Armenian Journal of Physics, 2018, vol. 11, issue 4, pp. 303-308

Content-Aware Cross Layer Optimisation for IMT-Advanced Systems

(Proceedings of the Int. Conference on " Microwave and THz Technologies and Wireless comm.")

M. S. Johal[1], G. Markarian[2], A. Awang Md Isa[1], Y. Dasril[1]

[1] *Centre for Telecommunication Research and Innovation, Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka, 76100 Durian Tunggal, Melaka, Malaysia*

[2] *School of Computing and Communications, InfoLab21, Lancaster University, Lancaster United Kingdom LA1 4WA*

Received 15 November 2018

Abstract: Radio Resource Management (RRM) is crucial to properly handle the delivery of quality-of-service (QoS) in LTE systems. One of the techniques used for RRM in IMT-Advanced is cross layer optimisation (CLO) which normally involves the interaction between PHY and MAC layers before proper resource scheduling can be decided [1]. As the IMT-Advanced standard [2] only defines the PHY and MAC layers [3, 4], the effect of CLO is limited as the nature of the transmitted information is not taken into account.

Keywords: Radio resource management, cross layer optimization.

1. Introduction

Recently, some initiatives have been taken to include the application (APP) layer as part of the CLO techniques for RRM in LTE networks. By having this type of cross-layer design architecture, the LTE/LTE-Advanced can achieve multitude objectives such as improving spectrum efficiency, multi-layer diversity gain, adapting to wireless channel and satisfy users with different traffic classes [5]. Most of the APP and MAC/PHY cross layer architecture are targeted for data hungry services such as video streaming applications where high quality video frames will be adjusted which are then scheduled appropriately to particular user(s) whilst taking into account the channel state information (CSI) for each individual user as demonstrated by [6-9]. In these methods, the video frames or the encoding parameters are dynamically adjusted to suit the channel conditions for all users. However, the studies on the performance parameters, such as system throughput, packet loss ratio and delay for a certain time, are not clearly stated in those papers. Furthermore, compatibility with the legacy systems and standards is not considered as one of the major criteria for design. In this article, we are proposing a new technique which employs the CLO concept, namely "CONTENT AWARE RADIO RESOURCE MANAGEMENT". This CLO concept will be expanded from the PHY layer up to the APP layer and will utilise specific properties of the data and overhead transmitted over the network to ensure backward compatibility with the legacy standards and systems.

2. LTE simulation model

In addressing the problems mentioned in the previous section, initially, we establish a classical or baseline LTE simulation model which exhibits basic RRM only. The importance of this baseline simulation model is reflected by its conformity to the 3GPP Release 8 standard, and thus, is considered a normal performing LTE platform. In fact, it will serve as the benchmark for our proposed content-aware RRM model. The LTE topology. The design of the LTE topology begins with a Remote Host connected to a SGW/PGW Gateway which is then linked together with an eNodeB before finally acquiring a wireless interface with four UEs. The purpose of having four UEs is to represent four types of applications or services, namely web browsing, file transfer, voice-over-IP and video conferencing as shown in Fig. 1 [10]. The simulations are repeated for various distances between the UEs and the eNodeB and the output performance parameters such as the throughput, packet loss ratio, average delay and SINR values for a specific UE having video rate of 4 Mbps are also recorded. In this paper, only the throughput versus SINR graphs are plotted for both uplink and downlink transmissions as indicated in Fig. 2. Those results are expected due to the link adaptation performed by the eNodeB which result in various AMC schemes in both transmissions producing staircase-like pattern.

3. Cross layer optimization of RRM model

Based on Figs. 2 (a) and (b), we can draw the correlation between the Throughput and SINR and thus, recommending the suitable video packet generation rate at the sources for both uplink and downlink transmissions. Based on that observation, we want to introduce a new concept in radio resource management system which can dynamically adjust the transmitted data rate depending on the UE or eNodeB SINR performance in order to minimise the packet loss.

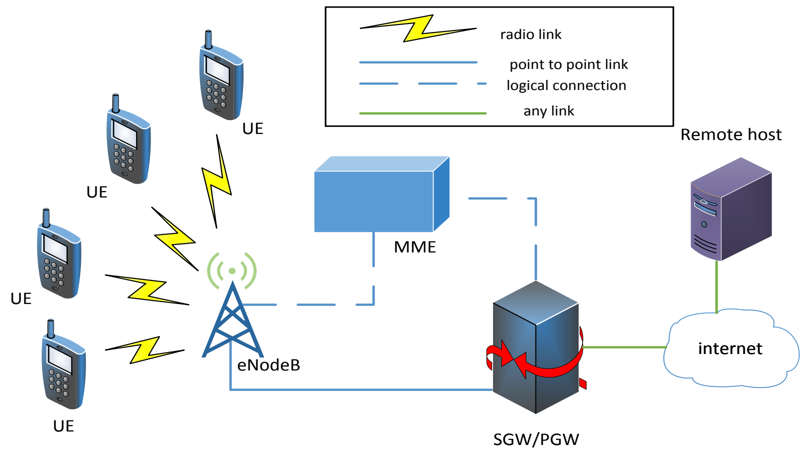
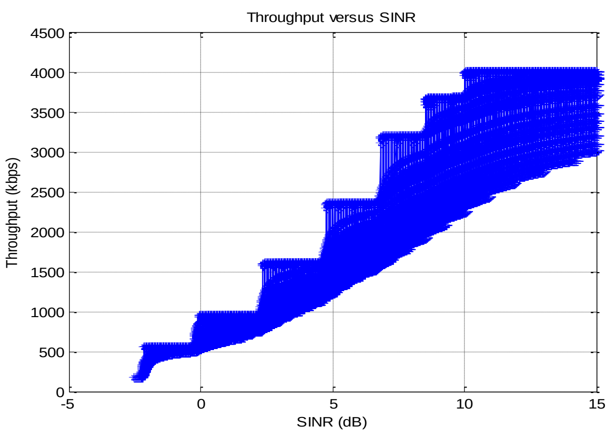
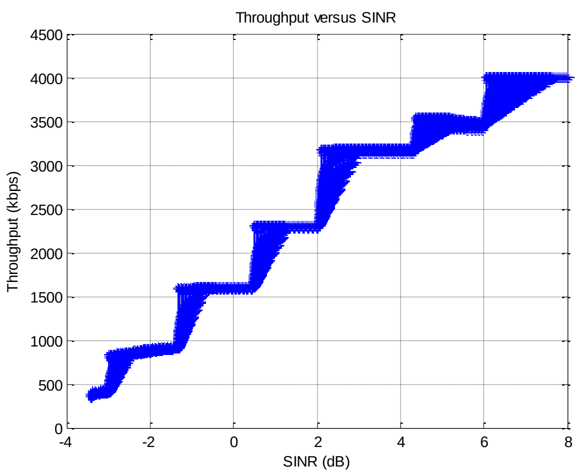


Fig. 1 Single eNodeB LTE – EPC simulation topology [10].



(a) LTE uplink transmission



(b) LTE downlink transmission

Fig. 2 Throughput against SINR plot for video rate, R = 4 Mbps.

This concept, which involves the cross-layer optimization approach, is called the content-aware RRM model or sometimes it is also called joint source and channel coding. In order to realise this, we propose a cross-layer look-up table that sets up the matching rules between the specific UE SINR and the assigned data rate for delivering video packets through the protocol suite for both uplink and downlink transmissions as shown in Table 1 (a) and (b). Both tables are derived from the Fig. 2 respectively.

Table 1: Proposed look-up table for content-aware RRM model.

(a) Uplink

Proposed Data Rate, R (Mbit/s)	SINR (dB)
0.20	< –2.19
0.6	–2.19 – –0.2
1	–0.2 – 2.29
1.650	2.29 – 4.63
2.450	4.63 – 6.77
3.250	6.77 – 8.33
3.750	8.33 – 10
4	> 10

(b) Downlink

Proposed Data Rate, R (Mbit/s)	SINR (dB)
0.415	< –3.03
0.875	–3.03 – – 2.0
0.92	–2.0 – – 1.4
1.625	– 1.4 – 0.41
2.33	0.41 – 2.0
3.21	2.0 – 4.26
3.5	4.26 – 6
4	> 6

4. Simulation results

For evaluation purposes, a new set of comparison parameters has been established in order to compare the performance of the proposed model and that of the baseline model. The new parameters are defined as follows:

$$\varphi_T = \int_0^t Throughput\, dt, \tag{1}$$

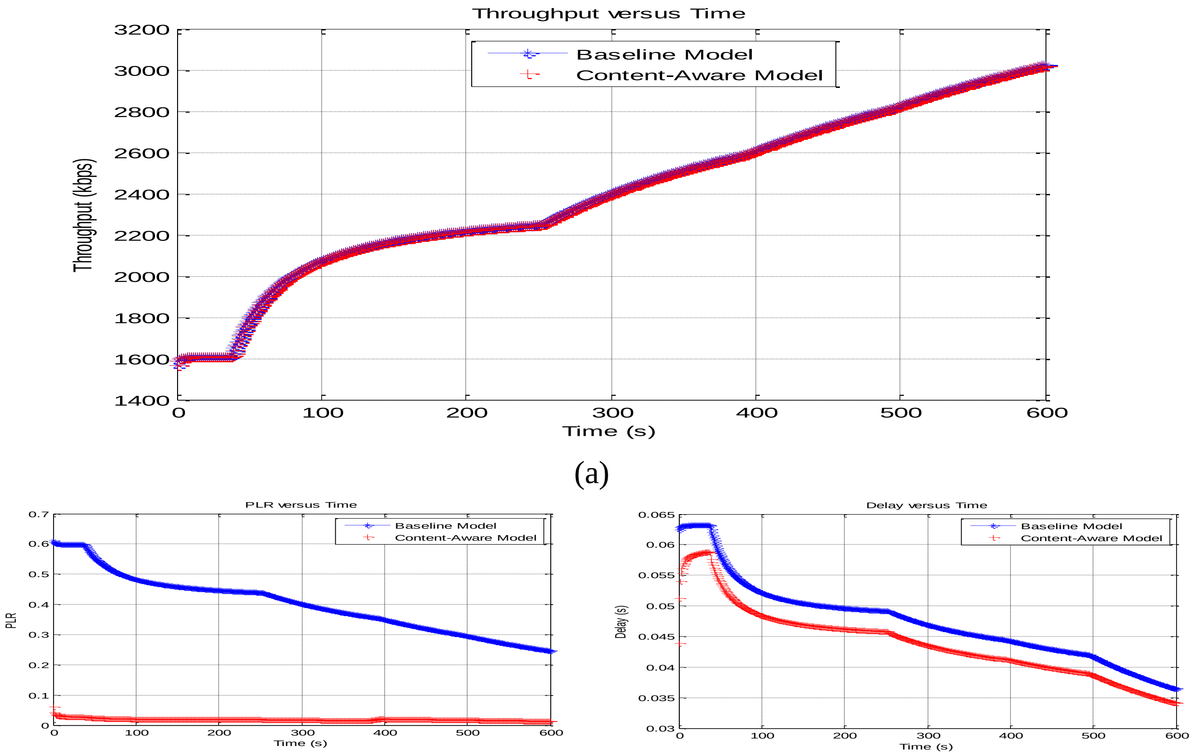
$$\varphi_P = \int_0^t PLR\, dt, \tag{2}$$

$$\varphi_D = \int_0^t Delay\, dt, \tag{3}$$

where φ_T is the total received data or area under the curve for throughput, φ_P is the area under the curve for packet loss ratio and φ_D is the area under the curve for average end-to-end delay. Practically, all the abovementioned parameters represent the areas under the curves calculated with respect to total simulation time for all the three output performance parameters; namely throughput, packet loss ratio and average end-to-end delay. Improvements can only take place if φ_T for one system is greater while φ_P and φ_D are smaller than those of its counterpart.

Fig. 3 shows output performance of the uplink video delivery over the course of 10 minutes, when one UE transmits video packets to the Remote Host via the eNodeB, while moving towards the eNodeB from the edge of the cell at $50 km/h$. In Figure 3 (b), the content-aware model outperforms the baseline model in terms of packet loss ratio by a staggering 95.32%

improvement. For the same amount of data transmitted in both models as reflected in Fig. 3 (a), the total number of packets lost during the transmission in the channel is huge in the baseline model, thus resulting in the wastage of bandwidth. As a matter of fact, the content-aware model also experiences much less average delay with 7.27% improvement as shown in Fig. 3 (c) and, this means QoS for the video streaming application can be preserved.



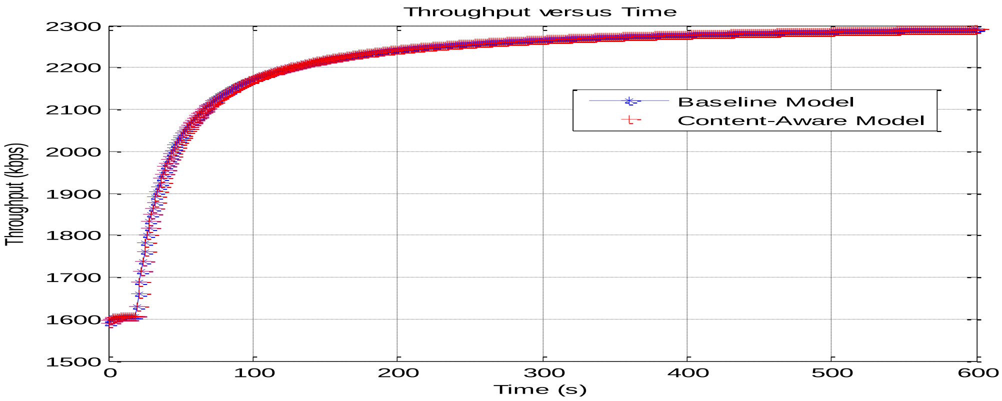
(a)

(b)

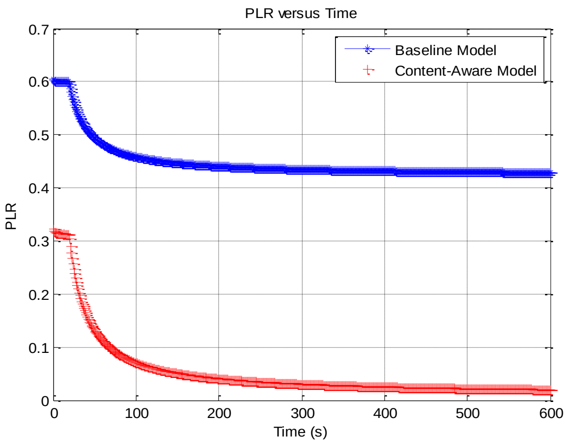
(c)

Fig. 3 Output performance for uplink video delivery at UE velocity of 50 km/h. (a) Throughput against time (b) Packet loss ratio against time (c) Average delay against time

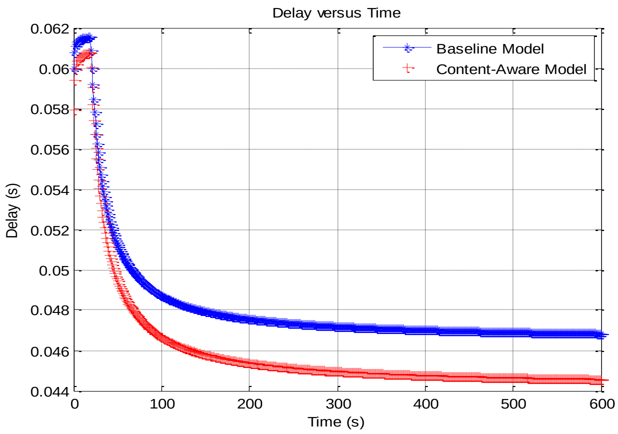
Again, the much better performance of the content-aware model in the uplink video delivery is further supported by the same content-aware model in the downlink video transmission as indicated in Fig. 4. Over the 10-minute simulation and for the same amount of throughput, the content-aware model totally outperforms its counterpart, the baseline model with a 87.9% improvement in packet loss ratio and a significant 4.4% gain in average delay. This means that by employing content-aware model, we can avoid a great deal of bandwidth wastage and also preserve the QoS of the video streaming application, as opposed to the baseline model where the QoS could be effectively compromised. In short, it can be summarized that the Content-Aware RRM model produces much better performance than the Baseline Model in either the uplink or downlink video transmission.



(a)



(b)



(c)

Fig. 4 Output performance for downlink video delivery at UE velocity of 50 km/h. (a) Throughput against time (b) Packet loss ratio against time (c) Average delay against time

5. Conclusion

In conclusion, a content-aware RRM model by employing cross layer optimization with the proposed look-up tables for single cell LTE system is proposed for both downlink and uplink video packet transmissions. The results have indicated that for the same amount of throughput, the proposed content-aware RRM model has vastly outperformed the LTE baseline model in terms of packet loss ratio, as well as providing significant gain in terms of average delay. Thus, the proposed model is highly recommended to be used in the current LTE-Advanced system to further improve video delivery performance.

Acknowledgments

The author would like to thank Universiti Teknikal Malaysia Melaka for sponsoring his PhD study.

References

[1] K. I. Pedersen, T. E. Kolding, F. Frederiksen, I. Z. Kovacs, D. Laselva, and P. E. Mogensen, "An overview of downlink radio resource management for UTRAN long-term evolution," *IEEE Communications Magazine*, 2009, pp. 86–93.

[2] 3GPP RAN Workshop on IMT-Advanced, Shenzhen, China, 07-08 April 2008, available at ftp://ftp.3gpp.org/workshop/2008-04-07_RAN_IMT_Advanced/Docs/.

[3] S. Kumar and N. Marchetti, "IMT-Advanced: Technological requirements and solution components," *Second International Workshop on Cognitive Radio and Advanced Spectrum Management,* 2009, pp. 1-5.

[4] S. Parkvall and D. Astely, "The Evolution of LTE towards IMT-Advanced," *Journal of Communications*, Vol. 4, No. 3, 2009, pp. 146-154.

[5] M. K. Ismail, M. S. Johal and A. Awang Md Isa, "Current Developments in LTE-ADVANCED: Radio Resource Management Review," *Proceedings of IEEE Student Conference on Research and Development (SCOReD 2014)*, 2014.

[6] R. Radhakrishnan, B. Tirouvengadam, and A. Nayak, "Cross Layer Design for Efficient Video Streaming over LTE Using Scalable Video Coding," *Network Protocols and Algorithm*, Vol. 4, No. 4, 2012, pp. 6509-6513.

[7] H. Luo, S. Ci, D. Wu, J. Wu, and H. Tang, "Quality-Driven Cross-Layer Optimized Video Delivery over LTE," *IEEE Communications Magazine,* 2010, pp. 102–109.

[8] S. Karachontzitis, T. Dagiuklas, and L. Dounis, "Novel Cross-Layer Scheme for Video Transmission over LTE-Based Wireless Systems," *IEEE International Conference on Multimedia and Expo (ICME 2011)*, 2011.

[9] D. Wang, V. S. Somayazulu, and J. R. Foerster, "Efficient Cross-layer Resource Allocation for H.264/SVC Video Transmission over Downlink of an LTE System," *IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWWMoM)*, 2012.

[10] M. S. Johal, G. Markarian, A. Awang Md Isa, and Y. Dasril, "Content-Aware Radio Resource Management for IMT-Advanced", *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, Vol. 9, Issue 2, 2017, pp. 125-131.