A Frequency Efficient Packet Scheduling For 3GPP Long Term Evaluation down Link

Radandi naresh[1], Abdul Wasay [2], Parameshwar[3]

#P.G scholar (M.tech), Lords Institute of Engineering & technology

Assistant prof, Lords Institute of Engineering & technology

H.O.D (E.C.E) ,Lords Institute of Engineering & technology

***Abstract*—** This paper describes the main activities involved in defining 4G technologies within the International Telecommunications Union (ITU) under the IMT-Advanced banner, the work of the Third-Generation Partnership Project (3GPP) towards LTE-Advanced. We formalize a general FrequencyDomain Packet Scheduling (FDPS) problem for 3GPP LTEDownlink (DL). The DL FDPS problem incorporates the Single-User Multiple Input Multiple Output (SU-MIMO) technique, and can express various scheduling policies, including the *Proportional-Fair* metric, the *Max Weight* scheduling, etc. In Rel 7, 3GPP standardized HSPA Evolution (HSPA+) which was specified to deliver maximum user data rates up to 42 Mbps by using dual Carrier Aggregation and 64 QAM in the Downlink. Although Long Term Evolution (LTE) network performance was studied by other researchers, the aim of this paper is to analysis the performance of LTE advanced and HSPA in different spectrum bands to meet the International Mobile Telecommunications Advanced (IMT-Advanced) requirements.

***Keywords*—** frequency domain packet scheduling (FDPS), HSPA, LTE, IMT, ITU, 3GPP and QAM.

I. INTRODUCTION

Mobile broadband is expected to contribute substantially to acontinued spreading of Internet access; either as complementto, or substitute for, wire-line broadband access. Similar to theformidable success of mobiletelephony, it is envisaged that the3rd Generation Partnership Project (3GPP) family of standardswill contribute substantially to a high penetration of mobilebroadband globally. While GSM/GPRS/EDGE has been themost successful system for mobile telephony and rudimentarydata access, and LTE is an attractive technology in the longerterm, High Speed Packet Access (HSPA) – including High Speed Downlink Packet Access (HSDPA) and High SpeedUplink Packet Access (HSUPA; also known as EnhancedUplink, or EUL) – will in many markets be the primary mobile broadband technology for the next decade.After its launch in 2005/2006, HSPA is today (2009) aglobal success with commercial deployments in more than 100countries [1, 2, 3]. The number of HSPA subscriptions exceeds 80millions and show an accelerated growth, which will lead togreater economies of scale and thereby increased affordabilityof mobile broadband services for different markets, customersegments, and applications.

It is precisely that this increasing market demand and itsenormous economic benefits, together with the new challengesthat come with the requirements in higher spectralefficiency and services aggregation, raised the need to allocatenew frequency channels to mobile communications systems.That is why the ITU-R WP 8F started in October 2005 the definition of the future Fourth GenerationMobile (4G), alsoknown as International Mobile Telecommunications (IMTs)Advanced, following the same model of global standardizationused with the Third Generation, IMT-2000. Theobjective of this initiative is to specify a set of requirementsin terms of transmission capacity and quality of service,in such a way that if a certain technology fulfills all theserequirements it is included by the ITU in the IMT-Advancedset of standards. This inclusion firstly endorses technologiesand motivates operators to invest in them, but furthermoreit allows these standards to make use of the frequency bands.

The race towards IMT-Advanced was officially started inMarch 2008, when a Circular Letter was distributed askingfor the submission of new technology proposals [4]. Previousto this official call, the 3rd Generation Partnership Project (3GPP)established the Long Term Evolution (LTE) standardizationactivity as an ongoing task to build up a framework forthe evolution of the 3GPP radio technologies, concretelyUMTS, towards 4G. The 3GPP divided this work into twophases: the former concerns the completion of the first LTEstandard (Release 8), whereas the latter intends to adaptLTE to the requirements of 4G through the specificationof a new technology called LTE-Advanced (Release 9 and10). Following this plan, in December 2008 3GPP approvedthe specifications of LTE Release 8 which encompassesthe Evolved UTRAN (E-UTRAN) and the Evolved Packet Core (EPC).Otherwise, the LTEAdvanced Study Item waslaunched in May 2008, expecting its completion in October2009 according to the ITU-R schedule for the IMT-Advancedprocess. In the meantime, research community has beencalled for the performance assessment of the definitive LTERelease 8 standard.

Actually, several papers deal with the performance evaluationof LTE. However, up to date this assessment has beenpartially done because of one of

these two reasons. First,some of these works only focused on the physical layer,leaving out the retransmission processes and error correction[6–10]. System level analysis needs MAC layer performanceinformation and cannot be carried out with only a physicallayer characterization. Second, other papers assessing theperformance of LTE radio access network assumed idealchannel estimation, which results in an optimistic estimationof LTE capacity [11–13].
This paper describes the main characteristics of LTERelease 8 and evaluates LTE link level performance consideringa transmission chain fully compliant with LTE Release8 and including realistic HARQand turbo-decoding. Besides the capacity of LTE systems is analyzed in terms ofmaximumachievable throughput and cell capacity distribution in aconventional scenario. These studies allow having a roughidea on the benefits and capabilities of the new standard.Finally, this paper offers an overview of the current researchtrends followed by 3GPP in the definition process of LTEAdvancedthus foreseeing the main characteristics of nextgeneration mobile.

II. SYSTEM MODEL

A.HSPA Analysis

In this section briefly describe the impact of Multi-CarrierHSPA on radio access network architecture & protocols andthe user equipment. Focus is on Dual-Carrier HSDPA,standardized in 3GPP Release 8, but the concept is readilyextendable to uplink and beyond two carriers in downlink.If both the network and the user equipment are capable ofDual-Carrier HSDPA operation, the network will be able toconfigure the user equipment not only with a (primary) servingcell but also with a secondary serving cell originating from thesame base station but on an adjacent carrier frequency.From the point of view of the user equipment, only theprimary serving cell has a corresponding uplink channel, andnon-HSDPA-related information such as the synchronizationchannel (SCH) and transmit power control (TPC) commandsare always mapped to the primary serving cell, never to thesecondary serving cell as shown in the figure 1. However, from a network point ofview, a particular cell can be the primary serving cell for someusers and the secondary serving cell for others. Furthermore,legacy single carrier users can be supported in any cell.The user data processing – including channel coding,interleaving, modulation and hybrid ARQ retransmissionprotocol, as well as the corresponding signaling of relatedphysical layer control information to the user equipment areperformed independently for each one of the two serving cells,meaning that the user can be scheduled independently in thetwo serving cells.

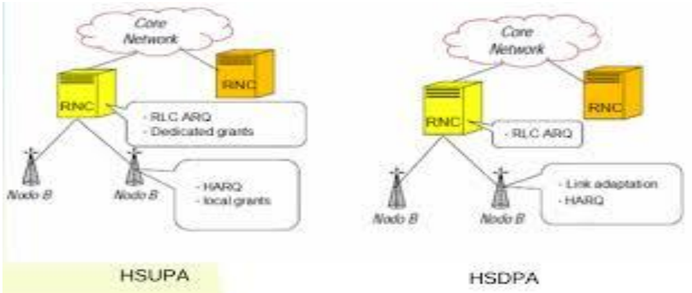

Figure1: HSPA architecture

The introduction of multi-carrier operation opens up thepossibility to exploit an increased system bandwidth forindividual connections, which increases system capacity andthe end-user experience. In particular, assuming *N* carriers, the*N*-fold increase of system bandwidth directly translates to an *N*-foldimprovement of the peak data rate of the system. In fact, given that the transmission power is scaled accordingly suchthat the power spectral density is maintained users served bythe multi-carrier system will experience an *N* -times higher datarate on the physical layer throughout the network. In addition,channel aware scheduling can now operate also in thefrequency dimension, and the opportunity to balance the loadof the carriers *per sub-frame* (2 ms) is introduced.

B. LTE DL SU-MIMO FDPS

We consider a general SU-MIMO FDPS problem for theLTE DL system with *m* RBs and *n* users. In each TTI, foreach set of RBs *a* ($a \in A$ and should be allocated in only onemode $j \in L$), we have a profit $p(a, i, j)$ for each user *i*. Ourgoal is to figure out a feasible FDPS solution in each TTI as shown in figure:2.More specifically, we intend to find the most advantageousway to assign a set *a* ($a \in A$) to user *i* in mode *j* so thatthe total profit is maximized. Thus the LTE DL SU-MIMOFDPS problem is formalized as the following combinatorialoptimization problem.As a matter of fact, the objective function already contains
the constraint that each user is scheduled in only one MIMOmode. Besides, the first constraint in (7) shows that everyRB is assigned to at most one user, and the second constraintensures each user gets no more than one set of RBs. Evidently,problem (7) is a binary integer programming and it is not hardto figure out the PF-FDPS problem studied in [1] is a specialcase of (7). The SU-MIMO FDPS algorithm aims at findinga subset of $A \times N \times L$ which maximizes the total profit in each TTI.

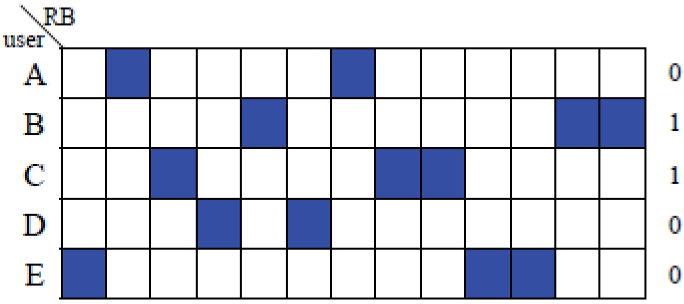

Fig. 2: A feasible SU-MIMO FDPS example for the LTE DL

C.LTE-Advanced and the Fourth-Generation Mobile

3GPP Long Term Evolution is the name given to the newstandard developed by 3GPP to cope with the increasingthroughput requirements of the market. LTE is the nextstep in the evolution of 2G and 3G systems and also inthe provisioning of quality levels similar to those of currentwired networks.3GPP RAN working groups started LTE/EPC standardizationin December 2004 with a feasibility study for anevolved UTRAN and for the all IP-based EPC.Besides, EPC functionalspecifications reached major milestones for interworkingwith 3GPP and CDMA networks. In 2008 3GPP workinggroups were running to finish all protocol and performancespecifications, being these tasks completed in December 2008hence ending Release 8.The process of defining the future IMT-Advanced familywas started with a Circular Letter issued by ITU-R callingfor submission of candidate Radio Interface Technologies (RITs) and few candidate sets of Radio Interface Technologies (SRITs) for IMT-Advanced. However, all documentsavailable in that moment concerning IMT-Advanced didnot specify any new technical details about the propertiesof future 4G systems. Instead, they just reference the Recommendation M.1645, in which the objectives ofthe future development of IMT-Advanced family was barelydefined: to reach 100Mb/s formobile access and up to 1Gb/sfor nomadic wireless access. Unfortunately, it was not until November 2008 when the requirements related to technical performance for IMT-Advanced candidate radio interfaces were described [20]. If you look at the Home eNode B (Femtocell) architecture, the HeNB is connected to its gateway which in turn is connected to MME/S-GW. There is a considerable amount of technology investment in this approach. The HeNB consists of complete protocol stack, the HeNB-GW is an expensive piece of equipment and there are lots of other things including the management software, etc.

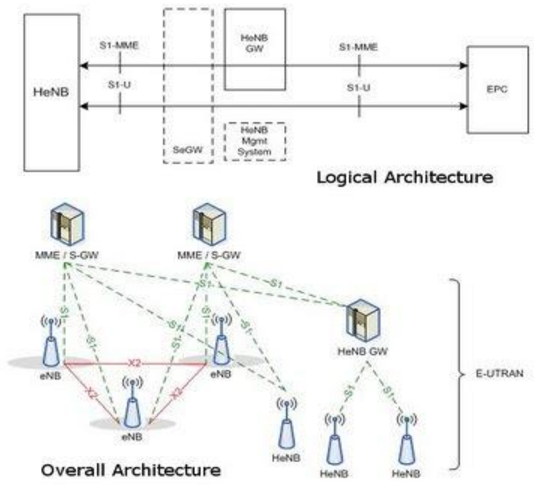

Figure3: LTE architecture

Figure 3.represents a high-level viewof LTE architecture. This is a snapshot of the part that mostclosely interactswith the UE, or mobile device. The entire architectureismuch morecomplex;acomplete diagramwould showtheentire Internet and other aspects of network connectivitysupporting handoffs among 3G, 2G, WiMAX, and other standards. This particular device shows the eNodeB,which is anothername for the base station, andthe interfacesbetween the eNodeB and UEs.The E-UTRAN is the entire network,which is the “official” standards name for LTE.

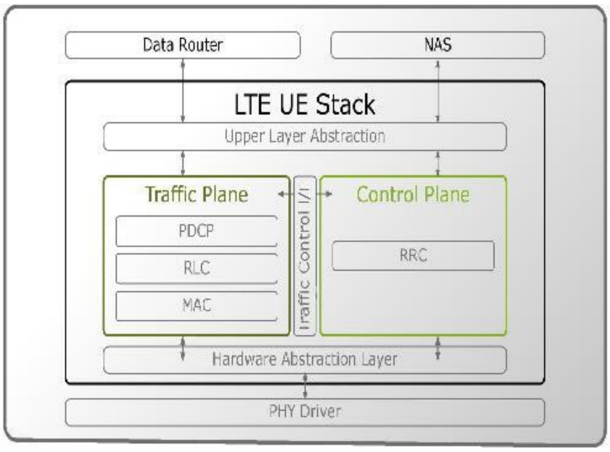

Figure4: LTE protocol stack

The figure 4 represents all the mandatory and optional features stated in the latest version of the 3GPP LTE standard. This grant UE chip manufacturers a complete interoperability with the LTE ecosystem. "With a highly skilled on-site support team and a standardized design that exactly fits with the customer needs and "chip-friendly" protocol stack that gives them the chance to be the first into the LTE market."

III. SIMULATION RESULTS

In figure 4 the average user throughput is plotted as afunction of offered load (average sector throughput). Theperformance is depicted for different number of carriers forsingle-carrier HSDPA and Multi-Carrier HSDPA systems, respectively. Up to the points where systems become severelycongested (and user throughput approaches 0 Mbps), the Multi-Carrier HSDPA system configurations with *N* carriers bring theexpected *N*-fold gain in average user throughput as comparedto the single carrier HSDPA system with an equal number ofcarriers.

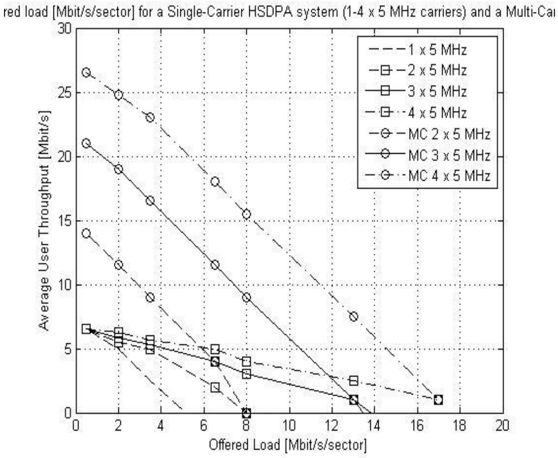

Figure 4: Average user throughput [Mbit/s] as a function of offered load[Mbit/s/sector] for a Single-Carrier HSDPA system (1-4 x 5 MHz carriers) and a Multi-Carrier HSDPA system (2-4 x 5 MHz carriers), respectively

The gain can also be expressed in terms of supportedoffered load for a given quality of service level. From this pointof view, the gain of Multi-Carrier HSDPA is a decreasingfunction of fractional load. However, we believe that from anend-user experience point of view, the gain seen in userthroughput at given offered load should in the context ofmobile broadband access services be the most important toconsider when assessing the gain of Multi-Carrier HSDPA.Moreover, it is interesting to note that Multi-CarrierHSDPA will increase the user throughput by a factor *N*-throughout the system coverage area; that is, even at the celledge. This fact is illustrated in figure 5, which shows the CDFof user throughput for a system composed of 2 carriers and anoffered load of 6.4 Mbit/s/sector.

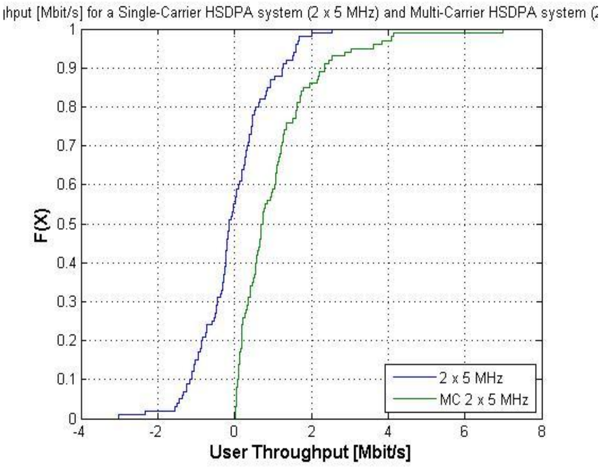

Figure 5: Empirical Cumulative Distribution Function (CDF) of userthroughput [Mbit/s] for a Single-Carrier HSDPA system (2 x 5 MHz) andMulti-Carrier HSDPA system (2 x 5 MHz), respectively. The offered loadequals 6.4 Mbit/s/sector.

In LTE downlink, according to the results shown inFigure 6, MIMO 4 × 4 scheme provides a clearly betterperformance than the other schemes for almost all theuseful SINR margin. Nevertheless, MIMO 2×2 scheme doesnot provide an important performance improvement untilSINR reaches a value of 15 dB. Also, it can be observedthat improvement factor in peak throughput due to MIMOschemes is far from being equal to the number of antennas (2or 4). Instead, peak throughput is multiplied by 1.7 and 3.6in MIMO 2×2 andMIMO4×4 respectively. This is basicallydue to the higher quantity of reference signals needed in theMIMO schemes.

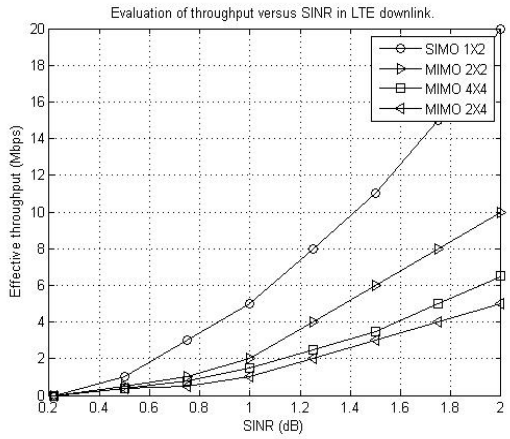

Figure 6: Link level evaluation of throughput versus SINR in LTEdownlink.

IV. CONCLUSION

The evolution ofHSPA towards higher rates has inthis paper been discussed with emphasis on the possibility touse multiple carriers simultaneously for individual users;socalled multi-carrier operation, or Multi-Carrier HSPA.Based on these results, this paper concludes that LTE will offer peak rates of more than 150 Mbps in the downlink and 40Mbps in the uplink with 10MHz bandwidth. Besides, in the downlink the minimum average throughput will be around 30Mbps, which represents a quite significant improvement in the cellular systems performance. As compared with current cellular systems, LTE entails an enhancement of more than six times the performance of HSDPA/HSUPA. This analysis allows those who are interested in wireless communications to get aligned with theresearch community towards the definition and optimization of next Fourth-Generation mobile.

REFERENCES

[1] UMTS Forum, URL: www.umts-forum.org, accessed 2009-01-28

[2] Johan Bergman et al, "HSPA Evolution – Boosting the performance ofmobile broadband access", Ericsson Review, No 1, 2008, availablewww.ericsson.com

[3] Johan Bergman et al, "Continued HSPA Evolution of mobilebroadband", Ericsson Review, No 1, 2009, available www.ericsson.com3GPP TR 25.825, "Dual-cell High Speed Downlink Packet Access(HSDPA) operation", V1.0.0 (2008-05).

[4] ITU-R Circular Letter 5/LCCE/2, "Invitation for submissionof proposals for candidate radio interface technologies forthe terrestrial components of the radio interface(s) for IMTAdvancedand invitation to participate in their subsequentevaluation," March 2008.

[5] J. J. S´anchez, D. Morales-Jim´enez, G. G´ omez, and J. T.Enbrambasaguas, "Physical layer performance of long termevolution cellular technology," in *Proceedings of the 16thIST Mobile and Wireless Communications Summit*, pp. 1–5,Budapest, Hungary, July 2007.

[6] A. Osman and A. Mohammed, "Performance evaluation of alow-complexity OFDM UMTS-LTE system," in *Proceedings ofthe IEEE Vehicular Technology Conference (VTC '08)*, pp. 2142–2146, Singapore, May 2008.

[7] K. Manolakis, A. Ibing, and V. Jungnickel, "Performanceevaluation of a 3GPP LTE terminal receiver," in *Proceedingsof the 14th European Wireless Conference (EW '08)*, pp. 1–5,Prague, Czech Republic, June 2008.

[8] C. Spiegel, J. Berkmann, Z. Bai, T. Scholand, and C. Drewes,"MIMO schemes in UTRA LTE, a comparison," in *Proceedingsof the IEEE Vehicular Technology Conference (VTC '08)*, pp.2228–2232, Singapore, May 2008.

[9] N. Wei, A. Pokhariyal, C. Rom, et al., "Baseline E-UTRAdownlink spectral efficiency evaluation," in *Proceedings of theIEEE Vehicular Technology Conference (VTC '06)*, pp. 2131–2135, Montreal, Canada, September 2006.

[10] P. Mogensen, W. Na, I. Z. Kov´acs, et al., "LTE capacitycompared to the shannon bound," in *Proceedings of the 65thIEEE Vehicular Technology Conference (VTC '07)*, pp. 1234–1238, Dublin, Ireland, April 2007.

[11] 3GPP TR 25.913, "Requirements for Evolved UTRA (EUTRA)and Evolved UTRAN(E-UTRAN),"v.8.0.0,December2008.

[12] 3GPP TR 25.814, "Physical layer aspects for evolved UniversalTerrestrial Radio Access (UTRA)," September 2006.

[13] 3GPP R1-070674, "LTE physical layer framework for performanceevaluation," February 2007.