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Link-Level Simulator for Wireless local Area Network

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Abstract-

Now a days in Wireless Local Area Networks (WLANs) used in different fields because its well-suited simulator and higher flexibility. The concept of WLAN with advanced 5th Generation technologies, related to a Internet-of-Thing (IOT). In this project, representing the Network Simulator (NS-2) used linked-level simulators for Wireless Local Area Networks and still utilized IEEE 802.11g/n/ac with advanced IEEE 802.11ah/af technology. Realization of the whole Wireless Local Area Networking linked-level simulators inspired by the recognized Vienna Long Term Evolution- simulators. As a outcome, this is achieved to link together that simulator to detailed performances of Wireless Local Area Networking with Long Term Evolution, operated in the similar RF bands. From the advanced 5th Generation support cellular networking, such explore is main because different coexistences scenario can arise linking wireless communicating system to the ISM and UHF bands.

Index Terms-WLAN, IEEE 802.11, LTE, 5G, physical layer, link-level, simulation, coexistence, interference.

I. INTRODUCTION

Wireless Local Area Network (WLAN) based technologies, frequently mentioned under the name Wireless-Fidelity (Wi-Fi), are very popular between the users. During the last decade, several WLAN technologies (marked as IEEE 802.11) have been developed to full fill demand on increasing data traffic. The aim of new IEEE 802.11af/ah specifications is to effectively solve data demand of popular equipments (smart phone, tablet) and enable to provide multimedia services in a high range of radio frequency (RF) spectrum. In the development and verification of IEEE 802.11 technologies, advanced. simulation tools are necessary to explore and understand the applied signal processing techniques. Presently, several advanced simulators, focused on wireless communication systems, have been developed and released. The LTE system-level simulator (and its advanced version LTE-A), developed at TU Vienna, allows to simulate signal transmission on Long Term Evolution (LTE) system level and take into account numerous system parameters.

The GNS3 simulator is recommended for a real-time network simulation and for custom dynamic network maps creation. Established Network Simulator (ns-2 and ns-3) is a discrete-event simulator which supports research on both Internet Protocol (IP) and non-IP based networks, including routing and multicast protocols. One of the most popular network simulators OPNET has a high flexibility to emulate behaviour of communication networks, including protocols and applications. All mentioned network simulators have been mainly developed to design and analyse different network protocols. On the other hand, link-level simulator to explore and evaluate performance of the most used IEEE 802.11 standards is not available yet. The main aim of this work is to introduce an advanced NS-2 based link-level simulator for exploring and evaluating performance of IEEE 802.11g/n/ac/af/ah technologies. Moreover, our proposed simulator is highly compatible with the mentioned Vienna LTE system-level simulator. Such solution allow to explore the performance of WLAN and LTE, operating in the same RF band. To the best of our knowledge, no similar simulator in this form has been presented in any scientific paper so far.

The project is organized as follows. The proposed link-level simulator for WLAN networks and their possible connection with Vienna LTE-simulator is described in details. Illustrative simulation results, to verify the functionality of the proposed simulator, are presented. Finally, Section V concludes the project.

II. IEEE802.11 STANDARDS

IEEE 802.11 is a set of physical layer (PHY) and media access control (MAC) specifications for definition of an interface between a user and a base station. This section contains a brief description of the IEEE 802.11 technologies, implemented in the developed link-level WLAN simulator. Main system configurations of all briefly described standards, used in Europe.

A. IEEE 802.11g, IEEE 802.11n and IEEE 802.11ac

Technology IEEE 802.11g was developed for transmission over a short distances in the 2.4 GHz industrial, scientific and medical (ISM) band. It was standardized in 2003 and was fully compatible with its predecessor (IEEE 802.11a, uses orthogonal frequency division multiplexing (OFDM)). It allows to achieve data rate up to 54 Mbps. The IEEE 802.11n can be considered as a milestone in the evolution of IEEE 802.11 technologies. It improves the previous specification mainly by employing of multiple-input multiple-output (MIMO) transmission. Such solution allows to increase the data throughput (up to 600 Mbps) not only in 2.4 GHz but also in 5 GHz band. It is possible to use either 20MHz or 40MHz channel bandwidth. The IEEE 802.11ac (marked also as Gigabit Wi-Fi) specification, presented in 2003, basically improves the features of IEEE 802.11n. The bandwidth for transmission was increased up to 80MHz and 160MHz in the 5 GHz RF band. Furthermore, new forward error correction (FEC) schemes (binary convolutional coding (BCC) and low-density parity-check (LDPC)) and modulation type (256QAM) were added. The maximum data rate is 433 Mbps per spatial stream. It improves the previous specification mainly by employing of multiple-input multiple-output (MIMO) transmission. Such solution allows to increase the data throughput (up to 600 Mbps) not only in2.4 GHz but also in 5 GHz band.

Table I: Comparison of IEEE 802.11 standards used in Europe(2)

Standard rate	Release Date	Band	Bandwidth	Modulation	Transmission mode	Maximum data rate
IEEE 802.11g	2003	2.4 GHz	20MHz	DSSS or OFDM	SISO	54 M bit/s
IEEE 802.11n	2009	(2.4;5) GHz	(20; 40) MHz	DSSS or OFDM	MIMO	600 M bit/s
IEEE 802.11ac	2013	5 GHz	(20; 40; 80; 160) MHz	SC or OFDM	MIMO	6.93 G bit/s;
IEEE 802.11af	2014	(470 to 790) MHz	(6; 7; 8) MHz	OFDM	MIMO	568.9 M bit/s
IEEE 802.11ah	2016	(863 to 868) MHz	(1; 2) MHz	OFDM	MIMO	7.8Mbit/s

It is possible to use either20MHz or 40MHz channel band width. The IEEE 802.11ac (marked also as Giga bit Wi-Fi) specification, presented in 2003, basically improves the features of IEEE 802.11n. The bandwidth for transmission was increased up to 80MHz.

B. IEEE 802.11ah and IEEE 802.11af

From the point of future 5G networks, related to emerging Internet-of-Things (IOT), the IEEE 802.11ah specification (called as "Wi-Fi Ha Low") will play a key role. It is a Wi-Fi oriented technology to operate in TV white space spectrum (TVWS) in the UHF band (in Europe around 900 MHz). Such step allows to realize Wi-Fi based wireless stations. Furthermore, the modulation and coding scheme (MCS) level can be adjusted based on the amount of transmitted data. The IEEE 802.11af, marked as "Wi-Fi", is an another UHF oriented Wi-Fi technology that allows to provide services in a wider range of TVWS spaces (in Europe from 470MHz.

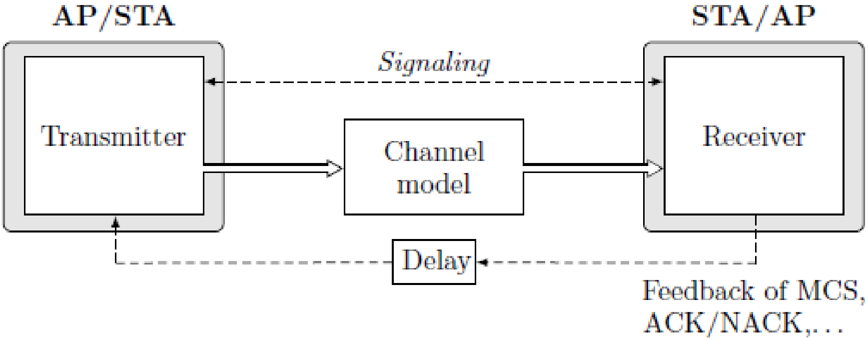

Figure (a) error-free feedback model

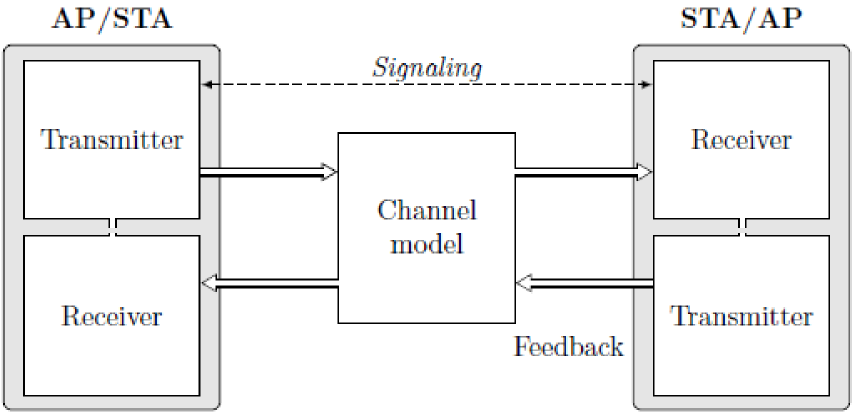

Figure (b) system feedback model

Figure 1:General structure of the IEEE 802.11g/n/ac/af/ah Link-Level Simulator

III. IEEE 802.11 LINK-LEVEL SIMULATOR

This section focuses on the description of the IEEE 802.11g/n/ac/af/ah link-level simulator and its general structure. The simulator (see Fig. 1 and Fig. 2) is completely realized in NS-2 according to the IEEE 802.11 standard.

A. General structure of the IEEE 802.11 link-level simulator

General structure of the created IEEE 801.11 simulator is depicted in Figure 1. The output baseband signal from the transmitter enters to the channel model block, defined by a channel matrix and Signal-to-Noise ratio (SNR). Afterwards, it is processed in the receiver (RX). The Wi-Fi employs half duplex transmission mode, thus each entity in the structure (labeled by a gray color in Figure 1)

Could be either Access Point (AP) or Networking Station (STA). In contemporary OFDM - based standards, it is necessary to give a feedback information between entities about the channel state, MIMO pre coding, previous transmissions confirm, etc. The basic method of feedback reporting is using the error-free feedback with variable-symbols delay (see Fig. 1a). This type of feedback is the most common in similar link-level simulators. Our simulator adds the system feedback model (see Fig. 1b) as an extension. In this case, the receiver (AP or STA) sends the feedback information to the transmitter (STA or AP) via the same channel model as it was used in the direct transmission. Before the simulation starts, all necessary settings (e.g. Wi-Fi standard, transmission mode, system bandwidth, initial MCS, number of frames, type of data) are reported to all entities of the simulator. The signaling information also includes all received data or control information. Performance metric of the simulator includes bit error rate (BER), frame error rate (FER) and packet throughput value. Randomly generated data bits are scrambled and forwarded to coder parser. There might be one or two coding branches. Parsed data are coded using either BCC or LDPC channel coder. Coded data is divided into several spatial streams. In the case of SISO transmission (e.g. IEEE 802.11g), only a single spatial stream is defined. Each stream is interleaved and constellation mapping is performed (BPSK, QPSK, 16QAM, 64QAM and 256QAM). Space-time block coding (STBC) is employed for MIMO operation pre coding together with insertion of cyclic shift. Spatial mapping has three modes: direct mapping, spatial expansion and beam forming. Next, OFDM symbol is formatted by mapping data symbols and pilot signal, according to defined system bandwidth. Finally, transmission mode and Inverse Fast-Fourier Transform (IFFT) are performed and the cyclic prefix (CP) is inserted (either 400 ns or 800 ns).

B. Common Link-level WLAN simulator and Vienna LTE- Simulator: utilization for exploring of the coexistence use case

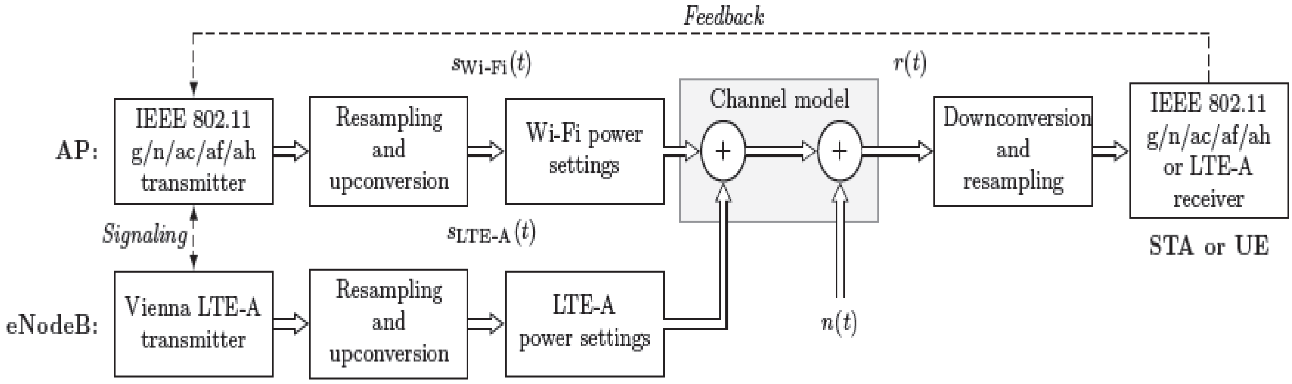

Figure 2 : Joint of the proposed IEEE 802.11g/n/ac/af/ah vs. LTE-A link-level simulators-coexistence use case.

We have also proposed link-level simulator structure to emulate and explore coexistence issues between IEEE 802.11vs. LTE-A (down link). The basic structure of such coexistence simulator is shown in Fig. 2. The Wi-Fi baseband signals Wi-Fi(t) is created in the IEEE 802.11g/n/ac/af/ah transmitter (AP) according to required Wi-Fi standard and system parameters. Simultaneously, the LTE-A baseband signal s LTE-A (t) is created in the Vienna LTE-A transmitter block (e Node B).

Power of both re sampled and up converted signals is adjusted related to defined Carrier–to-Interference ratio (CIR) or Carrier-to-Interference plus Noise ratio (CINR).In the channel model block, both of these signals are added together with a random noise vector n(t). The affected signal r(t) is down converted and re sampled and it is led to the IEEE 802.11g/n/ac/af/ah receiver (STA) and/or LTE-A receiver (UE), respectively (depending on the investigated system performance). All necessary system information are led to the transmitters via error-free feedback link. Signaling could contain information needed for coordinated or uncoordinated services .

IV. EXPERIMENTAL RESULTS

Figure 3 shows the Micro cell location. Red Colored nodes indicate old micro cell location and purple Colored nodes indicate new microcell location. Node1 indicated a base station. And node 29 indicates a wireless session protocol. It is used for standard network browsing sitting it start as the customer attach to the uniform resource location with the customer leaved on URL (Uniform Resource Location).

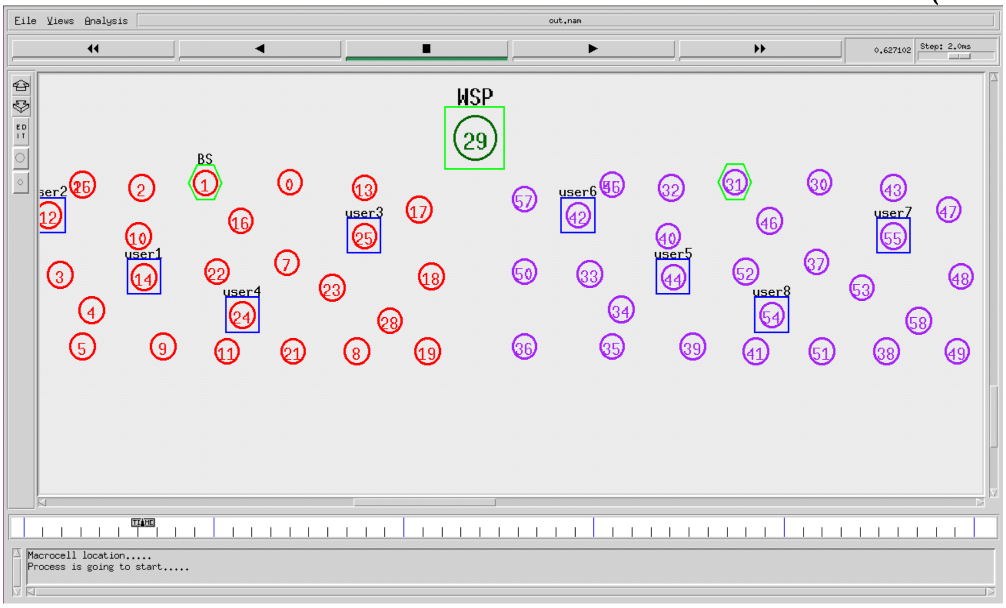

Figure 3: Micro cell location users and base station.

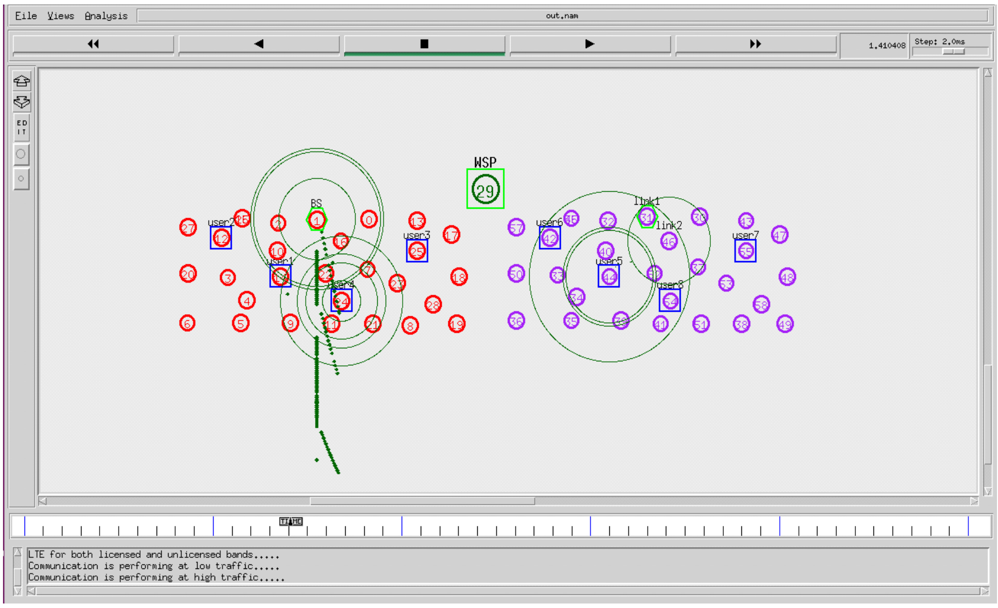

Figure 4: Communication is performed at low traffic and high traffic

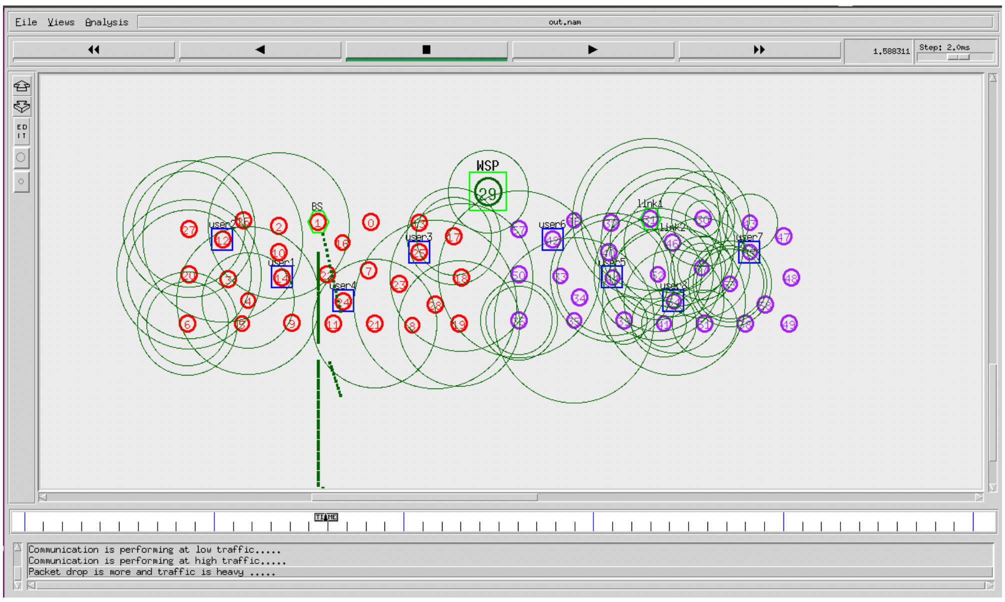

Figure 5: Packet drops is more and traffic is heavy

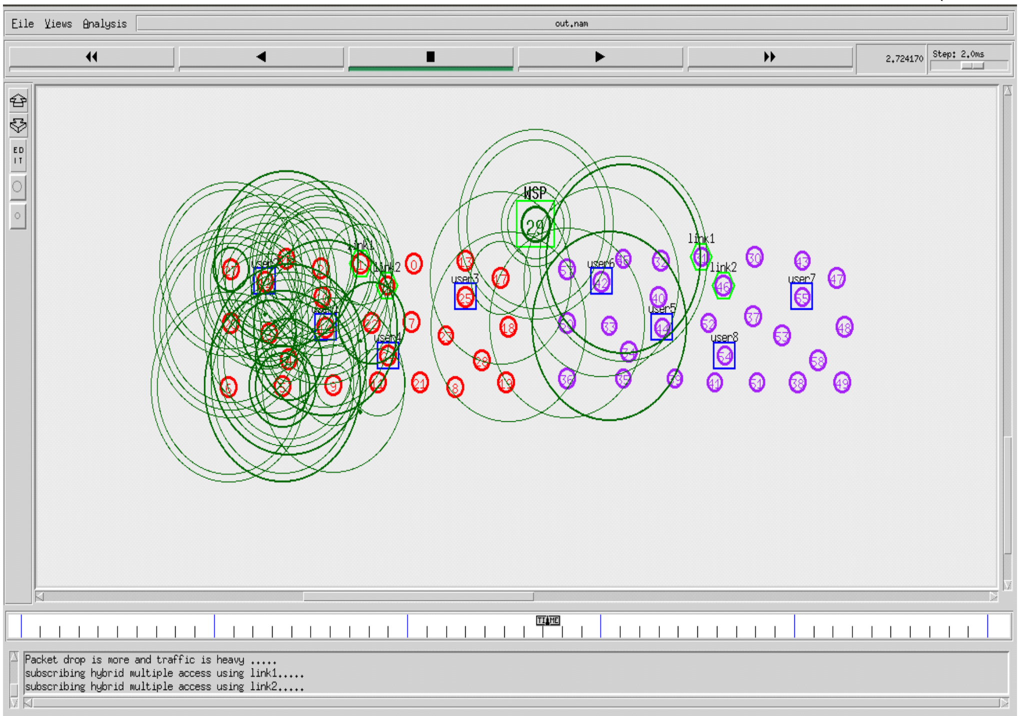

Figure 6: Subscribing Hybrid multiple access using link1 and link2

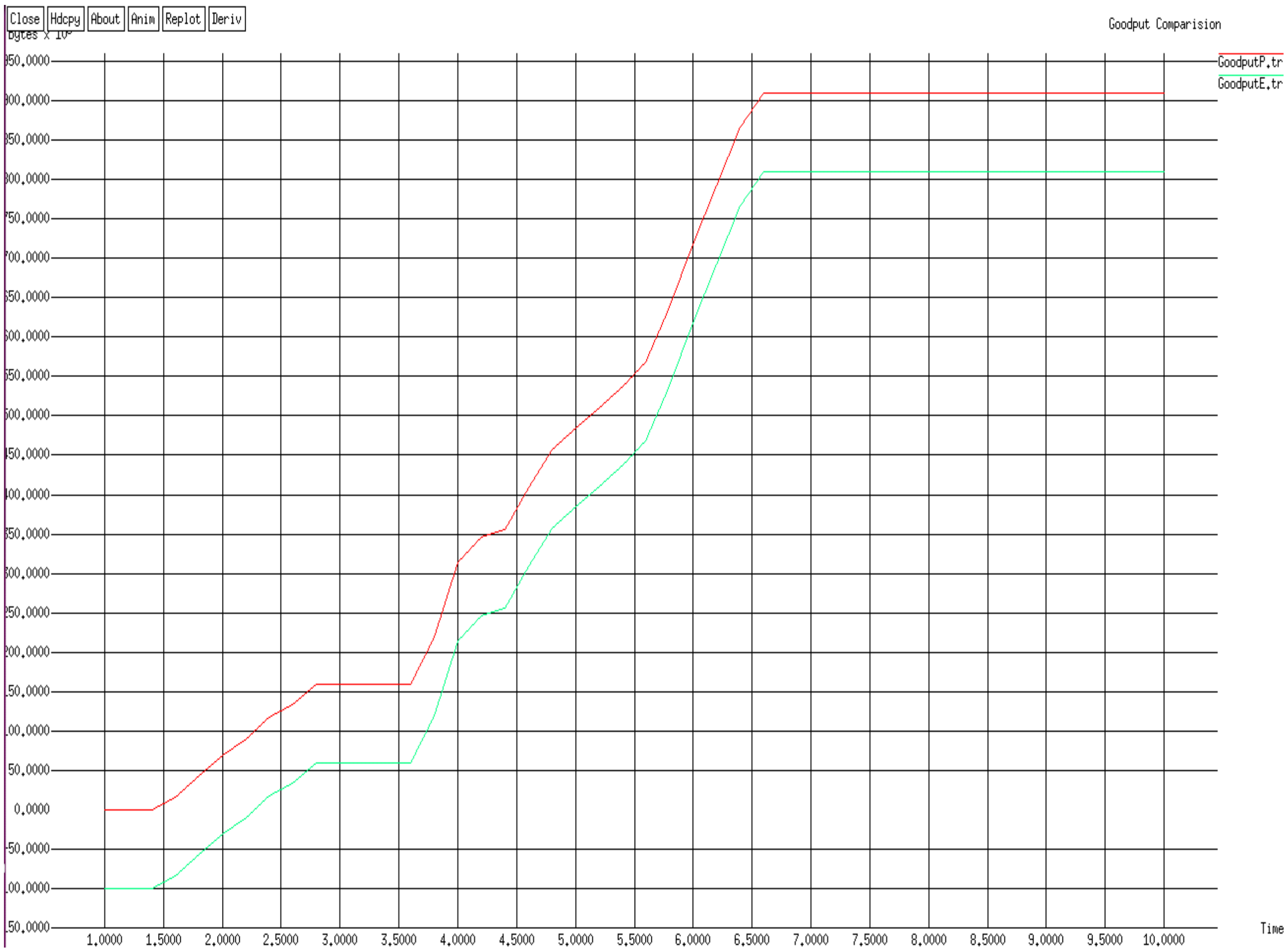

Figure 7: Throughput of proposed system

It is defined as the number of packets transmitted per unit time. Figure 7 shows the throughput of proposed system. Here x-axis indicated times in milliseconds with y-axis indicated number of packets in bytes. This graph shows the throughput is also known as good put. Red colours indicate proposed system and green colour indicates existing system. Its throughput is high.

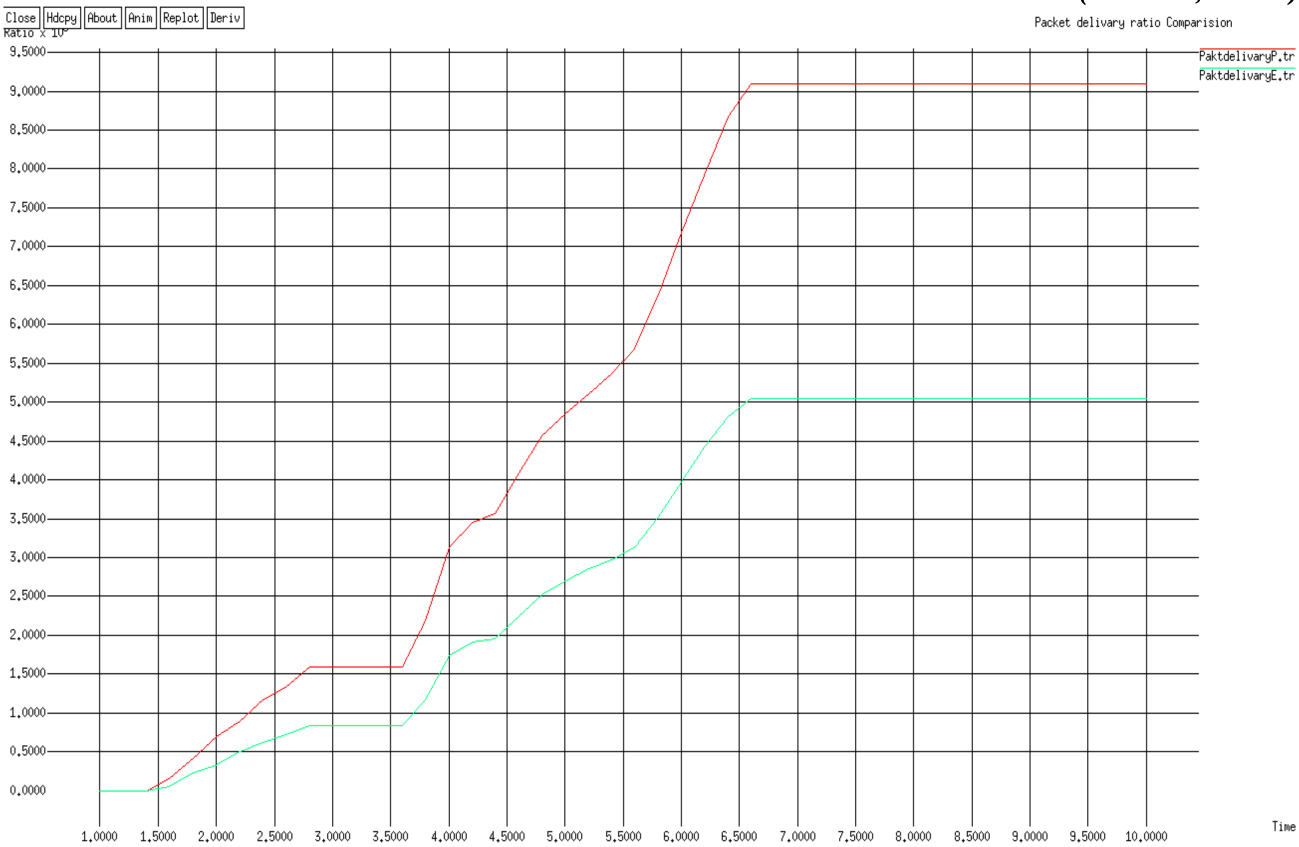

Figure 8: Packet delivery ratio comparison of proposed system.

It is defined as the ratio of number of packets delivered to number of packets transmitted over a network. Figure 8 shows the graph for packet delivery ratio comparison of proposed system. Here x-axis indicated times in seconds with y-axis indicated number on packets delivered in ratio. The red colour line represents the packet delivery ratio of source to destination. It is defining as the numbers of bits error dividing by the total numbers of transferring bit in a considered time periods and green colour indicates existing system.

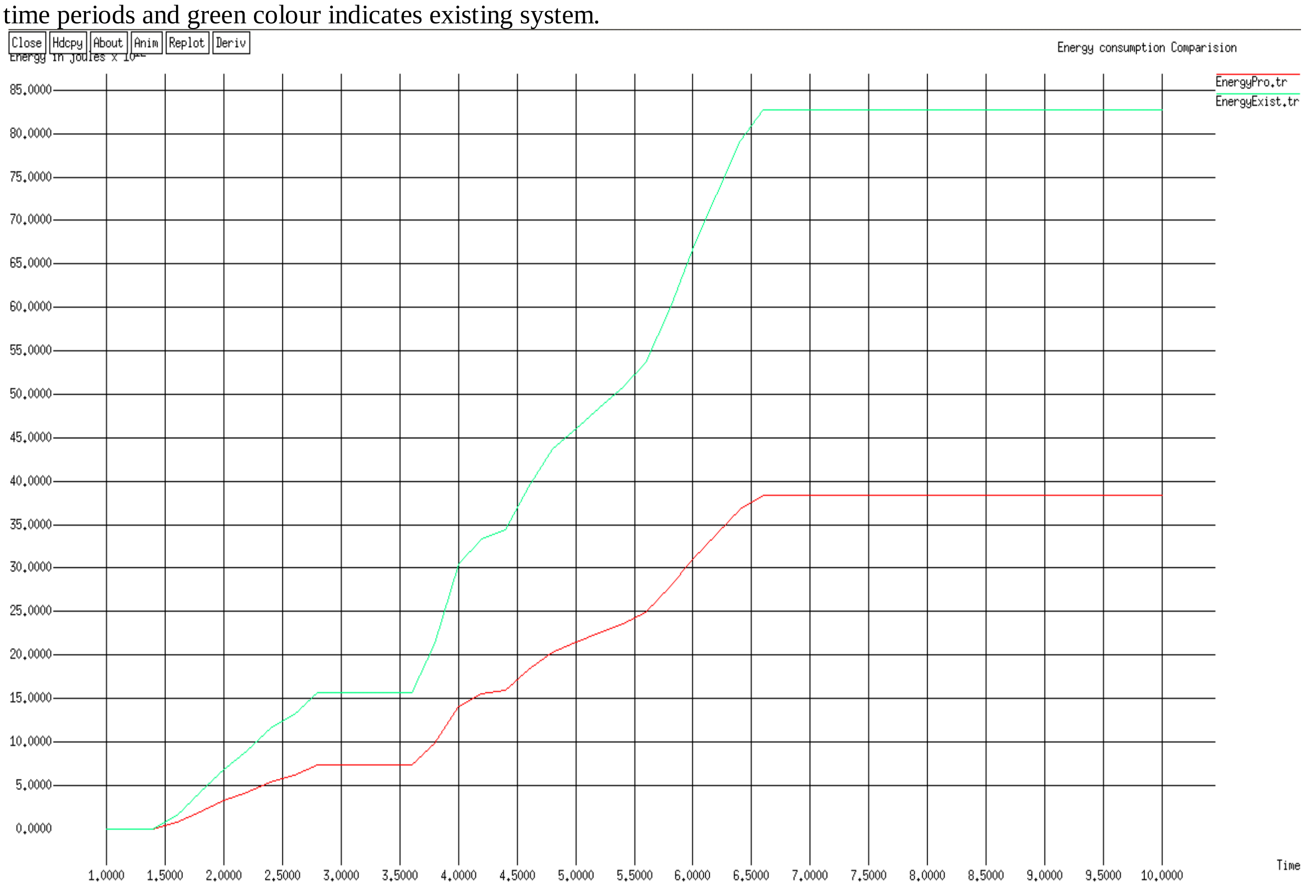

Figure 9: Energy Consumption Comparison of proposed system

It is characterized as the proportion of the control data sent to the real information got at every hub. Figure 9 shows the graph for energy consumption comparison of proposed system. Here x-axis indicated time in seconds with y-axis indicated energy in joules. This red colour line represents the control information of messages reach the destination but some intermediate hop will be passed then reach the destination.
It is defined as the ratio of number of packets delivered to number of packets transmitted over a network. Figure 10 shows the graph for packet delay comparison of proposed system. Here x-axis indicated times in seconds with y-axis indicated numbers of a packets delay in micro seconds. The red colour line represents the packet delivery ratio of source to destination. The graphs show the time variation of packets transmitted through the source to destination and improved for the different systems.

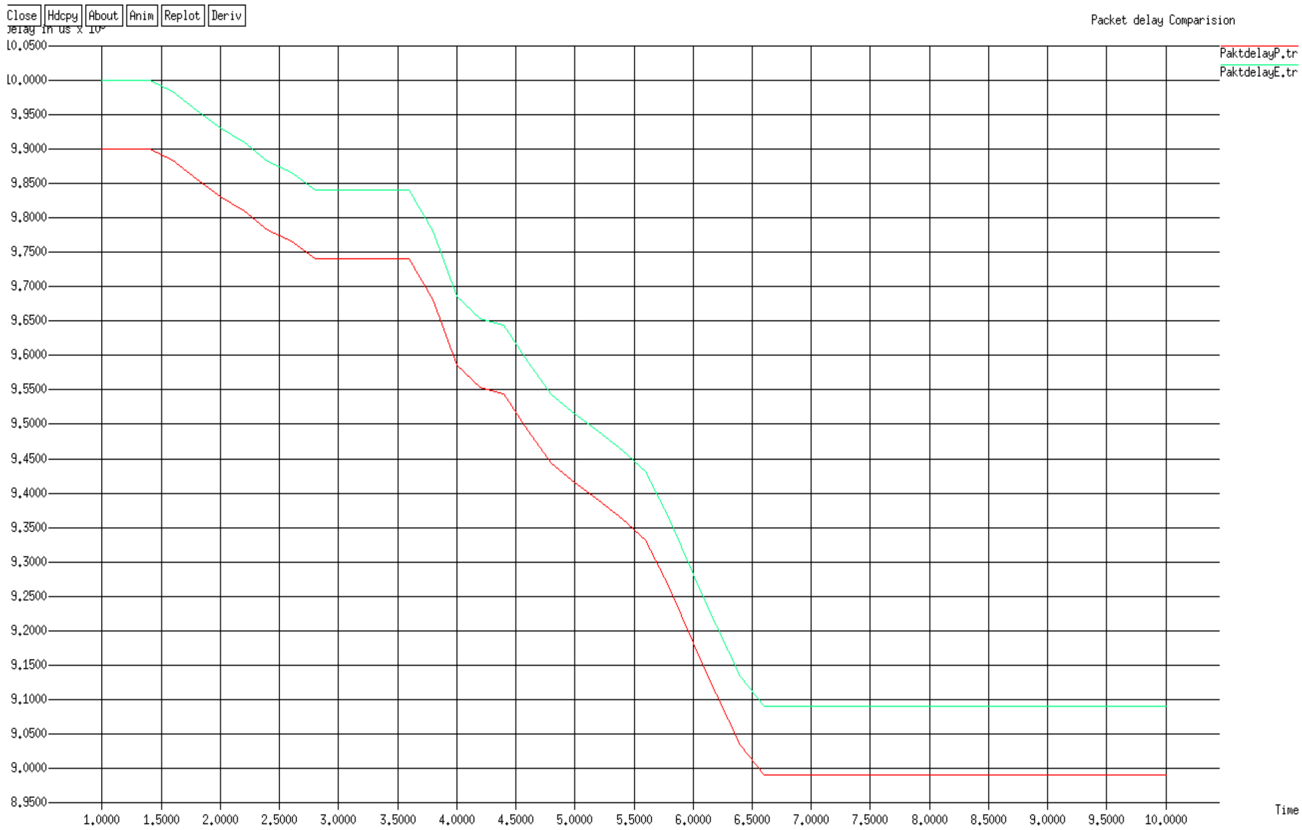

Figure 10: Packet Delay Comparison of proposed system

V. CONCLUSION

An universal link-level simulator for Wireless Local Area networks, supporting technologies IEEE 802.11g/n/ac/af/ah, was presented. The communication is performed at low traffic and high traffic. Wireless Local Area Network (WLAN) subscribing hybrid multiple access using link1 and link2 simulation. Basic function of the simulator for the IEEE 802.11n standard was verified by simulations. Between the main advantages of the proposed simulator is that it is compatible with Vienna Long Term Evolution (and LTE-A) simulator which allows to investigate possible coexistence issues of these systems in shared Industrial, Scientific And Medical (ISM) band (2.4 GHz and 5 GHz). From the point of emerging 5^{th} Generation networks such exploring will be important. In Future this project can be continued and the optimization of the proposed with creating linked-level Wireless Local Area Network simulations. Addition of that simulations and extra useful block (e.g. massive Multiple Input Multiple Output) is also planned.

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