Congestion Relief Enhanced ULPC Scheme in LTE Networks for Efficient Power Utilization

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Abstract : we have observed a continuous rapid increment in demand for wireless cellular services (WCS) but the elements of radio resources of a network are remains same, which leads a great criticality in management of Wireless cellular Networks to meet the QOS of all users. There are several limitations that greatly affects the QOS such as network congestion, improper handovers and several types of interferences such as inter channel and inter symbol, fading etc. Congestion limitations are depends on cellular system design where as other depends on radio signal nature. Therefore Congestion Control is the key component of Radio Resource Management to avoid the performance degradation. In this paper we propose a promising technique to solve the QOS degradation problems due to the network congestion by reducing the average cell load. Average Cell Load (ACL) is greatly reduced by exploiting the cell isolation by increasing the user transmit power.

Index Terms - Wireless Cellular Networks (WCN), Radio Resource Management (RMM), Wireless cellular services (WCS), Network congestion, Power control, Average Cell Load (ACL), Quality of Service (QoS), Group mobility, Internet Of Things (IOT).

I. INTRODUCTION

Due to the great proliferation of WCN (Wireless Cellular Networks[1]) and emerge of several new multimedia applications with the Quality of Service[2] (QoS) offers many challenges to wireless network operators such as Network Congestion, fading and improper[3] handovers etc. Therefore the shared resources are have to be managed in a very efficient way by network managers in order to provide a satisfied Quality of Service (QoS) to the end users. Network operators utilizes the concept of Radio Resource management[2] (RRM) to achieve the satisfactory level of Quality of Service (QoS). Congestion Control is one of the most important key point that is managed by RRM.

Network Congestion[1] will occur whenever a base station does not have sufficient bandwidth in its queue to keep the new arrival packets. Network bandwidth generally overloaded due to the access of large number of users at the same time in congested areas. Due to the network congestion, service break down will happen due to the unavailability of resources. In simple words whenever a network links or nodes carrying more data than its capacity Network Congestion will occurs which will greatly effects the packet loss, queueing delay and new connection blocking. Congestion may increase due to the aggressive retransmissions of network protocol to compensate the packet loss. Such type of networks feels a congestion stable state with low throughput known as congestive collapse.

Congestion Control[4] is the network mechanism and techniques aimed towards to reduce the congestion and to keep the network load under network capacity[5]. And the congestion control is divided as Congestion Recovery and Congestion Avoidance. Congestion Recovery means whenever the demand reaches to max the restores the operating state of the network, and Congestion Avoidance means anticipate the congestion and avoid it so that congestion never occurs. Congestion Control and Congestion Avoidance schemes use protocols such as CSMA/CA in 802.11 and CSMA/CD in Ethernet and in TCP.

User group mobility[7] is one of the closest factor that causes Network congestion. The usage of smart devices such as smart mobiles, tablet and IOT devices increasing rapidly today and these devices are utilizing rich data services. In congested areas[8] such as stadiums if most of the devices are trying to access the same mobile bandwidth at same time then bandwidth becomes overloaded and cause services to break down[9] which is another type of congestion loss. Generally the user groups[10] at cell edge required more radio resources than in cell due to link handover procedure[11] and the load impacted in this scenario increases the system load is larger than in LTE. In this paper we propose a stochastic process that uses Up Link Power Control parameters to avoid the congestion due to group mobility. In this proposed scheme to avoid the network congestion due to the group mobility we propose a nominal power parameter to Up Link. Here the cell load is reduced by achieving the cell isolation by increasing the transmit power at Up Link.

II. RELATED WORK

In wireless communication networks QoS is greatly affected by user mobility. And the user mobility affects the communication system at many layers:

- In physical layer[11]: with respective to the location of the user channel characteristics will be varied due to the mounted antenna propagation characteristics.
- In data link layer: with respective to the specific symbol/character of fading radio[12] channel coding will be done in this layer.
- In network layer: signal routing will be done in network layer[14] and this requires localization of the mobile terminal to find the efficient routing.
- In Transport Layer: Anticipation for fluctuation of channel throughput and fading will be performed in transport layer protocol.
- In Presentation Layer: Required spectrum efficiency[15] will be achieved in presentation layer by applying advanced coding techniques.
- In Application Layer: personal mobility and transportation of goods require specific services and facilities.

However the mobility models[16] are depends on application and the several application models will affects the performance of network protocols. Generally in cellular networks BS is situated at the center of the cell and within the service area call will be originated or terminated. Depending the mobile host mobility aggregate traffic will be estimated. There are several mobility models[23] are available today such as Random walk model, Random Gauss-Markov Model, Random mobility model, Random waypoint model[24], etc.

Group mobility[20] refers to the group of mobile hosts in a network and dynamically shares the bandwidth[17], context, data channels, handover schemes and loading information of the network. In real time networks suffers from congestion problem due to the group mobility. In this paper we propose a stochastic scheme that reduces the network congestion caused by group mobility by tuning the Up Link power control parameter. Fractional Power Control Scheme is applied in Up Link in order to avoid the network congestion. The impact of group mobility on QoS is depends on number of mobile terminals per cell and the overall size of cell. Group mobility is broadly classified into 2 categories such as group mobility for infrastructure systems and group mobility for wireless ad hoc networks[30].

III. PROPOSED SCHEME

In this section we describes a self-tuning algorithm based on dynamic fractional adoption of power at mobile equipment. Concept behind the fractional power control scheme is it makes the signal level received by the mobile equipment strong enough to ensure the quality of service by dynamically adjusting the transmitted power by the user equipment. Value of user equipment transmit power P is described as

$$P = min\{P_{max}, P_0 + \propto PL + \Delta_{TF} + f(\Delta_{TPC}) + 10\log_{10} M\} \tag{1}$$

P_{max} refers to the transmit power by the user, Average received signal power per physical resource block is indicated by P_0, $\propto$ is the path loss compensation factor, PL is the total losses due to propagation at the user equipment, M is total number of Physical Resource[21] Block assigned to the user and limited by bandwidth maximum user transmit power, $\Delta_{TF} + f(\Delta_{TPC})$ is dynamic offset. Here we considered path loss compensation $\propto$ as 1.

Control Algorithm:

As shown in equation 1, we will dynamically adjust the transmitted power at user equipment to avoid the network congestion by adjusting the average received signal powerP_0.

Here by increasing the P_0 the transmit power at user equipment is as much as equals to transmit power at base station[29] so that the signal to interference plus noise ratio improves. In LTE higher spectral efficiency is achieved by improving the uplink signal to interference plus noise ration and it is possible by adaptive modulation and coding schemes in data link layer.

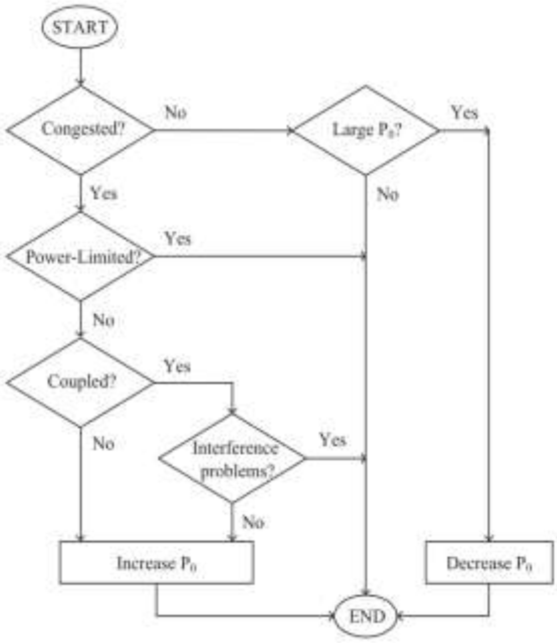

Fig. 1. Flow diagram of the self-tuning algorithm for P0.

Above figure represents the flow diagram of the iteration in a cell. Process starts by the existence of congestion[30] in cell or not. A cell is considered as congested if the ratio of accessibility is less than considered certain threshold value with in the evaluated time period. As per the current cell strategy and if the cell is considered as congested then we need to increase the P_0 if the cell is isolated from the neighbor cells and UL power limited block is small. While increasing the P_0 we have to consider the interference ratio also, there is a certain limitation about the increase in P_0 in order to avoid the interference problems surrounded by other users and cells too. Generally we consider a cell has interference if the unacceptable SINR ration is less than -3 dB, and if this the current cell condition we need to increase the P_0. And finally if the congestion is disappeared we need to reduce the P_0 slightly to the real default value. In this work the ratio of uplink interference received by cell j from users in cell is computed as

$$k(j,i) = \frac{I(j)}{I(j) + N_0(j)} * \frac{HO(i,j).L(i).P_0(i)}{\sum_n HO(n,j).L(n).P_0(n)} \tag{2}$$

And the cell coupling[36] is calculated using radio network planning[33] tools. Cell coupling is little high whenever the total uplink interference level in the interfered cell is well above the noise floor, the number of handovers between cells is large, and the UL load and nominal power in the interfering cell are large. All these data is available in the network management system.

In equation 2, $I(j) + N_0(j)$ is the signal plus interference power which is nothing but total received undesired signal level of the uplink of the cell j, and $N_0(j)$ is the external interference and noise value, HO is the number of hand overs of cell j to neighbor cells, $P_0(n)$ is the nominal power of neighbor cell 'n'.

IV. Results and Analysis

We have implemented the proposed self-tuning algorithm using MATLAB.

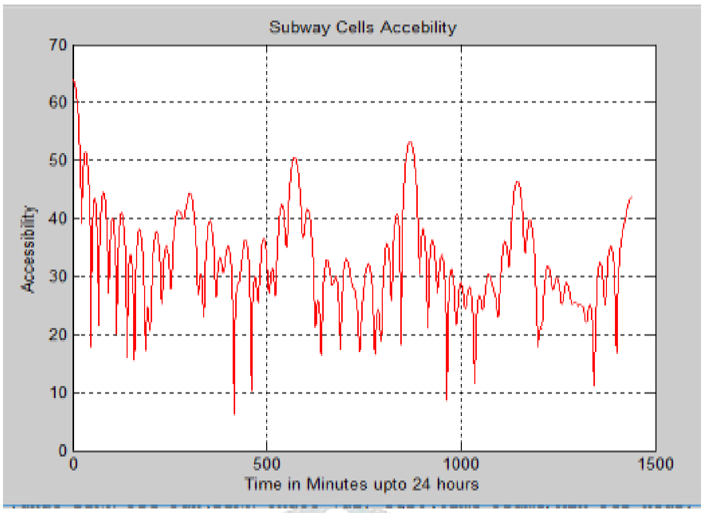

Fig2: Accessibility Ratio at acceptable SINR

Above figure represents the accessibility of users in a congested network at acceptable SINR ratio. We have implemented this for every minute of a day. The number of users that are accessing the congested network shown in the figure for every minute. Whenever the SINR at the user equipment is less than -3dB then the transmitted power at the user equipment will be increase and then will access the network.

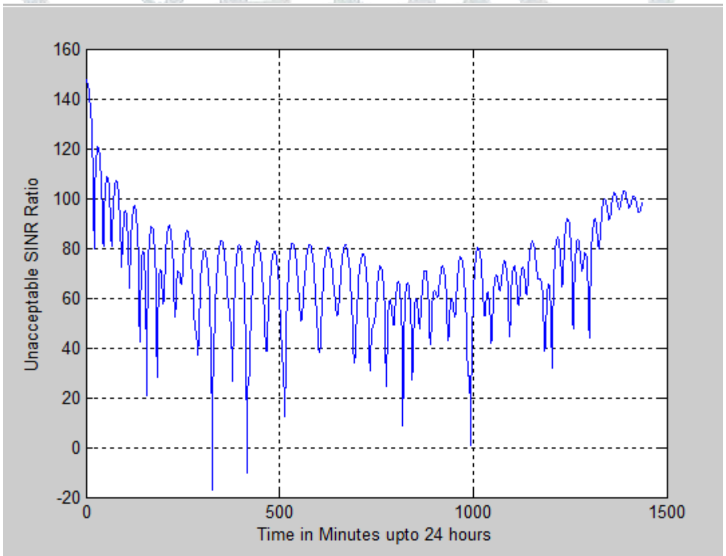

Fig3: Accessibility Ratio at unacceptable SINR

Above figure represents the accessibility of users to a congested network at unacceptable SINR ratio. Whenever the SINR at the user equipment is not reached required level then those mobile equipment will be disconnected from network which means that degradation of QoS.

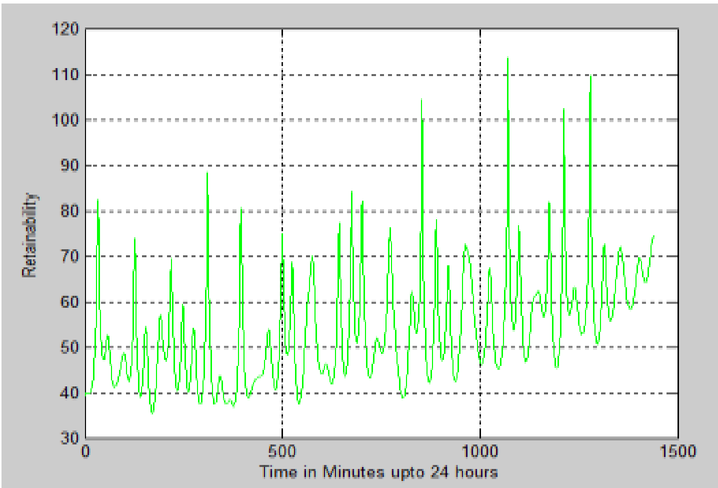

Fig4: Retainability of users

Figure 4 represents the Retainability of users per every minute. As with accessibility, retainability in cells increasing P0 gets closer to that of non-modified cells after the iterations, and retainability degrades after reversion. Retainability values in confirm that connection quality is also degraded during rush hours in subway cells.

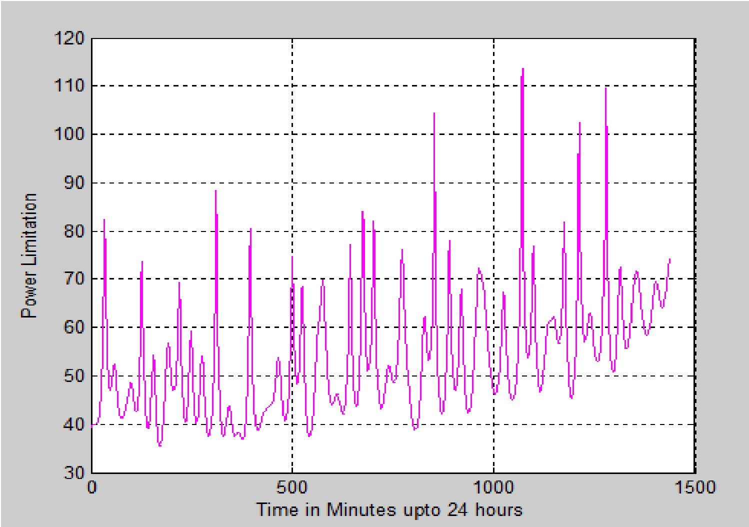

Fig5: UL power limitation

Figure 5 shows that the power-limited user ratio is lower in subway cells than in outdoor cells because of the smaller cell radius and better

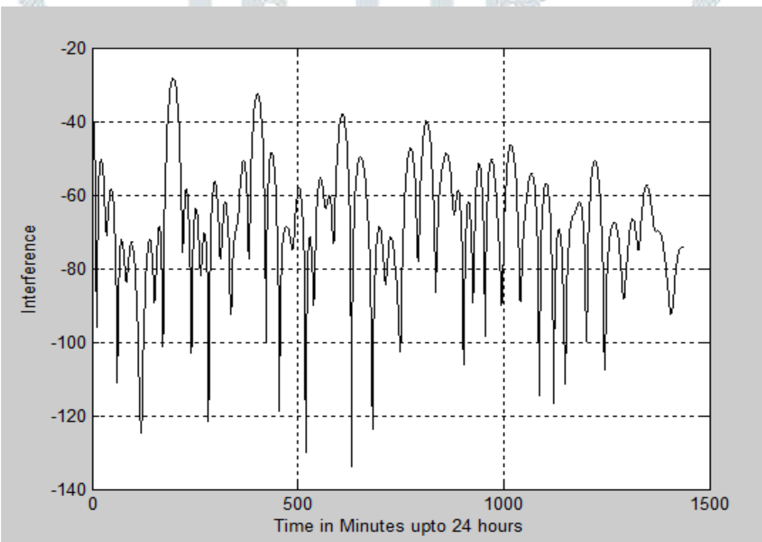

Fig6: Interference per minute.

Figure 6 shows the average UL interference level. Note that peaks observed in accessibility, retainability and UL acceptable SINR Ratio are not reproduced in this figure.

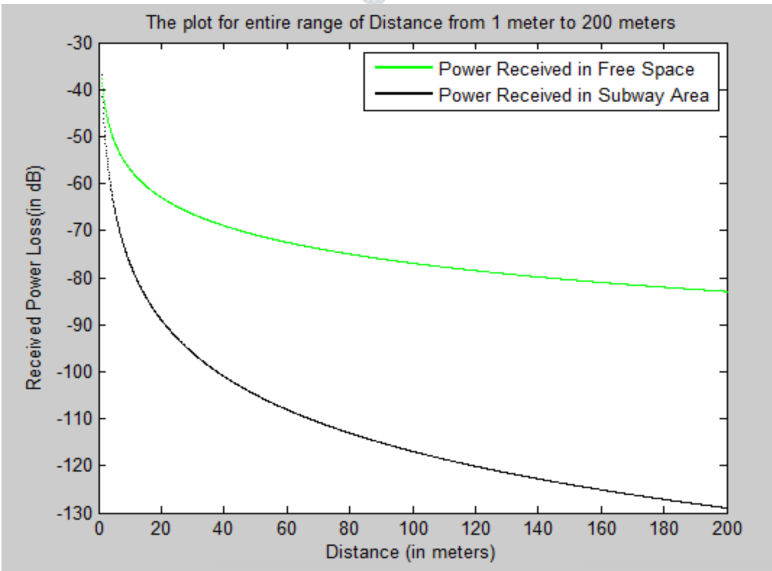

Fig7: Received Power.

Figure 7 represents the comparison between the received power losses at mobile equipment in free space and as well as in congested areas. In above results negative scale represents the power losses due to the mobility of mobile equipment to away from the base station. As simply we know whenever a mobile user moves away from the base station the received signal strength will gradually decreases where it is high in congestion areas.

V. Conclusion

We have discussed analyzed the reasons of network congestion in this work. We have proposed a self-tuning algorithm based on dynamic fractional adoption of power at mobile equipment, however our software analysis results proved the efficiency our proposed scheme in all the perspective views of network like user acceptability, user retainability, user group mobility, power limitation, interference limitation etc. As we addressed the congestion problem at mobile equipment by dynamically adjusting the power levels at mobile equipment increment in power consumption levels will exist. Thus, the transmit power increase produced by the algorithm is partially compensated by the reduction in the transmission time and frequency resources from the increased spectral efficiency. Therefore the further investigations on the concept will be considered to reduce the computational load at mobile equipment

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