Channel Sensing Based Dynamic Adjustment of Contention Window in LAA-LTE Networks

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Introduction

- The phenomenal growth in mobile data demand.
- Limited and costly licensed spectrum.
- One solution is to use unlicensed spectrum.
- 23 non-overlapping channels in 5GHz.

### LTE in Unlicensed Spectrum

- LTE can utilize unlicensed spectrum in two ways:
  1. Use Wi-Fi for LTE traffic offloading.
  2. Use LTE itself in unlicensed spectrum.
- Use of LTE in unlicensed spectrum is a better option because of unified network, efficient spectrum utilization and easer management of the network with same technology.
- But due to its always on nature of operation, it is not fair to use LTE in unlicensed spectrum as it will be difficult for Wi-Fi to grab the channel from LTE.
- To use an unlicensed spectrum, LTE needs to fairly coexist with Wi-Fi and other technologies.

Motivation

- To provide high data rate and to reduce the load on licensed spectrum, 3GP is introducing Licensed Assisted Access (LAA) in Release 13 for LTE operation in unlicensed spectrum.
- One of the mandatory functionalities of LAA is Listen Before Talk (LBT) to coexist fairly with other technologies in unlicensed spectrum like Wi-Fi.
- Contention Window (CW) adjustment is one of the important issues in LAA-LBT.

### LBT Category 4 with Dynamic CW Adjustment

- LBT category 4 has mainly two parameters: Defer period and Extended Clear Channel Assessment (ECCA).
- Defer period is the minimum time a device has to wait after the channel becomes idle before its transmission. Defer period ≥ 20 μs to avoid collision with Wi-Fi ACKs.
- If the channel is busy, a device also has to sense channel idle for random ECCA drawn from [0, CW) before transmission of data. ECCA slot < 20μs.
- If ECCA countdown is interrupted, a defer period is applied after the channel becomes idle as shown in Fig. 3.

#### Algorithm Parameters

- Important parameters of algorithm:
  - **Observation Window (OW):** Time elapsed since a device wants to transmit on the channel to actually starts its transmission after ECCA counter reaches zero as shown in Fig. 3.
  - **Waiting Threshold (WT):** It is the threshold used to adjust current CW. \(WT_{\text{max}}\) is initial value of WT.
  - **\(CW_{\text{min}}\) and \(CW_{\text{max}}\):** Minimum and maximum value of CW, respectively.
- The proposed algorithm considers load on the channel and adjust CW dynamically.
- The algorithm updates current CW & WT values for every transmission based on OW of the last transmitted packet.

#### Algorithm 1: Dynamic CW Adjustment in LAA

**Inputs:** CW, WT, OW
**Outputs:** CW, WT
**Initialization:** CW ← \(CW_{\text{min}}\), WT ← \(WT_{\text{min}}\)
1: if OW ≥ WT then
2: \(CW ← 2 \times CW\)
3: WT ← 2 \times WT
4: if CW > \(CW_{\text{max}}\) then
5: \(CW ← CW_{\text{max}}\)
6: end if
7: else
8: \(CW ← CW_{\text{min}}\)
9: WT ← \(WT_{\text{min}}\)
10: end if

Simulation Setup & Parameters

- For simulation, 3GP indoor scenario is considered with two operators (A & B) deployed 4 small cells in a single floor building as shown in Fig. 4.
- Each operator deployed 10 users in each cell and positions of the users are same for both Wi-Fi - Wi-Fi and LAA - Wi-Fi case.

#### Results & Analysis

**Figure 5:** CDF of LAA-CTP over Law - Fi Scenario

**Figure 6:** CDF of Delay over Law - Fi Scenario

**Case 1:** Wi-Fi - Wi-Fi Scenario
- Both the operators deployed Wi-Fi. In Fig. 5 & 6 solid lines show the performance for Case 1. Solid lines are close to each other as both the operators are using Wi-Fi.

**Case 2:** LAA - Wi-Fi Scenario
- In this case, Wi-Fi of operator A is replaced with LAA and the above simulations are repeated. In Fig. 5 & 6, dotted lines shows the performance of LAA and Wi-Fi in LAA-Wi-Fi scenario.
- The performance of Wi-Fi in Case 2 is better than Case 1 because LAA utilizes spectrum efficiently and gives more channel access opportunity to Wi-Fi.

Conclusions

- LAA with proposed dynamic CW adjustment algorithm can fairly coexist with Wi-Fi and the performance of Wi-Fi in LAA - Wi-Fi scenario is better than Wi-Fi - Wi-Fi scenario.
- Future work comprises of optimal WT value selection for CW adjustment as the lower WT value can lead to increase the backoff time and higher WT value can result in more number of collisions.

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