Self-Organizing Schedulers in LTE System for Optimized Pixel Throughput Using Neural Network.

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Abstract—**One of the most important requirements for Long Term Evolution (LTE) is to minimize the costs and effort of network planning, optimization and configuration to the lowest possible level, while keeping a very good acceptable performance level which can be achieved by using self-organizing networks (SON) concept. This paper presents an efficient technique to train base station (E-NodeB) in order to choose the most appropriate and optimized scheduler in LTE system for each pixel inside an image using Neural Network technique, which leads to an optimized bandwidth and hence increased capacity. The simulation results using our proposed method using self-organizing assigning scheduler indicate an overall 33% saving in bandwidth as compared to Best Channel Quality Indicator (BCQI) scheduler.**

Keywords: LTE; neural network; Scheduler; image pixel, E-NodeB.

I. INTRODUCTION

Long Term Evolution (LTE) is one of the most advanced mobile cellular telecommunication technology, which is going to be widely spread among users in the coming years [1]. It is desired to have large channels bandwidth up to 20 MHz or even 100 MHz as in LTE advanced [2], with low latency and high spectral efficiency [3] and the peak data rate can go upto50 Mbps in the uplink without using MIMO technology [4]. With OFDM as the radio access technology in the downlink and SC-FDMA in the uplink, LTE has very promising features, such as spectrum flexibility, cost effective migration from current/future 2G/3G systems in addition to less complexity and signaling, auto and self-configuration e-NodeB (i.e. Self-Organizing Network SON Technology) [3][5].

This (SON) feature is so greatly needed, as it minimizes operator cost in the area of planning, configuration, integration, and management of the network by converting most manual and complex configurations into completely automatic self- configuration (less parameter to worry about), self- optimization (less tuning effort), and self-healing (automated recovery and fault isolation) [4].

In fact, SON concept is not limited to planning parameters, but it can be extended to include schedulers, which are responsible for radio shared access coordination in medium access control (MAC) layer. In [6], authors discuss several distributed and centralized scheduling algorithms, which enhance the system performance. They suggest a new centralized scheduling algorithm based on the ratio of wait time and traffic demand in an optimized way (Kind of SON). Their results show that the proposed algorithm can not only get lower average delay similar as LTD, which is another algorithm used in scheduling, but rather keeps the delay of higher traffic demand lower. In [7], authors suggest a new OSA (Optimized Service Aware) scheduling algorithm for LTE, which achieve an acceptable balance between multi-quality of service (QoS) and system performance maximization in a fair situation.

This paper shows how different types of schedulers, which give different throughputs in LTE, can be assigned automatically to different services, and to be much more closer to the real case where schedulers can be changed many times during providing just one service, such as frames inside a video. The smallest component inside a video is chosen, which is pixels inside GIF, PNG, JPEG or any image type or size, even those pictures that are taken with Nokia Pureview 808 smart phone with size reaches up to 41 Mega pixels, these pixels are mapped to different schedulers based on the importance of a color pixel inside an image. Then using neural network (NN) system is trained to choose the best optimized schedulers for whole pixels inside an image. After the training, any new image enters the system, a suitable optimized matrix of schedulers of the same size of the entered image will be generated. The whole process leads to save bandwidth and a better utilization for resources while keeping quality of service as good as possible.

This work introduces a novel technique, that enables E-NodeB in LTE networks to choose the most appropriate schedulers for each pixel inside an image, which may be a JPEG image as this may contain more than 16.7 Giga different Colors, where each pixel is represented by 24 bit (8bit-red, 8bit-green,8bit-blue).

II. SYSTEM DESIGN

The system design is divided into three parts as follows: first, finding schedulers that give different throughput values for different services. Second, building and finding target matrix for the system. Third, training using neural network concept to make the process of assigning schedulers intelligent and automatic.

A. Finding Schedulers.

It is important to know that schedulers are used to provide efficient resource usage, where resources on the physical downlink shared channel (PDSCH) and physical uplink shared channel (PUSCH) are assigned to users and radio bearer on sub-frame basis according to the users momentary traffic demand, Quality of service (QoS) requirements, and estimated channel quality. This task is done by the uplink and downlink schedulers, both situated in the (E-NodeB) [5].

Scheduling is also referred to as Dynamic Resource Allocation (DRA) and is part of the Radio Resource Management (RRM), where there are important interactions with other RRM functions such as power control, link adaptation and inter cell interference control (ICIC) [8].

using the power of LTE system level simulator; developed by Vienna Research Team [9][10], a launcher MATLAB code is prepared to run the simulator in such a way that gives visibility of compared results, that reflect the effect of most schedulers, which are used to provide efficient resource usage, on Key Performance Indicator (mainly on throughput). The relation between various throughput and various schedulers was extracted by using the LTE level simulator [9]. Results of simulation are presented by Figure 1, whose x-axis represents the scheduler type that is used and y-axis represents the throughput.

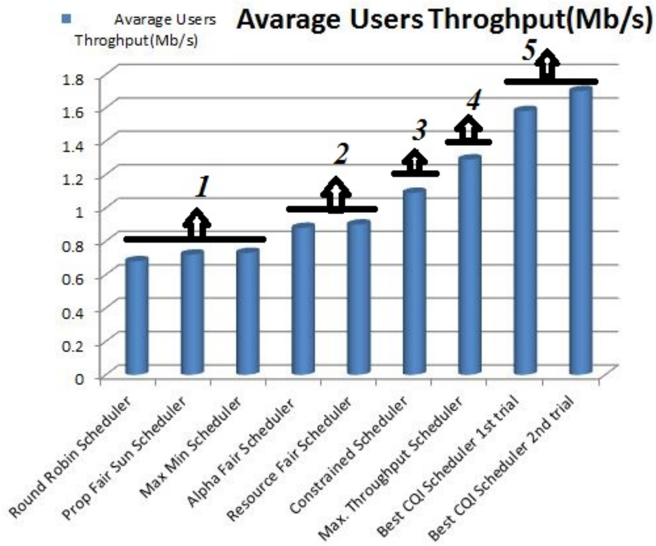

Figure 1: Throughput vs. schedulers when system *bandwidth=3Mhz*

As it is noticed from Figure 1, schedulers are classified into five categories coded by numbers 1, 2, 3, 4, 5 based on throughput values, where code 1 represents a scheduler that gives throughput of about 0.7 (Mb/s), code 2 gives a throughput of about 0.85 (Mb/s) and so on. Keeping in mind that system bandwidth in our case study is equal to (3 MHz), and the number of active attached users to the base station (E-nodeB) is 10 users. This process can be applied for all LTE system bandwidths.

B. Finding Target Matrix

It is desired to obtain the schedulers matrix that fits the input image matrix, this is a major, sensitive and complex step. Hence, it is assumed that only five different schedulers are available leading to five different noticeable throughputs. A question remains about which criteria should be used to assign and map such schedulers. The proposed criteria here depends on visual sight tests to determine the importance of each pixel. Accordingly, the RGB image format is transformed using a conversion algorithm [16] into HSB format (Hue, Saturation, and Brightness) as shown in Figure 2. The main reason is that changing in color is more obvious in this system HSB than RGB [16]. After this process it is possible to determine the importance of pixel inside an image and give it a suitable code for scheduler. Hence, the input and output matrices for a certain image (Penguins.jpeg) are formulated as shown in Figure 3:

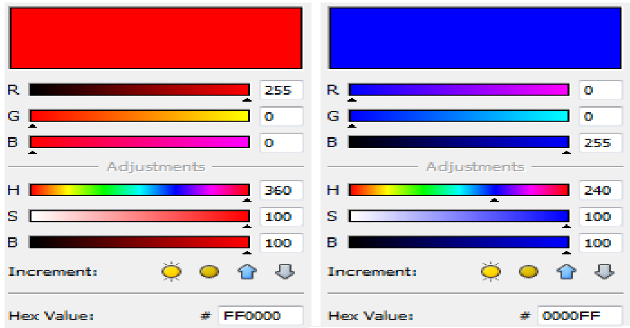

Figure 2: Hex values of two pixels in RGB and HSB color systems.

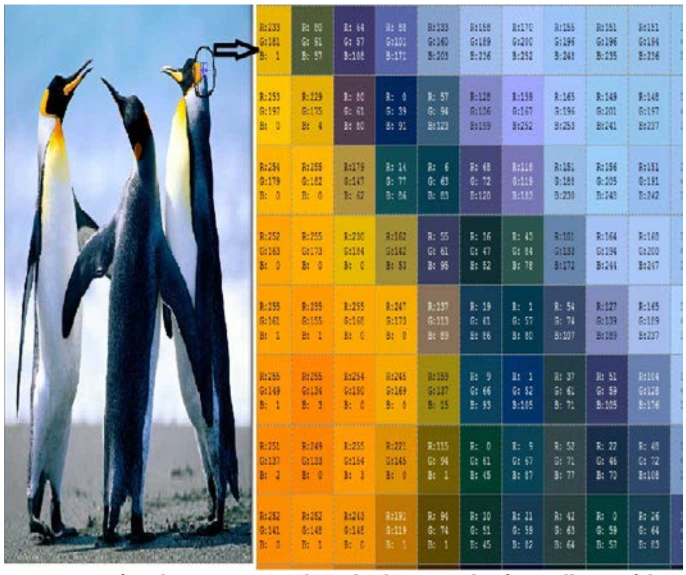

Figure 3: Left is the input image, the right shows pixels of a small part of the left image.

The above image is extracted and converted to large matrix of pixels {1024*768}, each pixel contains values for red, green and blue color, which is converted into their hex or decimal values. We obtained the target matrix (the suitable schedulers for image pixels) by writing a complete switching algorithm based on the values of the Hue, Saturation, and brightness. All of them together determine the importance of a pixel, where we divided the three slider region of each into five areas; each area is given a scheduler that gives a suitable throughput. Keeping in mind that HSB value are extracted from the hexadecimal or decimal value of the input pixel, and then a suitable scheduler is assigned based on that. Finally, we have ended up with two matrices, the first represents the hexadecimal values for image's pixels and the second represents the suitable scheduler's codes for that pixels.

C. Training Network.

In order to generalize the process of assigning schedulers to any future pixels coming from different images, It is required a Neural Network to map between image pixels as an input and schedulers code as an output as illustrated in Figure 4. The problem under consideration is much like a fitting problem [12], such that

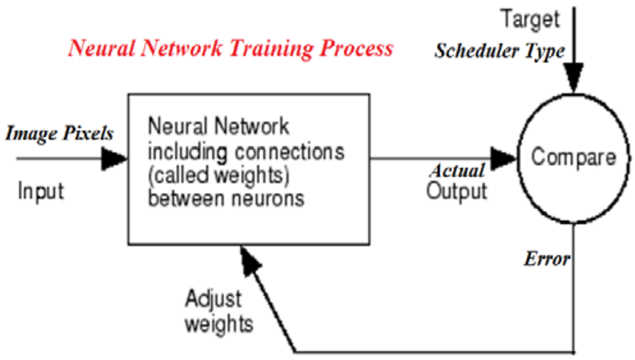

Figure 4: Neural Network System

a two-layered-feed-forward network with sigmoid hidden neurons and linear output neurons, also the network is trained with levenberg-marquardt back-propagation algorithm as shown in Figure 5:

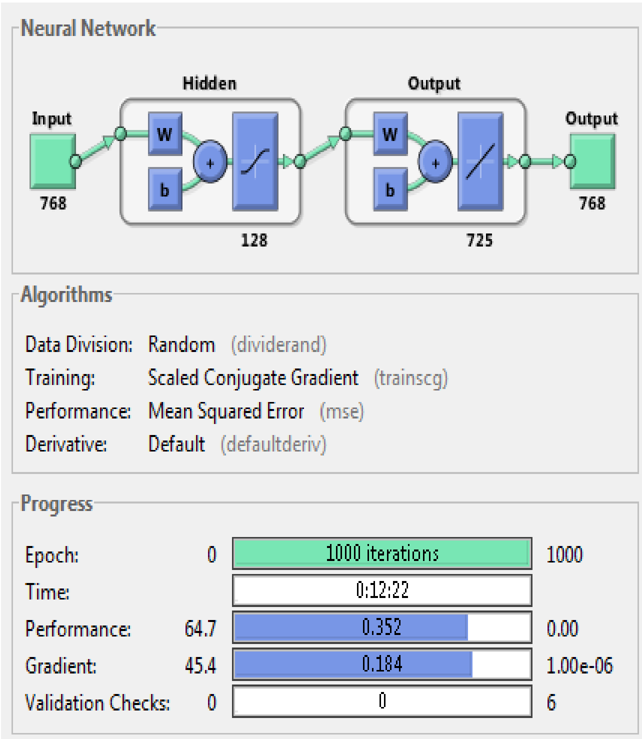

Figure 5: Structure, algorithms and progress of Neural Network

This training (learning) process enables the NN to improve its performance and learn from its environment leading to minimizing the error between the actual output and the desired one, where the training process continues until the difference between actual output and target becomes very small.

III. Simulation Results

As the NN gets trained an image is input to such a system which produces the output as shown in Figure 9, where actual output represents the code of schedulers that give a specific throughput for each pixel inside an image. Such values couldn't be obtained at once but several NN iterations are conducted to get an optimum output. It is important to note that the actual output schedulers for certain input image pixels, without using self-organization technique is just a fixed scheduler type for all pixels, all the time, independent of their sensitivity or importance inside an image, this way leads to either losing quality of image when the assigned scheduler has lower throughput than required, or wasting bandwidth and resources when the assigned scheduler has higher throughput than needed.

Figure 6 shows the overall Mean Square Error (MSE), which represents the average squared error difference between actual output values and target, also Regression values (R), which measures the correlation between the output and target values for training, validation, and testing sample.

	Samples	MSE	R
Training	716	0.35227	0.799951
Validation	154	0.62966	0.659391
Testing	154	0.61828	0.69166

Figure 6: Mean Square Error and Regression values.

The mean square error vs. epochs of NN is shown in Figure 7, and error histogram with 20 bins (bars) is also shown in Figure 8.

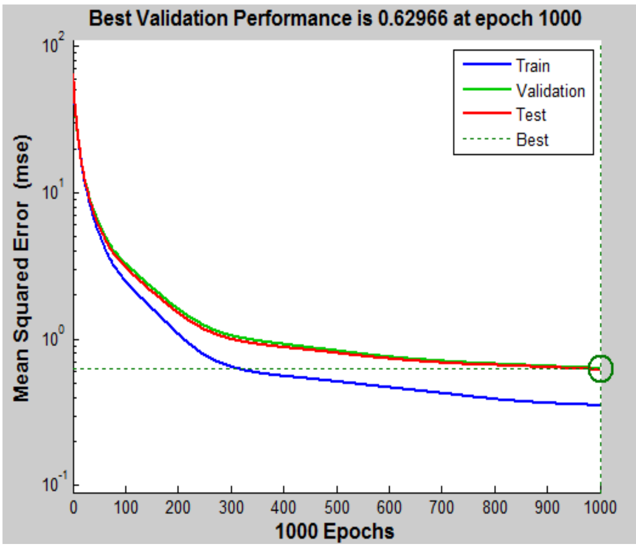

Figure 7: Mean Square Error vs. Epochs number

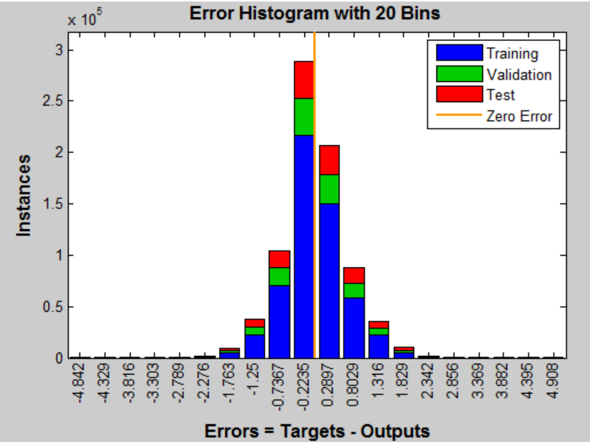

Figure 8: Error Histogram with 20 bins

Now, the NN becomes able to give optimized scheduler codes for any future image pixels. The optimum code value is obtained after some iteration process. To show how optimized scheduling can make the LTE system more efficient, we took a series of pixels and their corresponding assigned schedulers based on our proposed self-organizing scheduler method and compare it with fixed assigned scheduler for the whole chosen pixel which is the default conventional case.

From Figure 9, it can be concluded that when E-nodeB choses self-organizing scheduler (SOS) to assign resources for an image then average throughput values will be changed dynamically based on the coming pixel, while other schedulers will remain constant for the whole pixels in the whole frames of a video. This leads to save up to 0.55bit/s/Hz (33% improvement) for each user in case we use SOS instead of Best CQI schedulers. It should be noticed that it is not acceptable to compare SOS with scheduler that couldn't supply an image with the needed throughput.
This save depends on the throughput needed by pixels as well as on the fixed scheduler type that we compare with.

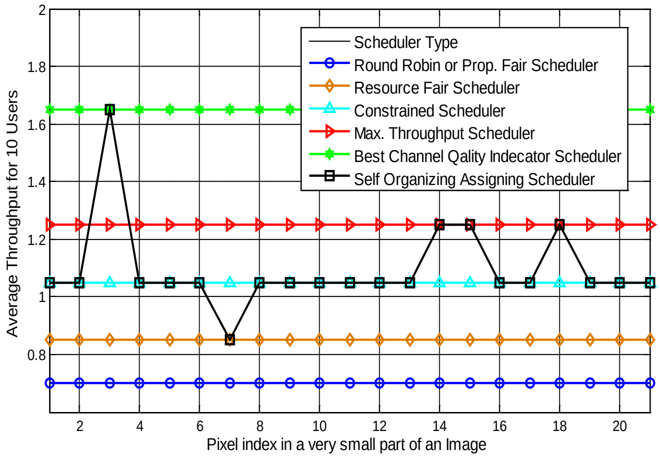

Figure 9: Comparison Between Fixed Assign Schedulers and Self-Organized Scheduler In terms of Average Throughput for 10 Users per 1E-nodeB When System Bandwidth=3MHz where x-axis represents a series of consecutive pixels in a very small part of an image.

IV. CONCLUSION

In this paper a novel self-organizing network has been proposed here. Neural network has been utilized as an intelligent and smart way to identify the importance of the pixel and assign accordingly. It has been found that adding such an intelligent process to the base station of LTE system (e-nodeB) leads to effective utilization of LTE system resources which in terns causes saving bandwidth and increase system capacity.

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