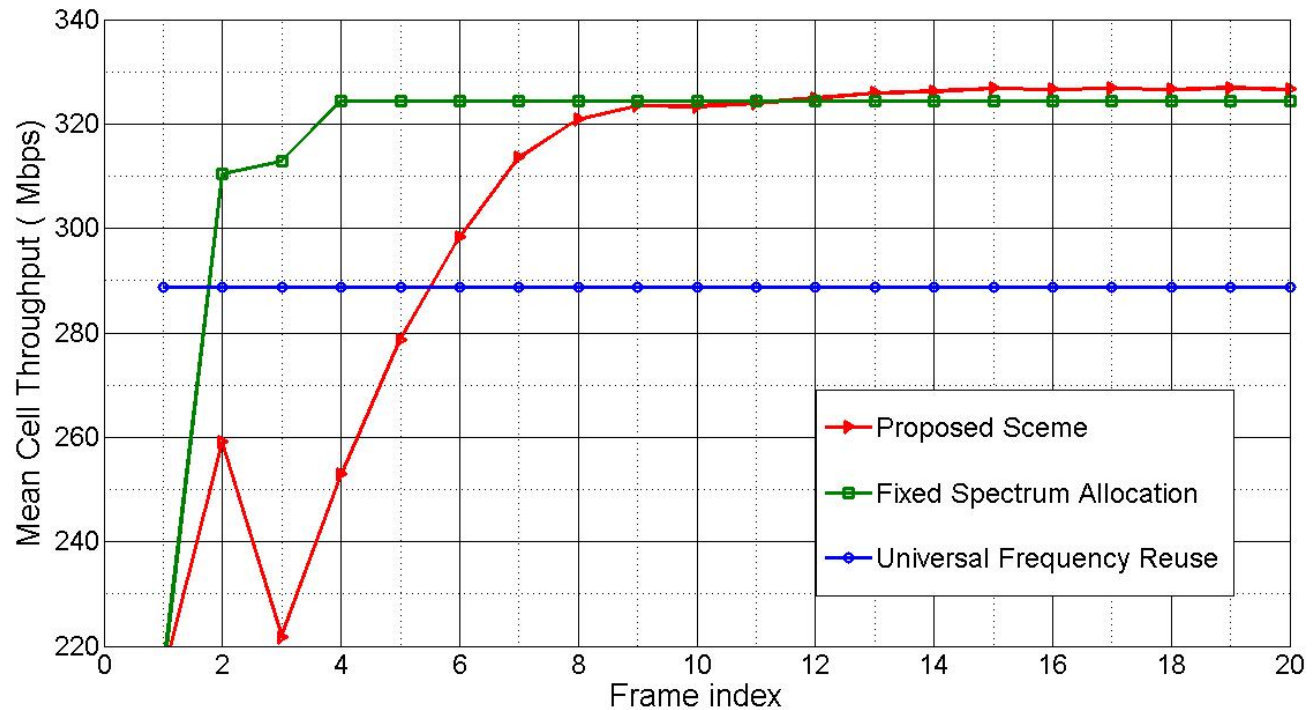
60% Average Cell Load for each operator is achieved at -70 dBm Interference Threshold



Average cell load with two Operators deployment

## Performance Evaluation (2)

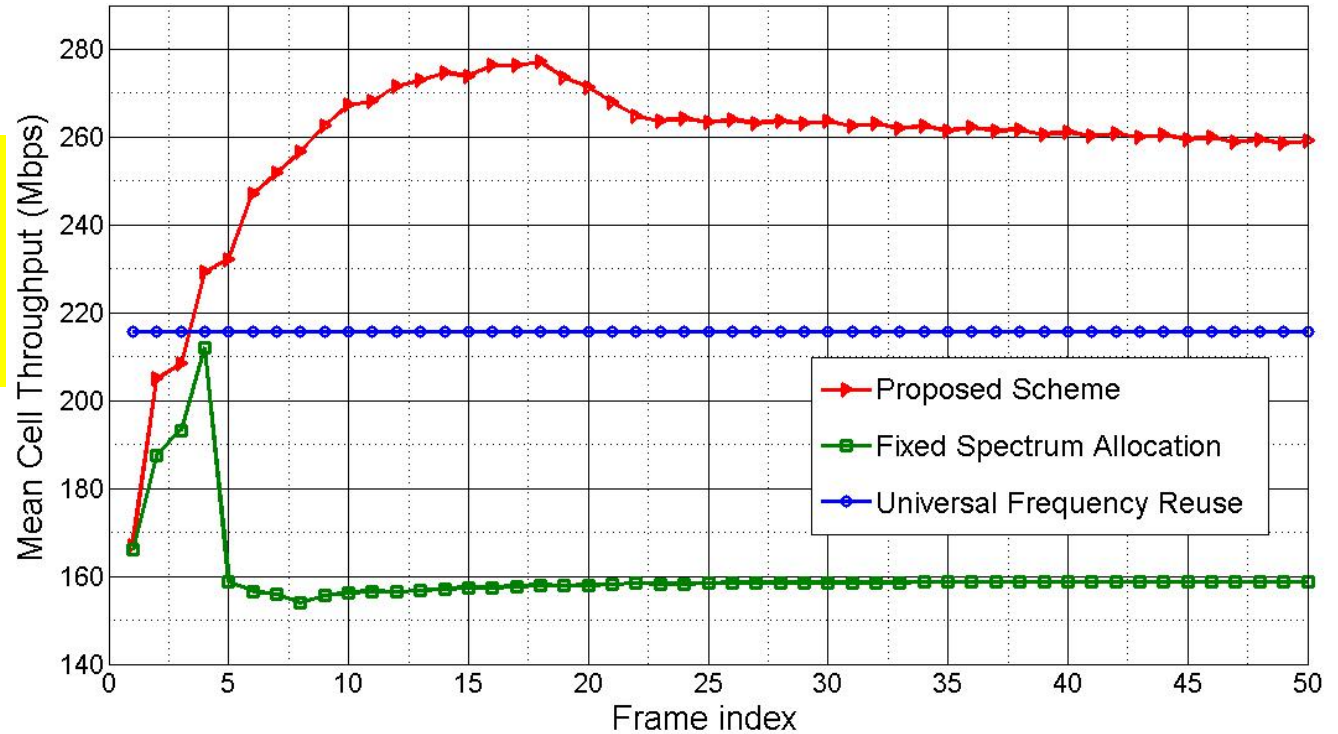
proposed scheme gives higher mean cell throughput than universal frequency reuse only at 60 % spectral resource usage. Performance is comparable with fixed spectrum allocation scheme.



Mean Cell Throughput with two operators deployment

# Performance Evaluation (3)

Proposed Scheme provides significantly higher throughput performance



Mean Cell Throughput with four operators deployment

# Conclusions

- ❑ A review of the technological advancements required in existing system and potential solution components to meet IMT-Advanced requirements are discussed.
- ❑ Critical issues related to Local area indoor deployment are highlighted.
- ❑ Policy Assisted LCR for multi operator scenario is suggested as potential solution
- ❑ The considered algorithms provides coexistence of Multiple operators in the given area and improves overall throughput performance over fixed Spectrum allocation and universal frequency reuse schemes

Thank You