Strategies to Improve the VoIP over LTE Capacity

Youness Jouihri and Zouhair Guennoun

Abstract In this paper, we analyze the voice communication over Long Term Evolution (LTE) network which is transmitted using a voice over internet protocol (VoIP), as in LTE the core network is purely packet switched, designed for high data throughput. Similarly to legacy circuit-switched network, serving the largest number of users performing simultaneous VoIP calls, and ensuring their satisfaction will be the main objective for LTE operators willing to introduce voice over LTE service. To simulate the impact of scheduling strategies in the VoIP capacity, we use the Open Wireless Network Simulator (OpenWNS). With the obtained results, we show the VoIP capacity bottleneck. We also recommend the best strategies to improve the VoIP capacity.

Keywords Voice over LTE · Fitting strategy · VoIP capacity

1 Introduction

In an LTE network, the core is purely packet-switched [1]. However, with the new core design, the voice service will be transmitted over IP (VoIP), and will be regarded as any data application, with specific requirements for real-time traffic. Consequently, to have an effective voice over LTE service, we should ensure the capability of handling a large number of simultaneous VoIP calls while keeping the user satisfaction above the recommended threshold value. The structure of our paper can be depicted as follows: in Sect. 2 we highlight the simulations' environment. In Sect. 3 we provide a theoretical analysis and we validate our study through the results of simulations showing the impact of fitting strategies on VoIP capacity. Finally, a conclusion is given in Sect. 4.

Y. Jouihri (✉) · Z. Guennoun
Electronics and Communications Laboratory (LEC), Mohammadia School of Engineering (EMI), Rabat Mohammed V University (UM5R), BP 765 Ibn Sina Avenue Agdal 10000, Rabat, Morocco
e-mail: Jouihri.Youness@gmail.com

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2 Simulation Environment

In this paper, all the simulations' results are obtained using the Open Wireless Network Simulator (OpenWNS) simulator [2].

2.1 Fitting Strategies

For a VoIP call, the technique of Transport Block (TB) selection from the free Resource Blocks (RBs) is very significant in the scheduling process, and can be impacted by interference and resource availability [3]. In the OpenWNS simulator, the available fitting strategies used to choose a TB from the available RB space in a sub- frame are the First Fit strategy, the Best Fit strategy, the Worst Fit or Least Fit strategy, and the Random Fit strategy, described in [4].

2.2 Test Environment

The simulations address the VoIP capacity in the different access nodes' or Base Stations' (BS) scenarios, under a Single-In-Multiple-Out (SIMO) based system. The environment consists of a 120 m by 50 m rectangular area (default spacing used for an Indoor scenario in the OpenWNS). There are two BS sites, each one has an omnidirectional antenna. The center of the graph has the coordinates (1000.0, 1000.0, 0.0). The coordinates of base stations are (0970.0, 1000.0, 0.0) and (1030.0, 1000.0, 0.0). The users performing simultaneous VoIP calls will be added progressively to this environment.

This layout is used for all the types of simulated access nodes (Indoor Hotspot (InH), Urban Micro (UMi), typical Urban Macro (Uma), Rural Macro (RMa), and Suburban Macro, described in [5]). This makes the comparison between the test results of the different BS possible. Consequently, parameters, such as distance of user from BS or user distribution, will be general parameters, and will have similar impact in all performed simulations. Our test consists of a gradual increase in number of users inside the selected test environment; the added users will be randomly and uniformly distributed over the area, using the "IndoorHotspotUE" placer defined within the ituM2135 scenarios of the OpenWNS [2]. The same placer is used in all simulations. For each BS type, we test all the fitting strategies available in the OpenWNS simulator. The simulation will be stopped once the user's satisfaction falls below the threshold of 98 %. This threshold value reflects the user satisfaction according to "the guidelines for evaluation of radio interface technologies for IMT-Advance" [6]. All simulations are carried out while considering the scenario of a Physical Downlink Control Channel (PDCCH) limit of 8, as it is used in a large number of test projects [7].

For the general parameters used in simulations, we used 5 dB for the BS noise figure, 7 dB for the UT noise figure, 0 dBi for BS antenna gain, 0 dBi for UT antenna gain, −174 dBm/Hz for thermal noise level, 5 + 5 MHz (FDD) for the simulation bandwidth, and 20 s for the simulation time span (single drop).

3 Theoretical Analysis and Simulation Results

3.1 Theoretical Analysis: the Impact of the Fitting Strategies on the Voice over LTE Service

The voice over LTE service requires a guaranteed bit rate (GBR) bearer, to establish a mobile originating or terminating call; which adds more constraints on the scheduling of voice service data [8]. However, once the call is scheduled, it will be less vulnerable to outages and drops, as it will benefit from the GBR specifications' advantages. To evaluate the subscriber satisfaction during a voice over LTE (VoLTE) call, we check the possible scenarios that can impact such call. The first impact is the failure during call establishment, either related to coverage or to resource unavailability; all these cases can be referred to as the blocking scenario. The second impact includes drops, noise, silence or any kind of outage that might affect an established call; these cases can be referred to as the outage scenario. The subscriber satisfaction percentage while using VoLTE service can be depicted in the following equation:

$$P_{satisfaction} = (1 - P_{blocking})(1 - P_{outage}). \tag{1}$$

where $P_{satisfaction}$ is the percentage of satisfaction, $P_{blocking}$ is the percentage of calls impacted by the blocking scenario, and the $P_{outage}P_{outage}P_{outage}$ is the percentage of calls affected by the outage scenario. Using a GBR bearer, the VoLTE service is more impacted by the blocking scenario then the outage scenario. The GBR bearer reduces the outage probability, but adversely increases the blocking probability. Based on the description of scheduling strategies given in Sect. 2.1, we realize that the Best Fit strategy results in a minimum number of left over RBs after the scheduling of TBs. But the Worst fit strategy results in a maximum number of left over RBs after the scheduling of TBs. We conclude that the Worst Fit strategy maximizes the number of served and satisfied users, unlike the Best Fit strategy.

3.2 The VoIP Capacity Bottleneck

Using the OpenWNS simulator, we start our simulations with the unrealistic case where we neglect the impact of fading. The simulation is done under an InH BS using the First Fit strategy. Figure 1 shows that the user satisfaction threshold (98 %) is maintained for the Uplink case until we reached about 600 nodes. After that,

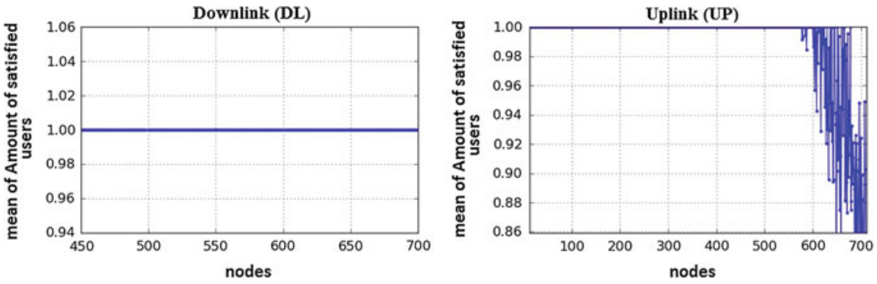

Fig. 1 Average amount of satisfied users under InH BS using First Fit in the uplink and downlink cases without the fading effect

further increase in the number of nodes led to a user satisfaction below the 98 % value. For the Downlink case, the impact was not visible; even after reaching 700 nodes, the user satisfaction remains 1 [Fig. 1 (Downlink)]. We conclude that the Uplink is the bottleneck of VoIP capacity, which is somehow expected. Besides the constraints applied for the Downlink channel, the Uplink channel has the constraint of RB allocation contiguity and a higher interference level. On the remaining simulations, only the Uplink cases will be considered. We will introduce also the fading impact to have a simulation environment near to the real world.

3.3 *Simulation Results of the Fitting Strategies Using Different Types of Access Nodes*

The simulation results of the First Fit and Random Fit strategies using different types of BS are presented in Fig. 2. The trend of user satisfaction is maintained

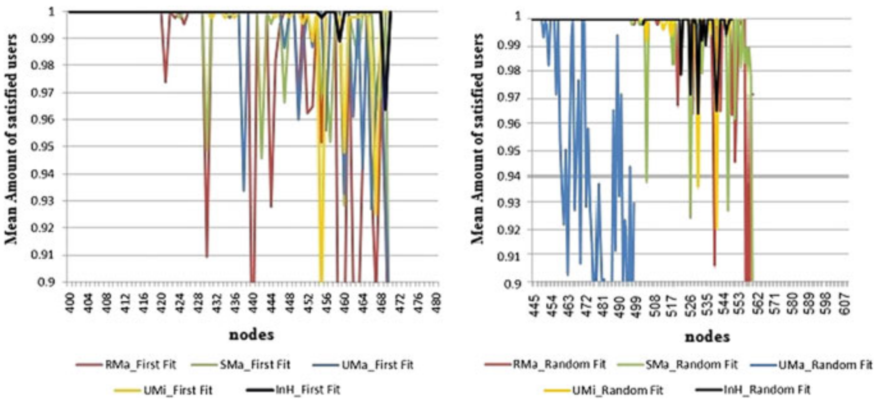

Fig. 2 Average amount of satisfied users using First Fit and Random Fit in the uplink case (with the fading effect) under different types of BS

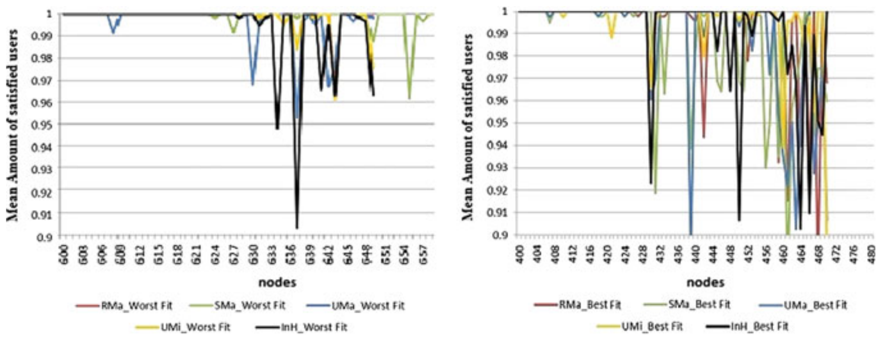

Fig. 3 Average amount of satisfied users using Worst Fit and Best Fit

greater than the 98 % threshold while reaching 421, 430, 440, 455 and 469 nodes for the First Fit case, and 520, 504, 457, 531 and 522 nodes for Random Fit case using RMa, SMa, UMa, UMi, and InH base stations respectively. Any subsequent increase in number of nodes leads to a value of satisfaction below 98 %. In Fig. 3, the Worst Fit and Best Fit cases are simulated, under different types of access nodes. The trend of satisfaction is maintained above 98 % while reaching 643, 655, 630, 643 and 634 nodes for the Worst Fit case, 430, 431, 430, 430 and 430 nodes for the Best Fit case using RMa, SMa, UMa, UMi, and InH base stations respectively.

From the various simulations' results, we conclude that, the Worst Fit strategy provides the highest VoIP capacity. By scheduling the largest number of simultaneous VoIP calls, under all types of simulated access nodes; while keeping the user satisfaction value above the 98 % threshold. Contrarily, the Best Fit strategy provides the lowest VoIP capacity under all types of access nodes. These results are in line with the theoretical analysis done in Sect. 3.1.

4 Conclusion

To evaluate the VoIP over LTE capacity, different types of base stations were considered and different fitting strategies were applied. Using the OpenWNS simulation results, we show the impact of the fading, where a 22 % decrease on VoIP capacity is observed. We also demonstrate that the Uplink traffic is the bottleneck of the VoIP capacity, and that improving it will substantially increase the VoIP capacity. Finally, after comparing the simulations' results, we conclude that assigning the adequate fitting strategy will significantly improve the VoIP capacity. In future work, we will explore other possibilities to improve the VoIP capacity using OpenWNS simulator.

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