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Smart Convergence of Culture Technology Letters SCCTL 02

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Baroque 2.0 –B001
Jong Chul Lee

Illusion
Min Gu Kang

My words, your words
Ju Ahn Koh

Rhythm
Young Hwa Park

Season Collection
Sung Yun Choi

NETWORK
Hyun Sook Park

Pictogram Olympic
Sung Tae Joe

The Satirical & Humorous Image of Koreans
Eun Seok Chang

Untitled
Hae Hyun Jung

Life come into bloom
So Youn Shin

Genesis 3:15
Eung Do Jo

Performance Evaluation of Contention Based LTE and Wi-Fi Network in Unlicensed Band

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Summary

Exponential increase in wireless data demands and limited nature of licensed spectrum for cellular network has motivated the consideration of unlicensed bands for the operation of Long Term Evolution (LTE). In unlicensed band below 6 GHz the large amount of spectrum approximately 600 MHz [1] are globally available for various purpose. Licensed Assisted Access (LAA) LTE use this unlicensed band to offload traffic through downlink-only and/or uplink and downlink. Although, the use of LTE in unlicensed band enhances capacity and seamless user experience, some issues need to be considered to enable different networks to work in common shared spectrum. One important issue is coordination and interference management between different systems [2]. Wi-Fi uses a Carrier Sense Multiple Access (CSMA) procedure to allow multiple Wi-Fi systems to coexist, while LTE uses continuous traffic generation with minimum time gaps even in the absence of mobile data traffic. From this operational structure in both networks, Wi-Fi is likely to have minimal chances to access the medium than LTE in coexistence scenario, resulting 70% to 100% performance degradation for Wi-Fi. Solutions in the literature include Listen-before-talk. (LBT) as important feature for coexistence in unlicensed band. According to 3GPP [1], LBT is one of the imperative functionalities required for fair and friendly coexistence.

LBT [3] is the carrier sensing mechanism for LTE devices. LBT uses energy detection to determine the presence or absence of other signals in a channel. The transmitter can immediately occupy this channel if the medium is idle during the Clear Channel Assessment (CCA) slot ($\geq 20\ \mu s$) else an Extended CCA (ECCA) check is performed. In an ECCA, the operating channel is observed for the duration of a random factor N multiplied by the CCA observation time. The value of back-off counter N is randomly generated for each ECCA check in the range of 1 to q, where q is selected in the range of 4 to 32[3,4]. The counter N is decremented every time a CCA slot is considered to be unoccupied and transmits when the counter reaches zero. LBT procedure for LTE is similar to 802.11 Distributed Coordination Function (DCF) [5] albeit, with some major difference. LBT does not considers Quality of service (QoS) for LAA. QoS is enabled in 802.11 using Enhanced Distributed Channel Access (EDCA) via four access priority i.e. voice, video, best effort and background. Additionally, the back off procedure in LBT is driven by a parameter Contention Window (CW), with values between 4 and 32 [3, 4] which is much lesser compare to Wi-Fi whose range lies in between 3 and 1023[5].The difference in range of LBT back off counter offers more opportunity to access the channel for LTE regardless of any priority level data of Wi-Fi contributing unfairness for Wi-Fi. In addition to this, LBT adjusts CW based on successful & unsuccessful transmission of frames. Initially, CW is set with a minimum value of $CW_{min,}$ and has a maximum CW value of CW_{max}. CW is doubled each time after a collision. And, it resets to CW_{min} after a successful transmission assuming the network is experiencing a low load and node can wait shorter in order to send a packet. However, in real environments, these assumptions are not always true. The successful transmission of a packet does not necessarily mean the network is not congested.

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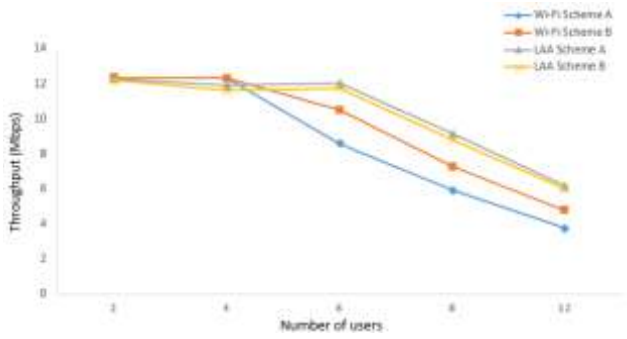

Figure 1. Throughput per user.

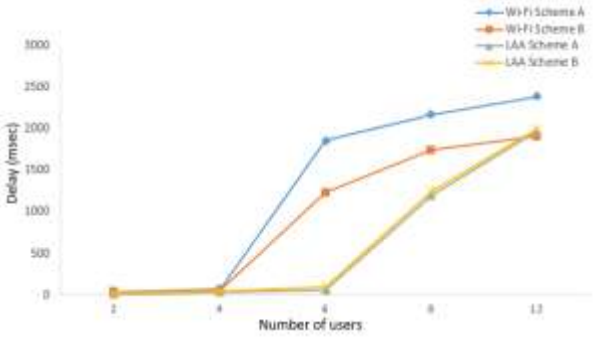

Figure 2. Delay per user.

Therefore, resetting CW to CW_{min} may cause more collisions leading a delay and waste of bandwidth. And, in heavy load networks, this continuous transmission opportunity of LTE can lead Wi-Fi towards bandwidth starvation.

In this paper, we study the effect of CW size on the performance and fairness of LBT LAA network. We use NS3 simulator based system-level analysis in order to assess the network performance. We establish simple coexistence scenario with two operators in overlap condition, with downlink-only traffic on unlicensed band. Our first analysis shows LBT LAA is viable technology in unlicensed band with much higher throughput performance than existing Wi-Fi solutions due to its better spectral efficiency, multi-user scheduling diversity, and spatial diversity gains. In second analysis, we compare the effect of contention window size for best effort traffic on LBT LAA network. The result shows that in coexistence the range used for best effort traffic for LBT LAA is unfair with Wi-Fi. LBT LAA with 802.11 DCF like contention window value increases Wi-Fi performance by 24% with 9% reduced throughput for LTE with negligible delay as shown in figure 1 and 2. Thirdly, the effect of CW_{min} value in fair coexistence is studied. Among all other schemes, scheme 3 shows the best value for coexistence with 18.5% of increase performance for Wi-Fi with negligible throughput and delay degradation for LTE. From this study, we conclude that the value of CW of LBT LAA has trivial effect on performance and fairness of the coexisting network thus it must be chosen carefully.

Keywords: *Coexistence, Contention window, Fairness, Listen before talk, LTE-U, Unlicensed spectrum.*

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