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A novel spectrum handoff management in cognitive 5G networks

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Abstract: Cognitive radio networks can facilitate seamless mobility to users considering their effective use of the dynamic spectrum access. One of these operations includes handoff between various wireless domains. The handoff is not just a registration with a new base station, but it is also a negotiation to get access to the available channels locally in coexistence with the primary users. The dynamic adaptation between channels is spectrum handoff (SH) and significantly impacts the time of handoff reconnection. It raises many questions about the functioning of the cognitive radio solution in the next generation of network systems. Therefore, it is necessary to develop a new method for roaming mobile users, particularly networks that employ small cells such as femtocells in order to reduce the unnecessary channel adaptations.

Keyterms: 5G, Cognitive radio,goodput, spectrum handoff, throughput.

I. Introduction

Wireless system designers have been facing the progressively increasing demand for immense data rates and mobility prescribed by new wireless applications and therefore have initiated research on fifth generation wireless systems that are anticipated to be spread out beyond 2020[14].

Both the cognitive radio (CR) and the fifth generation of cellular wireless standards (5G) are recognized to be the forthcoming technologies: on one side, CR endeavors the probability to significantly improve the spectrum efficiency, by smart secondary users (CR users) using the free licensed users spectrum holes; on the other hand, the 5G signifies the whole wireless world interconnection (WISDOM--Wireless Innovative System for Dynamic Operating Mega communications concept), together with tremendous data rates, Quality of Service (QoS) service applications.The architecture of 5G is highly advanced, its network elements and various terminals are characteristically upgraded to afford a new situation. Likewise, network providers can utilize the modern technology to adopt the value-added services easily.

Generation Mobile Network or simply 5G is the forthcoming revolution of mobile technology5th.As depicted in the figure 1,the features and its application are much beyond the expectation of a general human being. With its very high speed, it is great enough to alter the meaning of a cell phone usability. One can utilize broadband internet connection; other significant features that fascinate people are more gaming options, broader multimedia options, connectivity everywhere, negligible latency, quick response time, and high quality sound and thus the HD video transferred on other cell phone without compromising with the quality of audio and video.

Non-orthogonal multiple access (NOMA) has been considered as a highly efficient communication technology in the fifth generation (5G) networks by serving multiple users concurrently through non-orthogonal sharing communication resources.[3],[4],[7]. Highly efficient 3D resource allocation techniques for NOMA enabled massive MIMO and relaying systems in 5G are

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proposed developing an efficient antenna selection and user scheduling algorithms for sum rate maximization in the massive MIMO-NOMA system. These significantly improve the system capacity while mitigate the interference for future dynamic spectrum access networks.

A continuous-time Markov chain paradigm by using channel reservation concept which is specialized for unlicensed users to improve the utilization of the spectrum by primary and secondary together in a cognitive radio network is discussed in [5]. The co-existence and co-operation of Wi-Fi and cellular networks in the unlicensed spectrum can increase the overall capacity of heterogeneous wireless networks, provided that the mutual interference between Wi-Fi and cellular systems is addressed properly[6].

Cognitive radio technology behaves as a transceiver (beam) which positively receive and respond radio signals in its operating atmosphere. Further, it promptly differentiates the variations in its environment and hence reciprocate accordingly to provide uninterrupted quality service. Cloud computing makes use of internet as well as central remote servers to process data and applications of the users. Cognitive radio (CR) has developed as an assuring technology to exploit the unused portions of spectrum in an opportunistic manner. The fixed spectrum allocation of governmental firms results in unused portions of spectrum, which are called "spectrum holes" or "white spaces". CR technology overwhelmed this issue, allowing devices to sense the spectrum for unused portions and utilize the most relevant ones, according to some pre-defined criteria. Spectrum assignment is a key mechanism that fences the interference between CR devices and licensed users, sanctioning a more skilled usage of the wireless spectrum[12].

Earlier in the spectrum licensing schemes, the license cannot alter the nature of utility or relocate the right to other licensees. Besides, the radio spectrum is licensed for larger regions and generally in larger lumps chunks. To score better the efficiency and utilization of the radio spectrum, the mentioned constraints should be revised by customizing the spectrum licensing scheme and endorsing a dynamic spectrum management model. The basic perception is to make spectrum access more extensile by admitting the unlicensed users to access the radio spectrum under certain conditions and restrictions.

Author [2],[9] presented a new architecture which incorporates cognitive capabilities into the dynamic network architecture, resulting in cognitive dynamic network architecture. In CDNA, the primary users (PUs) share their connectivities and act as access points for secondary users (SUs). The resource allocation problem formulated as a centralized optimization yields a combinatorial problem that is NP-hard with complexity of the order $\Theta(N^{MB})$, limiting its applicability in a dynamic network. Also a cross domain system for a joint cognitive, automated management of heterogeneous industrial wireless networks and cellular networks is designed [8]. The approach is to adapt current mobile solutions in such a way that industrial networks are integrated.

A partially observable Markov decision (POMDP) process framework and a Markov decision process (MDP) framework are used to determine the optimal specrum sensing energy, the transmit energy and spectrum sensing interval to maximize the long-term average weighed sum of the throughput of the SU and the interference caused to the PU is being proposed in [10].A probabilistic approach in determining the initial and target channels for the handoff procedure in a single secondary user network. To characterize the network, a queuing theoretical framework is

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introduced[13], and "stay" and "change" handoff policies are both addressed.An efficient spectrum management techniques based on CR technology is implemented to share the spectrum between different types of users in order to maximize spectrum utilization and spectral efficiency in [2]. Also provided service for appropriate RSUs via the proposed method keeps the balance between network performance spectral efficiency and user satisfaction.

Three optimization models that aim at minimizing the network load cost as well as data center resources cost by finding the optimal placement of the data centers is proposed [3]. The optimization solutions demonstrate the trade-offs between the different data center deployments, i.e., centralized or distributed, and the different cost factors, i.e., optimal network load cost or data center resources cost. They had proposed a Pareto optimal multi-objective model that achieves a balance between network and data center cost.Characterized the network, a queuing theoretical framework is introduced, and "stay" and "change" handoff policies are both addressed [4]. The performance of the secondary user in terms of average sojourn and extended service times for secondary connections is analyzed, and convex optimization problems with the objective of minimizing those times as well as analytical solutions are presented.Author [11],[16] proposed a computationally and spectrally efficient resource allocation scheme for multiuser MIMO-OFDM based underlay CR networks to provide good spectral efficiency gain, and therefore increased communication range.

The secondary users can utilize this work result in multi-user case. In multi-user cooperative case, the secondary users can utilize this work result and adopt a cooperation protocol to effectively access the idle channel. In multi-user competitive case, the secondary users can utilize this work result and adopt a competition mechanism to maximize channel utilization, minimize collision and achieve an optimal state.

II. Problem Formulation

A methodology to manage the spectrum handoff delays by allocating channels based on the user QoE, minimizing the latency, providing seamless service is proposed [1] .In order to predict the arrival time of LUs as well as to select the best available channel, a DB-assisted and index-based scheme to collect channel usage information and rank the available channels in accordance with their quality is proposed. As per the figure 2,the cognitive base station (CBS) maintains a ranking index of the available channels based on their parameters such as detection accuracy, false alarm probability, LU idle time, and LU arrivals. The existing system adopted a time-slotted cognitive-based cellular system having X primary channels with identical bandwidth. Each primary channel has N time slots and each slot is composed of two parts, i.e., sensing (link setup) and data transmission.

As depicted in the figure 2, the operation of a CU in primary channels, it is assumed there are X primary channels having synchronized slotted structure. At the beginning, CH#2 is allocated to the CU by the CBS, because it is assumed as the best available and most reliable channel in the ranking list in comparison to the other available channels and it is matched with the traffic QoE requirements, e.g. CH#1. The CU calculates sensing accuracy and idle duration and forward to the CBS to store into the DB. In addition the CU monitors the other channels and maintains the ranking index to choose the backup channel in case of handoff. At time t0, a spectrum handoff is predicted to occur at t2. The handoff delay is predicted to be one slot. At time t2, an LU is detected by the CU. The sender pauses its transmission, while the receiver starts to show the pre-fetched BL code during the third time slot. As the best matched available channel in the ranking index, CH#3 is facilitated to

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the CU. The CU moves its transmission to CH#3 and resumes it at t3 without interference to the LU which starts its transmission over CH#2 at t2. One of the main problems in cognitive 5G cellular networks that need to be considered is dynamic channel allocation, which may seriously degrade service quality and increase transmission failure and delayetc.,

III. System Model

In order to overcome the overhead such as delayed throughput, poor spectral efficiency produced due to the existing system, some improvisation is made by employing a novel algorithm based on goodput which is utilized to update the congestion network.

In this algorithm, it helps to efficiently allocate the base station connection with respect to the hand set/ SIM network. It helps to maintain a congestion free network by proper updating quite often. Our objective is to allocate the best available channel and to manage the unavoidable spectrum handoff by minimizing the handoff latency and handle the handoff process in such a way to provide seamless multimedia service as well as improving QoE. In doing that, our system which is depicted in figure 3, consists of the three phases, each composed of some functionalities.

A.Channel Evaluation and Allocation

Data collection via ED spectrum sensing technique, Channel quality estimation based on sensing accuracy and channel idle duration, Channel allocation according to the CU's QoE requirements and the available channels' quality. The temporal spectrum sensing and data collection is performed through channel sensing at the start of each slot is adopted. During sensing time, the CU first senses the LU activity on the target band and decides to transmit if and only if there is no active LU. The ED technique for channel sensing due to its efficiency and fast non-coherent features that essentially calculates a running average of the signal power over a window of a given spectrum length is utilized. In our technique, CU compares its received signal with a sensing threshold. During the sensing part of each slot, the CU sense the target channel to collect the channel's information. If the channel is busy the CU just monitor busy period and forward its collected data to the CBS to update the index

B. Channel State Estimation

Parameter estimation using the Baum-Welch algorithm (BWA) under the HMM parameters, Channel decoding for channel state estimation. Here Considered a deterministic mode of traffic patterns, and hence we model the channel usage as an ON-OFF source alternating model, where ON means busy period and OFF means idle period. The model is confirmed as a suitable model because it approximates the channel usage pattern at public safety bands. The ON and OFF periods are independent identically distributed (i.i.d.). The alternating renewal process can be designed in form of a two-state birth-death process. The maximum-likelihood estimation method is used to obtain these mean values. To do that, the model uses the CU experiences and the collected information stored in the DB. However, such kind of networks face the challenges because of the fluctuating nature of the available channels and various requirements of different applications. This process, through interference nullification, is done by the listen-before-talk (LBT) policy in which the CU must sense the channel before transmitting any data packet.

Hence, it is assumed that the LU arrival is detectable by the CU within an acceptable time duration and collision percentage is negligible. The CBS informs the CU about the selected channel during the link setup. Therefore, to tackle this problem, in the proposed scheme we allocate the available channels to the CUs based on their requirements and the quality of the channels. In such a

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way that the channels with higher sensing accuracy and idle duration are provided to the more delay and failure sensitive traffic sources in order to enhance the QoE.

C. Handoff Interruption Management

In the previous subsection, the handoff prediction scenario in details is discussed and it is stated that to manage handoff interruptions when a handoff is predicted, the server extracts and sends only the lightweight BL code. In the figure 4, we present our proposed handoff management scheme. In cognitive 5G networks, the CUs needs to switch to another available channels when an LU reclaims the channel, and/or when the quality of the current channel become poor, and/or even when the CU moves to another cell.

IV.Performance Analysis and Discussion

The proposed method decreases the number of interruptions compared with random selection proactive method, the CU needs to leave the channel before LU arrival where the arrival of LU is predicted based on channel statistical information.. When the rate of LU arrival increases, the number of channel switching increases as well. It happens because of several reasons as explained in the previous sections as well: sensing errors, prediction errors, channel allocation regardless of channel quality and CU requirements.

In our priority based channel allocation scenario, according to the quality of the available channels, the CBS maintains a channel ranking index to provide the CUs the most reliable channel based on the quality of the available channels and QoE requirements of the various traffic classes. Hence, improving channel utilization and decreasing the number of interruptions. The simulation results of various parameters are given in figure 5-10 and the comparison of certain parameters are listed in table 1.

V. Conclusion

Spectrum is a very relevant resource in wireless communication systems and it has been a predominant research topic from the recent several decades. The improvement of the cognitive radio network requires the involvement and interaction of many recent techniques, including distributed spectrum sensing, interference management, cognitive radio reconfiguration management, and cooperative communications. Through the above simulation and execution of the proposed system, it is clear that the performance level in case of delay, throughput, and packet loss is reduced in goodput based cognitive 5G network compared with the other existing cognitive systems. The above given simulated output shows the function of the spectrum handoff implemented using the proposed system. The performance measures for packet delay, time delay, throughput and energy deception are represented graphically comparing the proposed cognitive 5G network verses the existing cognitive systems. From the result, it is inferred that the proposed cognitive 5G network has much more efficient way of spectrum allocation compared to any other cognitive networks. Furthermore, in order to fully realize the CR system in wireless communications for efficient utilization of scarce RF spectrum, the method used in recognising the interference and/or spectrum sensing should be steady and prompt so that the primary user will not get affected from the CR system to utilize their licensed spectrum.

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LIST OF FIGURES

Fig 1.Salient Features of 5G Technology

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Fig 2. Basic spectral handoff mechanism

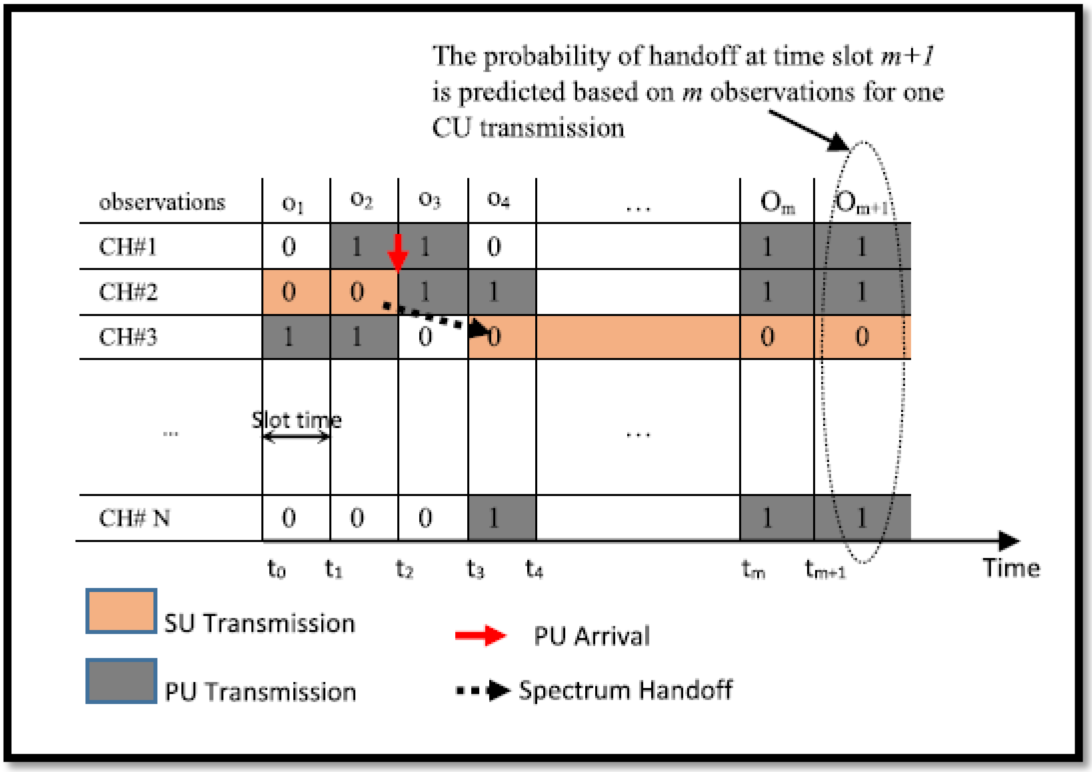

Figure 3: Proposed goodput aware handoff management model

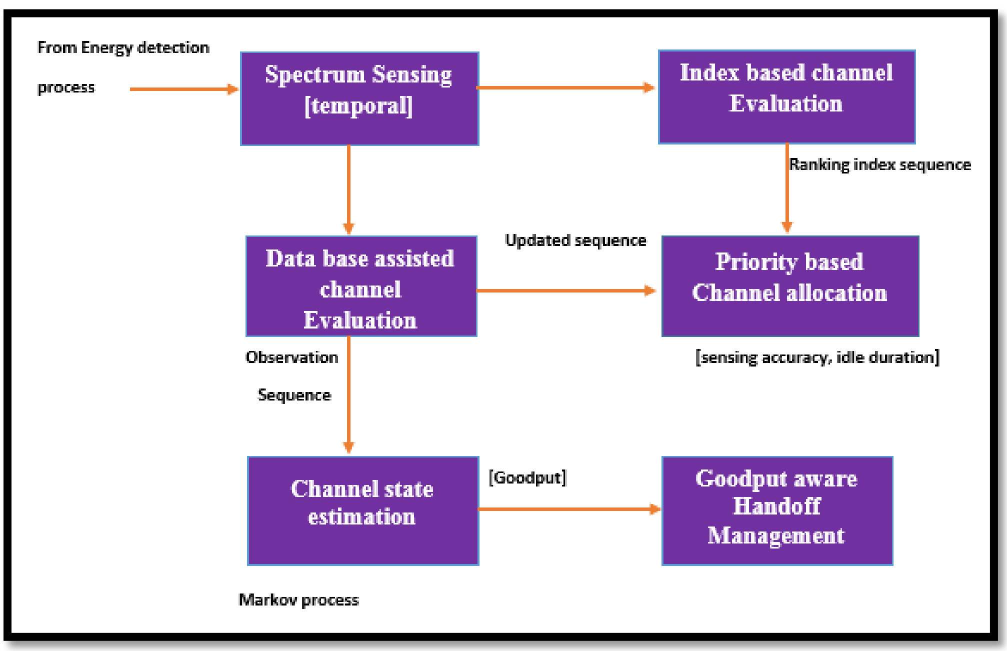

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Fig 4: Goodput aware handoff management -Flow diagram

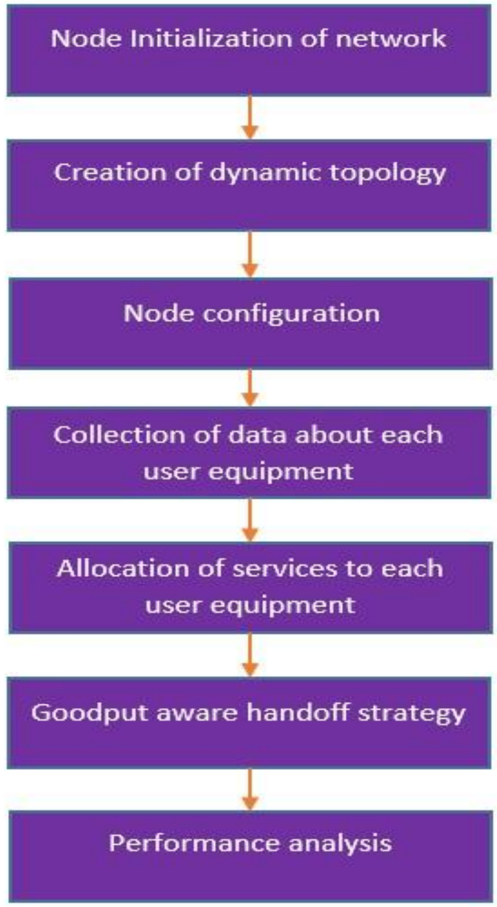

Table 1: Comparison Analysis of major parameters

Time(ns)	Packet Delivery Ratio (ratio in 10^3)		Goodput (bytes x 10^6)		Transmission Failure (ratio in 10^3)	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
2	1.624	2.920	0.119176	.292600	0.6	0.48
3.5	5.000	9.000	0.453266	.892739	2.5	1.6
5	11.424	20.480	0.579200	1.074640	4.2	3
8	23.464	41.920	1.1518823	2.048200	8.5	6
10	27.048	48.350	2.791694	4.835880	9.1	6.55

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Fig 5.Performance analysis-Transmission failure

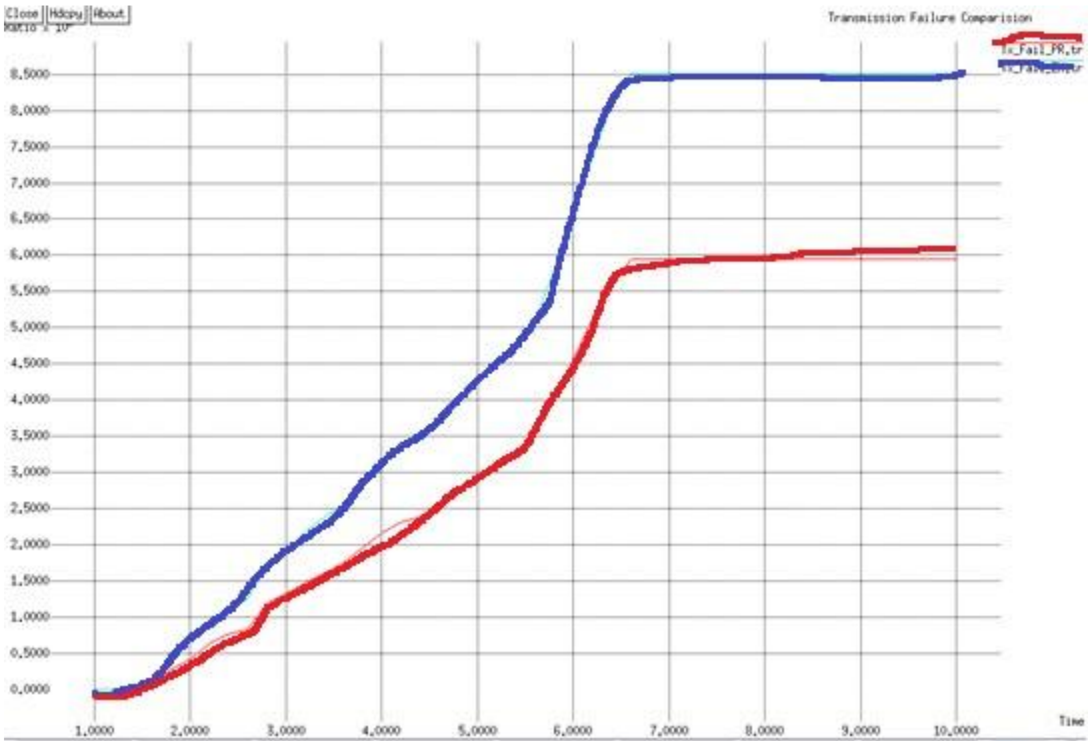

Fig 6.Performance analysis-Bandwidth

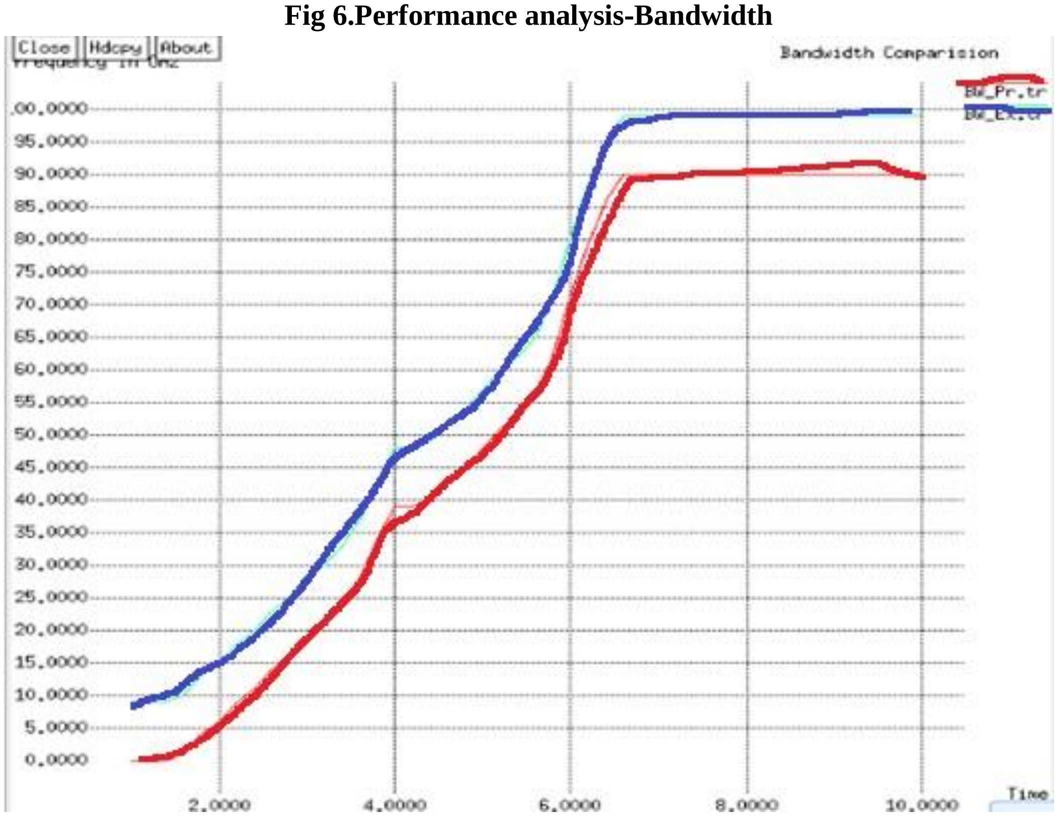

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Fig 7.Performance analysis-Energy Consumption

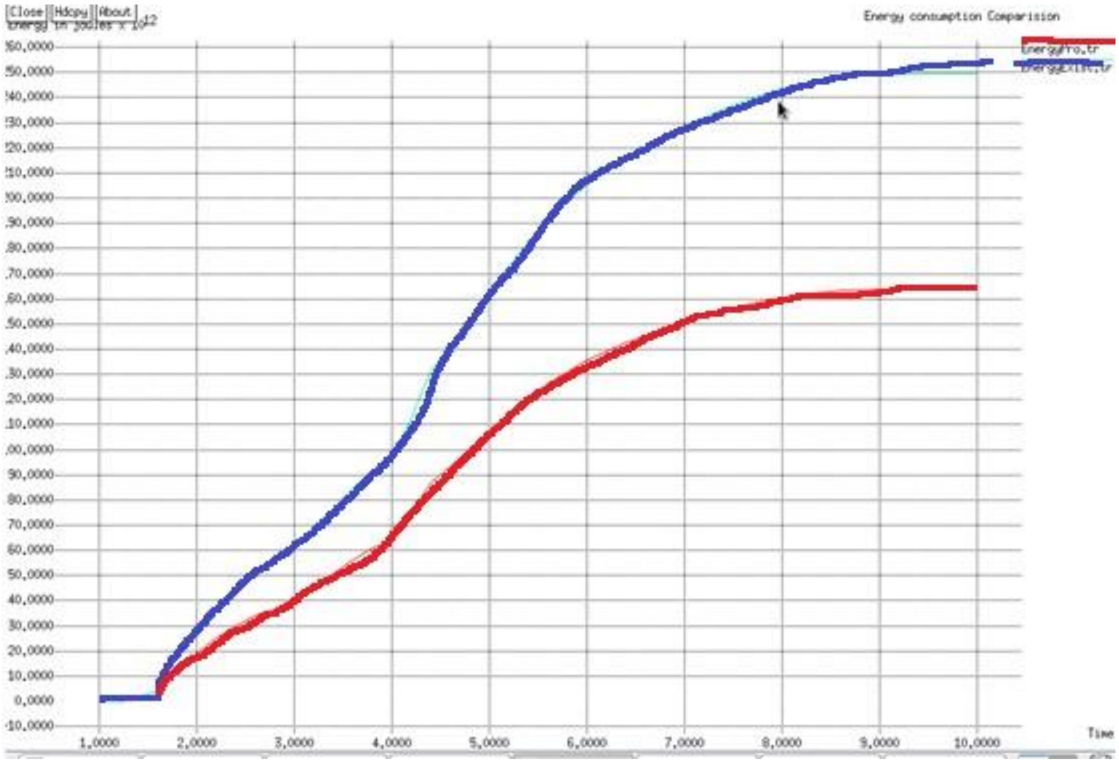

Fig 8.Performance analysis–Packet delivery ratio

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Fig 9.Performance analysis-Packet delay

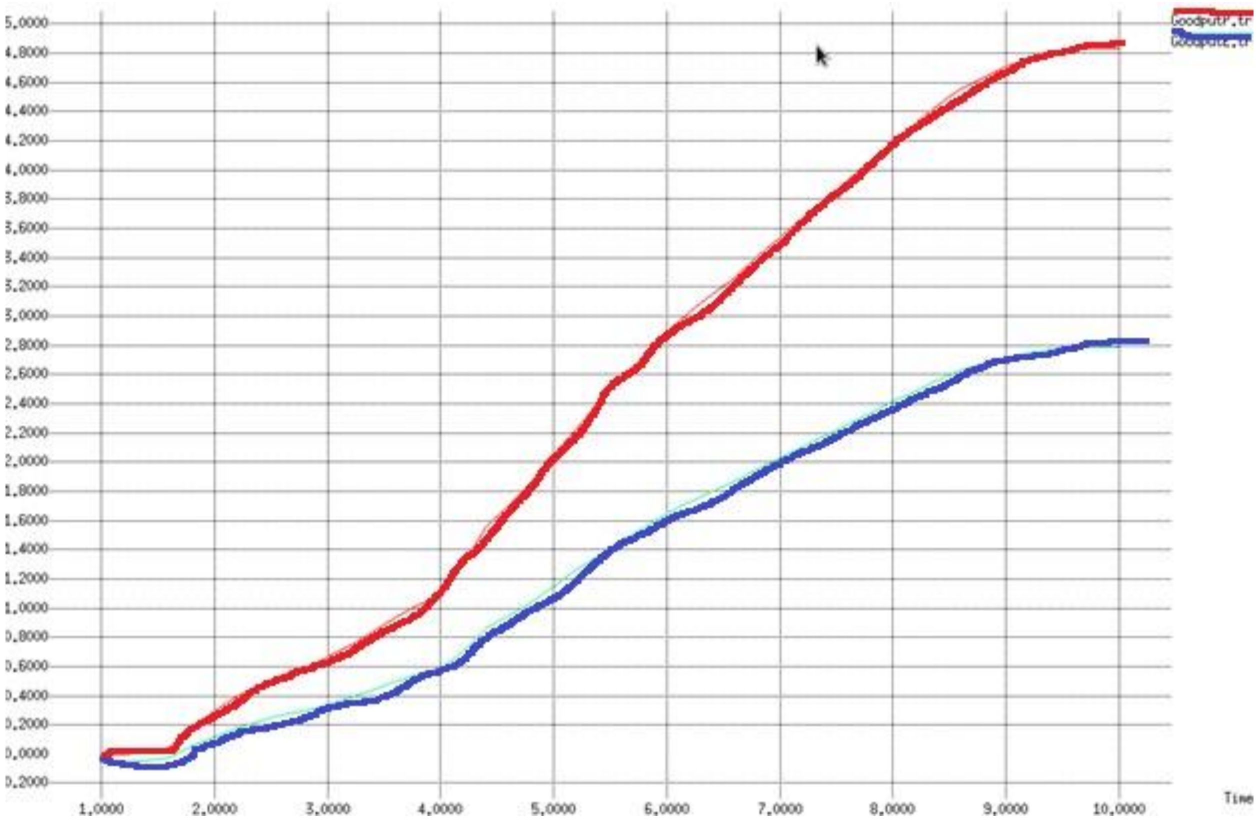

Fig 10.Impact of goodput on spectrum handoff