# Effective ARP Based Call Admission Control (CAC) Scheme for LTE Systems

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***Abstract*-- In wireless communication technologies like GSM, WCDMA, LTE, etc. Radio is stressed by the various traffic conditions, in terms of radio resources to provide the admission of new calls and required QoS. There are situations and scenarios, where the load takes unprecedented conditions and as part of services the requirements may change, like to improve on non-blocking calls though recessing on Quality of Service (QoS). Though such situations and scenarios are intermittent and last for limited periods of time, the importance of services becomes operator's credentials. We propose a top-up algorithm, which does not interfere with existing admission control mechanism in direct way, but provide them with effective Allocation and Retention Priority (E-ARP) for each call. This algorithm is based on "inferences and intensions based combinational logic". It works on the system specific inferences of certain parameters and intentional classification of existing and new demands based on weightage-based combinational logic, which results in modification of ARPs into effective ARPs. For evaluation of proposed Admission Control (AC) scheme blocking and outage probability of calls is used as performance metrics**.

***Keywords – LTE, RRM, Admission Control, Effective ARP, SON, Self organizing networks, scheduling algorithms, spectral efficiency, next generation networks, NGN, radio resource management, combinational logic, inferences and intentions.***

## I. INTRODUCTION

The task of radio admission control is to admit or reject a new connection request referred to as a call, depending on whether the required QoS of the new call request will be fulfilled. Each call request has its own ARP value, which describes its relative importance for admission and retention. In the proposed scheme we deduce effective ARP (EARP) for each call based on our top-up algorithm. The algorithm modifies the relative importance of the calls based on their inferred impact on the system and intentional bias for the services.

In industry perspective, admission control mechanisms are provided through vendor specific algorithms. There are various kinds of scheduler algorithms [4][5], available in LTE systems, like Proportional Fair, Modified Largest Weighted Delay First, and Exponential Proportional Fair etc. These algorithms take best use of system and resources for the specific load conditions. With the advancement of radio technologies like LTE, the spectrum efficiency of the system is of much concern from the vendors perspectives; that is to say, to provide maximum throughput with the limited resources within a system. The operators are also compelled for it, as for the sake of maximum Return on Investment (ROI). Such algorithms or scheme for admission controls become efficient in best possible scenarios. Though from a service provider perspective, the scenario changes with respect to many factors like multiplicity of applications and devices, geo-position, time, whether, social events, natural events, power conditions and so on. An operator need to plan his services as per, to retain his credentials. Some time may have to be intentionally biased, like compromise on QoS, service outage, blocking of calls, etc.

For LTE networks, where the resources are allocated through shared channels and various adaptations like link adaptation etc. The efficiency of schedulers could be improved through statistical measures of various parameters. These parameters, with respect to each call, could be made available at single point to take an inference for system specific impact of the call. We have taken into consideration QoS Class Identifier (QCI) [7], Allocation and Retention Priority (ARP) [7], Guaranteed Bit Rate (GBR) [7], Aggregate Maximum Bit Rate (AMBR) [7], Channel Quality Indicator (CQI) [1] and Buffer Status Report (BSR) [1], as parameters for inferences.

With the help of EARP based admission control we would be able to create intentional models, for the service credentials. As for evaluation here we use an intentional model, to reduce the blocking and outage probability, in simulated LTE set up.

The rest of the paper is organized as follows. Section II provides the inference specifics of system parameters used for the proposed algorithm. Section III gives the description of combinational logic for deduction of effective ARP. Section IV contains the advantages of algorithm. Section V of the paper evaluates the proposed algorithm, for the specific intentions like blocking probability, outage and cell throughput. Section VI concludes the paper.

## II. INFERENCES SPECIFICS

There are various algorithms [4][5] as part of Radio Resource Management (RRM) functionality. These algorithms provide admission control and resources, based on the availability and demands. Though such algorithms take care of best and efficient use of resources and system, but the traffic load on the system is not always under the controlled variations.

This algorithm approach helps to create intentional bias for exiting scheduler and to cater unprecedented traffic conditions.

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This is an inferences-based and intension-based algorithm. This algorithm will be effective into the systems, where the inferences for the given parameters could be rated fairly on a fixed linear scale. These inferences are basically system specific impacts, with respect to parameters taken for the inference, for particular call.

The specifics, to take inferences from the given parameters in LTE networks, are being expressed in the following way.

### *A. Allocation and Retention Priority (ARP)*

The priority level defines the relative importance of a resource request; values 1 to 15 are defined, with value 1 as the highest level of priority.

### *B. QoS Class Identifier (QCI)*

The QCI label for a bearer determines how it is handled in the eNodeB. It is defining the packet forwarding requirements, through packet delay budget, and acceptable packet loss rate. This parameter could be inferred as real time traffic requirements. Table 1 provides standardized QoS in LTE networks, as given below.

Table 1. Standard QoS Identifier for LTE [5]

| QCI | Bearer Type | Priority | Packet Delay | Packet Loss | Example |
|---|---|---|---|---|---|
| 1 | GBR | 2 | 100 | $10^{-2}$ | VoIP Call |
| 2 | | 4 | 150 | $10^{-3}$ | Video Call |
| 3 | | 3 | 50 | | Online Gaming (Real Time) |
| 4 | | 5 | 300 | $10^{-6}$ | Video Streaming |
| 5 | Non-GBR | 1 | 100 | | IMS Signaling |
| 6 | | 6 | 300 | | Video, TCP based services e.g., email, chat, ftp, etc. |
| 7 | | 7 | 100 | $10^{-3}$ | Voice Video Interactive gaming |
| 8 | | 8 | 300 | $10^{-6}$ | Video, TCP based services e.g., email, chat, ftp, etc. |
| 9 | | 9 | | | |

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### *C. Aggregate Maximum Bit Rate (AMBR)*

Each call would be having AMBR. The demand for the radio resource, for that call, would be inferred based on the existing load for AMBR. For higher Load the individual call impact for radio resource would be less.

### *D. Guaranteed Bit Rate (GBR)*

Each call with specified GBR could be inferred as reservation for radio resources. Call with higher GBR value will require more resources in comparison with the calls with lower GBR.

### *E. Channel Quality Indicator (CQI)*

CQI reports, the channel conditions. The value ranges from 1 to 15, where 15 indicate the most efficient. We can infer it like more data can be transferred using less resource blocks for a UE, which reporting higher CQI. The eNodeB can use higher Modulation and Coding Scheme (MCS) to send the data. Spectral efficiency increases with higher MCS as shown through Figure 1, which provides standard data with respect to SNR.

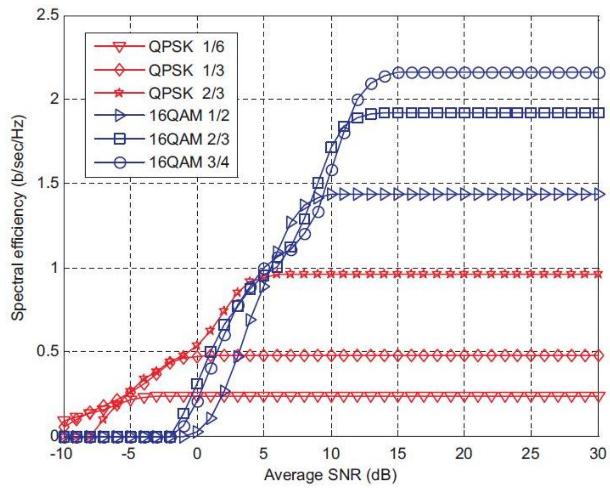


Figure 1. Spectral efficiency vs. SINR for different MCS [8].

### *F. Buffer Status Report (BSR)*

This is a kind of MAC layer control element, carrying the information, on how much data is in UE buffer to be sent out. The index varies from 0 to 63, where a UE reporting Index 0 indicates no buffered data bytes are available at UE buffer and 63 indicates that more than 150000 buffered data bytes are available at the UE buffer. This can be inferred as UE traffic durability.

## III. CONBINATIONAL LOGIC AND DEDUCTION OF EARP

The concept of EARP is based on the combinational logic. This logic depends on the system specific inferences for the parameters like QCI, ARP, GBR, AMBR, CQI and BSR. The deduction of EARP is done through combinational logic and classification based virtual scheduler, which is biased to intentions given in terms of weightage to parameters inferences.

The inferences could be direct or indirect (conditional, i.e., taking other parameter in consideration under specific conditions) based on the inference function's algorithmic decision.

For example, in some cases, impact on system resources by a call, could be inferred based on the combination of CQI and BSR values reported. So, for User Equipment (UE) reporting better channel condition would require less radio resource blocks for the call, in comparison to one reporting bad channel condition. But, if the buffer (inferred by BSR) that needs to be transmitted for second UE is very small when compared to the buffer of previous UE, in that case, impact on resources has to be the combination of CQI and BSR.

Explicitly stating the above example, it would be that even since low CQI can be inferred as poor impact on system, with intention for spectral efficiency, but could be tolerated to the extent BSR value is low.

That also means to say, that this combinational logic basically isolates the 'extremes' in terms of weightage of impact of individual call on the system. This weightage factor could be again magnified with intention factor, and this eventually helps in classification and deduction of Effective ARP or E-ARP through a virtual scheduler.

So, inferences of any parameter could be a combination of others. This is provided in the form of inferences function, implemented by inferences algorithms, as given below.

$$U_{ij} = f_j\,(J_{ARP}, J_{QCI}, J_{GBR}, J_{AMBR}, J_{CQI}, J_{BSR}) \qquad (1)$$

Function "$f$" takes all the parameters, for the call "i", with actual values and provides inferred value "Uij" for each parameter "j".

The inferred value of each parameter will be weighted with specified intentions with respect to the same parameter. The combined value with respect to all parameters will be used for classification, and that eventually used for the virtual scheduler. This combinational logic could be canonically represented in diagram below.

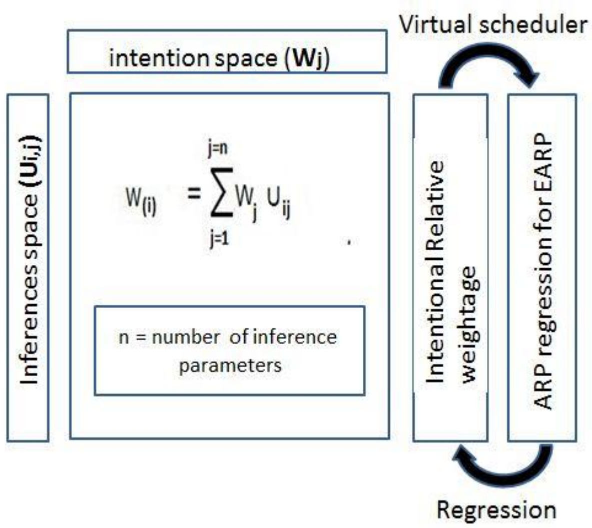


Figure 2. Combinational logic for deduction of E-ARP.

$W_{(i)}$ total weightage of a particular call "i" in the system.

$W_j$ corresponds to the intentional weightage of each parameter "j", e.g. ARP, QCI, GBR, AMBR, CQI and BSR.

$U_{ij}$ inferred value of parameters reported for inference space.

A virtual scheduler implements the logic to provide the EARP values. It works on the resulted weightage ($W_i$) and existing ARP and deduces EARP through classification based regression.

## IV. FORESEEN ADVANTAGE OF THIS MECHANISM

1. Various intentional model could be prepared for various traffic conditions in the system
2. Statistical regression could be performed for the EARP
3. This mechanism is independent of number of parameter and could be used in uplink downlink separately.
4. This mechanism is top-up mechanism, which does not interfere with existing mechanisms but to provide theirs intentional efficiency
5. This may need not to be in the existing RRM but may be in Self Organizing Networks (SON) servers etc.

## V. EVALUATION

This top-up algorithm is evaluated over the network simulator compliant with 3GPP LTE standards [1][2][3] and provide real radio environment as well. This is tested against a particular vendor specific RRM and load is generated with varying system specific conditions. We intend to improve on blocking and outage probability.

Blocking Probability ($P_b$) is defined as the ratio of the number of blocked users to the total number of users requesting admission and retention. Outage Probability ($P_o$) is calculated as the ratio of the number of users not fulfilling their GBR requirement.

In the given simulation, when the peak load is reaching above 40 calls, with various types of traffic, there is sharp increase in blocking rate. After implementing with this top-up algorithm, with traffic specific intentions, a significant drop in blocking call is observed as show in Figure 3.

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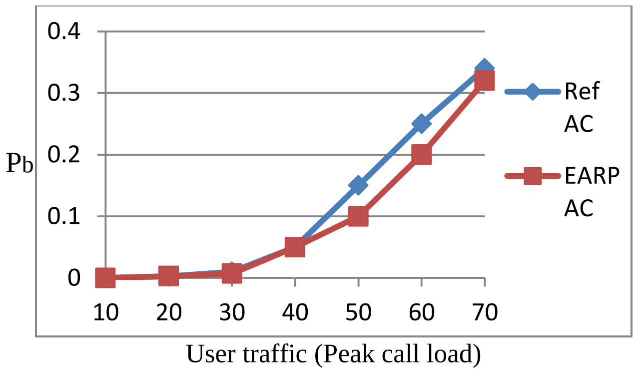


Figure 3. Traffic vs. Blocking Probability Graph.

Similarly, in the given simulation, when the peak load is reaching above 40 calls, there is sharp increase in outage under specific traffic load. After implementing this top-up algorithm, with traffic specific intentions, a significant drop in outage rate is observed as show in Figure 4.

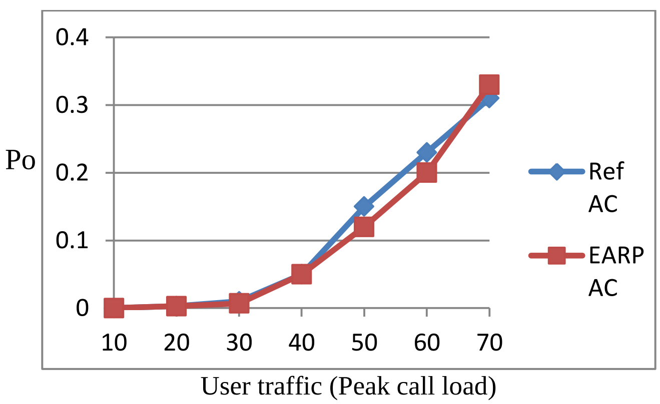


Figure 4. Traffic vs. Outage Probability Graph.

After implementing this top-up algorithm, there is significant improvement found in cell throughput, in almost all the traffic specific load, as shown in Figure 5.

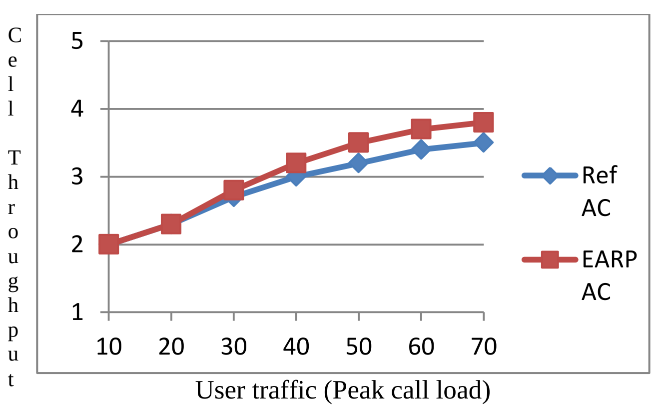


Figure 5. Traffic vs. Average Cell Throughput [Mbps].

The results showcase the significance of this top-up algorithm, in the extreme conditions. As it help to create various intentional models to provide control over unprecedented load conditions.

## VI. CONCLUSION AND FUTURE WORK

The results show that the given EARP based AC, unlike reference AC, is robust and automatically adjusts to the various traffic scenarios, cell load, and user channel conditions. Various models (intentions) can be prepared for different kind of unprecedented traffic statistically. It can also be incorporated in the SON techniques as part of top-up intentional modification and control of existing AC algorithms. Future studies will address to addition of more parameters in the inference space. Such top-up mechanism are being studied for SON perspective and would be developed for traffic load control and RAN selections.

The traffic classifications and traffic conditions are being studied at various levels in the LTE systems and such mechanism could be of help for effective forwarding and prioritizations of classified traffics under various traffic condition scenarios.

## REFERENCES

[1] 3rd Generation Partnership Project; Technical Specification Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification; 3GPP TS36.321 version 10.7.0, Jan. 2013.

[2] 3rd Generation Partnership Project; Technical Specification Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management; 3GPP TS 36.133 version 10.8.1, Oct. 2012.

[3] 3rd Generation Partnership Project; Technical Specification Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); 3GPP TS 36.300 version 10.9.0; Jan. 2013.

[4] H. Holma and A. Toskala, "LTE for UMTS: Evolution to LTE-Advanced", 2nd Edition, Apr. 2011.

[5] S. Sesia, I. Toufik, and Matthew Baker, "LTE – The UMTS Long Term Evolution: From Theory to Practice", 2009.

[6] Y. Fang and Y. Zhang, "Call Admission Control Schemes and Performance Analysis in Wireless Mobile Networks" IEEE Trans. Veh. Tech. vol. 51, no. 2, Mar. 2002

[7] 3rd Generation Partnership Project; Technical Specification 23.203 version 10.8.0 Release 10.

[8] M. Anas, PhD-Thesis; "Uplink Radio Resource Management for QoS Provisioning in Long Term Evolution", Aalborg University, Denmark, Jan. 2009.

[9] K. Spaey, B. Sas, and C. Blondia, "Self Optimizing Call Admission Control for LTE Downlink", 'FP7 ICT-SOCRATES' workshop, Feb. 2010.