

# A Coexistence model of IEEE 802.11b/g IEEE 802.15.4 and LTE-U

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## 1 Motivation

Coexistence of various networks in unlicensed band has been the focus of study for a long time now. 802.11, 802.15.4 and Bluetooth coexistence has been studied extensively in [1], [2], [3], [4], [5], [6], [7], [8]. Other modes of interferences including microwave ovens, cordless phones have also been studied in [9]. Recent advances have introduced LTE in unlicensed band and has led to extensive studies on coexistence of 802.11 or 802.15.4 with LTE-U [10], [11], [12], [13], [14], [15]. 802.11, 802.15.4 and Bluetooth are the most common networks deployed in 2.4Ghz. [15] discusses coexistence of LTE with ZigBee in 2.4Ghz. Coexistence of these common networks together with LTE-U has not been studied thus far. Bluetooth has the option of jumping to non overlapping channel using FHSS. However CSMA/CA based 802.11 and 802.15.4 MAC layer operation needs to be studied together with LTE-U since LTE-U does not sense the channel before transmitting.

Coexistence of networks in the same unlicensed band can be studied based on three modes of separation.

- Spatial separation where networks are separated out of co-channel interference range.
- Temporal separation where networks using the same frequency time share the medium to avoid interference and collisions.
- Frequency separation where networks use different channels avoiding interference.

Here we focus on temporal separation of LTE-U, 802.11 and 802.15.4 to communicate and time share the medium.

## 2 Problem Statement

Present a coexistence model of IEEE 802.11b/g, IEEE 802.15.4 and LTE-U to accurately explain their coexistence performances.

## 3 Problem Description

Consider a network consisting an LTE-AP,  $N_{lte}$  LTE nodes,  $N_{wifi}$  802.11bg nodes,  $N_{wsn}$  802.15.4 nodes. Herein after 802.11bg nodes are referred to as Wifi nodes and 802.15.4 nodes are referred to as Wsn nodes. LTE nodes and LTE-AP are expected to implement Fair LBT Algorithm described in [12]. LTE-AP is expected to continuously transmit downlink data to LTE nodes. Wifi nodes are expected to transmit data continuously to simulate continuous contention for medium access. Wsn nodes are expected to contend for the medium continuously by trying to transmit data continuously. Physical channel is expected to be error free and the only packet drops are due to collisions. All nodes are in co-channel interference range. Wifi nodes are expected to sense Wsn and LTE powers of transmission while Wsn nodes can sense transmit power levels of Wifi and LTE nodes. All three networks' nodes use the same 2.4Ghz channel and time share the medium to avoid interference and collisions. We now use this network model to understand and present a coexistence model of all three networks together.

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