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Energy-Efficient Resource Allocation and Equal Power on Multi –RAT Primary Licensed and Unlicensed Spectrum Users

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Abstract—Cognitive radio (CR) is one of the new long term communications technology developments taking place on the radio receiver devices. Due to the Software Defined Radio (SDR) approach realization cognitive radio technology will be the next major step forward enabling more effective radio communications systems to be developed over the multi access radio service providers. Multi-radio access technology (multi-RAT) can improve network capacity due to the data transmission by multiple RANs (radio access networks) simultaneously such as Wi-Fi LTE network topologies. In this concept, the network is considered as a new CRN model in heterogeneous multiple PU and secondary spectrum model is overlaid below the femto and macro cell networks. The energy-efficient resource allocation (EERA) problem for CR users with multiple primary user networks overlapping coverage region the concept proposes a equal power sensing algorithm-based search scheme to obtain an optimal solution in terms of the power and bandwidth. Various resource management processes also implemented to deduce the network overloading over the cognitive base network topology.

Keywords — Cognitive Radio, Water filling algorithm, WiFi, Energy efficient.

I. Introduction

In recent years,the eventof intelligent, adjustivewireless devicesreferred to as psychological featureradios, at the side of the introduction of secondary spectrum licensing, haslight-emitting diodetoa brand new paradigm in communications, psychological feature networks. Psychological feature networks area unit wireless networks that carry with it many varieties of users: usually a primary user (the primary license holder of a spectrum band) and secondary users (cognitive radios). These psychological feature users use their psychological featuretalentsto speak while not harming the first users.Psychological feature networks area unit initiated by the apparent lack of spectrum below the present spectrum management policies. the proper to use the wireless spectrum within the us is controlled by the Federal Communications Commission (FCC). Most of the frequency bands helpful to wireless communication have already been authorized by the FCC. However, the FCC has selected a number ofunauthorized bands, most notably the commercial scientific and medical (ISM) bands, over that the vastly Widespread Wi-Fi devices transmit. These bands area unit filling up quick, and, despite their quality, the overwhelming majority of the wireless spectrum is indeed authorized. Currently, the first license holders acquirefrom theFCCtheprerogativeto transmit over their spectral bands. Since most of the bands are authorized, and also the unauthorized bands are speedily filling up, it might seem that a spectral crisis is approaching. This, however, is way from the case. Recent measurements have shown that for the maximum amount as ninetieth of the time, massive parts of the authorized bands stay unused. As authorized bands area unit troublesome to reclaim and unleash, the FCC is considering dynamic and secondary spectrum licensing as an alternate to cut back the quantity of unused spectrum. Bands authorized to primary users might, below bound negotiable conditions, be shared with non-primary users while not having the first retailer unleash its own license. Whether or not the first users would be willing to share their spectrum would rely upon variety of things, as well as the impact on their own communication. The application of psychological feature networks, however, isn't restricted to simply fixing the present spectrum licensing different applications pullulate with shared spectra, like the philosophical system band (where completely different devices ought to exist while not inhibiting every other), device networks (where the sensors might have to work during a spectrum with higher power devices), and current services like the cellular network (where the operator might want to supply completely different levels of services to differing types of users). All of those potential litiesinspire the study of psychological feature networks. Psychological feature radios—wireless devices with reconfigurable laborious ware and software package (including transmission parameters and protocols)—are capable of delivering what these secondary devices would need: the flexibility to showing intelligence sense and adapt to their spectral setting. By fastidiously sensing the first users' presence and adapting their own transmission to ensure a particular performance quality for the first users, these psychological feature devices may dramatically improve spectral potency. at the side of this new flexibility comes the challenge of understanding the boundaries of and coming up with protocols and transmission schemes to totally exploit these psychological feature capabilities. Resource Allocation for Outdoor-to-Indoor Multicarrier Transmission with Shared UE-side Distributed Antenna Systems [1] High data rates are a basic requirement for the next generation wireless communication systems. As a result, orthogonal frequency division multiple access (OFDMA) has been adopted as an air interface for high speed wideband communication systems, due to its flexibility in resource allocation and resistances against multipath fading. On the other hand, multiple-input multiple-output (MIMO) technology has received considerable interest in the past decades as it provides extra degrees of freedom in the spatial domain which facilitates a trade-off between multiplexing gain and diversity gain. Besides, distributed antenna systems (DAS), a special form of MIMO, can be deployed to cover the dead spots in wireless networks, extending service coverage, improving spectral efficiency, and mitigating interference. However, the number of antennas available at the user equipments (UEs) is constrained by the physical size of the devices in practice which leads to a limited spatial multiplexing gain in MIMO systems. However, the system performance of the systems is limited by the system bandwidth which is a very scarce resource in the licensed frequency bands. On the contrary, the unlicensed frequency spectrum around 60 GHz offers a bandwidth of 7 GHz for wireless communications.

Millimeter-Wave Massive MIMO: The Next Wireless Revolution? [2] Multiple-input multiple-output wireless systems are deployed in BS's to increase throughout. Typical MIMO installations use access points or BSs with relatively few antennas and the corresponding improvement in spectral efficiency. To achieve more dramatic gains, a grander view of the MIMO concept envisions the use of orders of magnitude more antennas (e.g., 100 or more) at each BS, which is often referred to as *massive* MIMO. The primary application envisioned for massive MIMO is in a cellular network, where a BS with a very large number *Nt*of antennas serves a set of single antenna co-channel users. The advantages of massive MIMO can potentially be achieved using relatively simple signal processing approaches such as maximal ratio combining (MRC) and maximal ratio transmission (MRT).

Massive MIMO for Next Generation Wireless Systems Massive multiple-input multiple-output (MIMO) is an emerging technology that involves mostly in energy efficiency, exploitation of excess degrees of freedom, time-division duplex (TDD) calibration, techniques to combat pilot contamination, and entirely new channel measurements. With massive MIMO. Each antenna unit would be small and active, preferably fed via an optical or electric digital bus. Massive MIMO relies on spatial multiplexing, which in turn relies on the base station having good enough channel knowledge, on both the uplink and the downlink. On the uplink, this is easy to accomplish by having the terminals send pilots, based on which the base station estimates the channel responses to each of the terminals. The downlink is more difficult. [3] discussed about Reconstruction of Objects with VSN. By this object reconstruction with feature distribution scheme, efficient processing has to be done on the images received from nodes to

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reconstruct the image and respond to user query. Object matching methods form the foundation of many state- of-the-art algorithms.

II. COGNITIVE RADIO

A typical duty cycle of CR includes detecting spectrum white space, selecting the best frequency bands, coordinating spectrum access with other users and vacating the frequency when a primary user appears. Such a cognitive cycle is supported by the following functions:

1. Spectrum sensing and analysis.
2. Spectrum management and handoff.
3. Spectrum allocation and sharing.

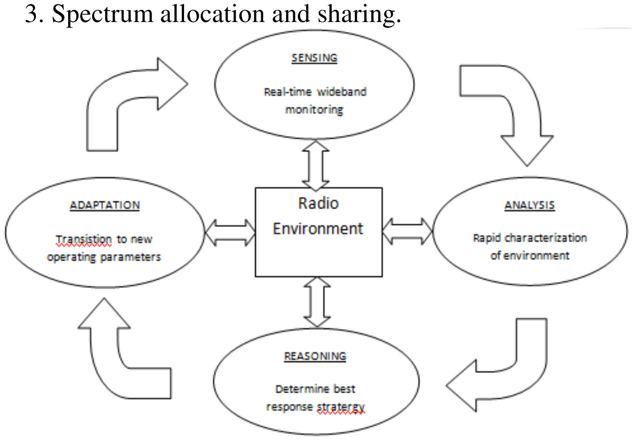

Fig1:Cognitive cycle

III.SPECTRUM SENSING AND ANALYSIS

Through spectrum sensing, metallic element will get necessary observations regarding its encompassing radio atmosphere, like the presence of primary users and look of spectrum holes. Solely with this datawill metallic element adapt its transmittal and receiving parameters, like transmission power, frequency, modulation schemes, and etc., so asto attain economical spectrum utilization Therefore, spectrum sensing and analysis is that the 1stessential step towards dynamic spectrum management. During this section, we are going to discuss 3 totally different aspects of spectrum sensing. 1st is that the interference temperature model, that measures the interference level discovered at a receiver and is employed to guard accredited primary users from harmful interference thanks to unaccredited secondary users. Then we are going to state the spectrum hole detection to see further out there spectrum resources and compare many detection techniques.

A. Spectrum Sensing

Spectrum sensing permits the potential of a metallic element to live, learn, and remember of the radio's operational atmosphere, like the spectrum accessibility and interference standing. once a waveband is detected as not being employed by the first accredited user of the band at a specific time during a particular position, secondary users will utilize the spectrum, i.e., there exists a spectrum chance. Therefore, spectrum sensing is performed within the time, frequency, and abstraction domains. With the recent development of beam forming technology, multiple users can utilize a similar channel/frequency at a similar time within the same geographical location. Thus, if a primary user doesn't transmit altogether the directions, further spectrum opportunities is created for secondary users within the directions wherever the first user isn't operational, and spectrum sensing desires conjointly to require the angle of arrivals into consideration. Primary users can even use their appointed bands by means that of unfold spectrum or frequency hopping, so secondary users will transmit in the same band at the same time while not severely busy with primary users as long as they

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adopt associate orthogonal code with relevancy the codes adopted by primary users. This creates spectrum opportunities in code domain, however meantime needs detection of the codes employed by primary users likewise as multipath parameters. A wealth of literature on spectrum sensing focuses on primary transmitter detection supported the native measurements of secondary users, since police investigation the first users that square measure receiving knowledge is generally terribly troublesome. In step with the priority data they need and therefore the ensuring complexness and accuracy.

B. Energy Detector:

Energy detection is that the commonest style of spectrum sensing as a result of it's straight forward to implement and needs no previous information regarding the first signal. Assume the hypothesis model of the received signal is wherever is that the primary user's signal to be detected at the native receiver of a secondary user, is that the additive white Gaussian noise, and is that the channel gain from the first user's transmitter to the secondary user's receiver. May be a null hypothesis, that means there's no primary user gift within the band, whereas means that the first user's presence. The detection statistics of the energy detector is outlined because the average (or total) energy of discovered samples,

$$T = \frac{1}{N}\sum_{t=1}^{N} |y(t)|^2$$

C. Spectrum Sharing

Considering the access technology of the secondary users, licensed spectrum sharing can be further divided in two categories:

1) *Spectrum underlay:*In spectrum underlay secondary users are allowed to transmit their knowledge within the commissioned spectrum band once primary users square measure transmittal. The interference temperature model is obligatoryon secondary users' transmission power sothe interference at a primary user's receiver is at intervals the interference temperature limit and first users will deliver their packet to the receiver with success. Unfold spectrum techniques square measure sometimesadopted by secondary users to totally utilize the big selection of spectrum. However, as a result of the constraints on transmission power, secondary users will solely succeed short-range communication. If primary users transmit knowledge all the time during a constant mode, spectrum underlay doesn't need secondary users to perform spectrum detection to search out obtainable spectrum band.

2) *Spectrum overlay:*Spectrum overlay is also referred to as opportunistic spectrum access. Unlike spectrum underlay, secondary users in spectrum overlay will only use the licensed spectrum when primary users are not transmitting, so there is no interference temperature limit imposed on secondary users' transmission. Instead, secondary users need to sense the licensed frequency band and detect the spectrum white space, in order to avoid harmful interference to primary users.

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D.Spectrum Handoff:

When the present channel conditions deteriorate, or the first user seemsand reclaims his allotted channel, secondary usershave to be compelled to stop transmittal information and realize altern ative out there channels to resume their transmission. This type of football play in atomic number 24 networks is termed as spectrum football play. Since the transmissions of secondary users are suspended throughout a spectrum football play, they're going to expertise longer packet delay. Therefore, an honest spectrumfootball play mechanism ought to offer with secondary users with swish frequency shift with the smallest amount latency. An honestthanks to alleviate the performance degradation because of long delay is to order an exact variety of channels for potential spectrum football play. Once secondary users have to be compelled to switch to a different frequency, they llinstantly choose one channel from the reserved bands. However, if a secondary user reserves an excessive amount of information measure for spectrum football play, the output is also unnecessarily low, as a result of the first user might not reclaims his accredited band terribly often. Therefore, there's an exchange in optimizing the channel reservation. By optimizing the amount of channels reserved for spectrum football play, the obstruction chance is decreased and also the secondary users' output is maximized. A location assisted relinquishing formula is planned, wherever the secondary users equipped with the situation estimation and sensing devices will report their locations back to the secondary base station. Whenever a football play becomes a requirement, secondary users will switch their frequency to 1 of the candidate channels reckoningon their locations. A joint spectrum football play programming and routing protocol in multi-hop multi-radio atomic number 24 networks is planned, which might minimize the overall football play latency underneath the constraint on network property. The protocol extends the spectrum football play of one link thereto of multiple links. so as to attain a reliable continuous communication among secondary users within the presence of random reclaims from a primary user, secondary users ought to choose their channels from totally accredited bands closely-held by different primary users. The multi-band spectrum diversity helps to cut back the impact of the looks of a primary user and improve the dependability of secondary spectrum access.

E. Cognitive Relaying

Utilizing the broadcasting nature of wireless networks, cooperative relaying is projected in recent years to enhance the network performance through spatial and multi-user diversity. Combined with metallic element technology, cooperative relaying can give additional important performance gain, as a result of psychological feature relay nodes will forward a supply node's knowledge by victimisation the spectrum white house they need detected. A psychological feature multiple access strategy within the presence of a cooperating relay is projected. Since the psychological feature relay solely forwards knowledge once the supply isn't transm ittal, no additional channel resources square measure allotted for cooperation at the relay, and thus the projected protocols give important performance gains over

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typical relaying ways. By recognizing the radio setting in every relay node, the system will autonomously avoid the transmission in AN interference space. In AN infrastructure-based secondary specification is projected to leverage relay-assisted discontinuous OFDM for knowledge transmission. Relay nodes which may bridge the supply and therefore the destination victimisation its common channels between the 2 nodes are selected, and relay choice and spectrum allocation is conjointly optimized

F. Spectrum Sensing and Access

Due to energy and hardware constraints, a secondary user may not be able to sense the entire spectrum space and can only access a limited number of channels from those it has sensed. To optimize spectrum access while considering physical layer spectrum sensing and primary user's traffic statistics, a decision-theoretic approach based on partially observable Markov decision process (POMDP) is proposed , which can optimize secondary users' performance, accommodate spectrum sensing error, and protect primary users from harmful interference. A separation principle reveals the optimality of myopic policies for the spectrum sensor design and access strategy, and reduces the complexity of the POMDP formulation by decoupling the design of sensing strategy from the design of the access strategy.

IV.Proposed System

In heterogeneous multi radio access technology network, utilization of various spectrum of LTE, Wireless local area network and radio networks is incredibly necessary. Hence the proposed Water-filling algorithmic program is employed to allocate spectrum to the unused secondary users in a very economical manner and provide equal power allocation

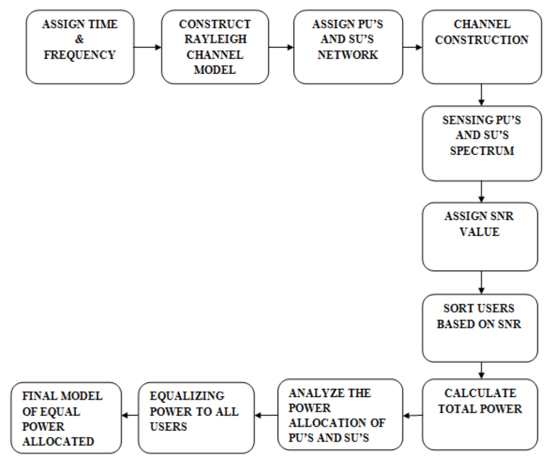

Fig 2:Proposed System

Proposed algorithm

Let *P m, n* to be the solution of the optimization problem.

Step1: According to the WFA scheme, we can find the maximum power that can be allocated to each subcarrier max *Pm,n*while keeping the interference introduced to the primary user equal to the interference limit.

$$\sum_{n=1}^{N} p_{m,n}^{max} \leq P_T$$

Then the solution of the problem is found max *P m,n= P m,n(max)* ,else continue.

Step2: Using the WF algorithm proposed, we can obtain the power allocation vector *Pstep*2 while maintaining the total allocated power equal to the total power budget, but we can't

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guarantee that the interference introduced to PU is under the constraint.

***Step3*:** Find the set of subcarriers $B \subset A$ in which max *Pstep*2 ≥ *Pm*,*n*, set *P wf*2 = *P m* max ,*n* . Evaluate the set of subcarriers C=A-B and the left available power

$P_{left}=\sum_{n=1}^{N} (p_{m,n}^{max} - p_{m,n}^{step\ 2})$

Step4: If = 0 *P left* , the solution of the problem is found where *Pm*,*n*= *Pstep*2 , else, update *Pm* max ,*n* = *Pm* max ,*n* - *Pm step* ,*n* 2 . Applying the LWFP scheme on the subcarriers in the set C under the power constraint *Pleft*and get the power
allocation *P step*4,update *P step*2 = *P step*2 + *P step*4 ;
Step5:

$\sum_{n=1}^{N} p_{m,n}^{step\ 2} * K_{m,n} \geq I^{th}$, then $p_{m,n}=p_{step\ 2}$

If else go to step 3. This algorithm converges to the required solution after several iterations.

V.SYSTEM MODEL:

In the model discussed in paper reach individual PU is allocated sub channel. There are N sub channels corresponding to NPUs in the networks. Each sub channel consists of Lj (j=1, 2...N) different subcarriers which have different channel gains. So the total number of subcarriers istherefore, in this OSA cognitive radio model, the SU Tx cannot transmit signal when the PUs are detected. While the PUs are not detected we have to make sure the transmit power is under a certain threshold. This condition can be formulated in as:

$$P_j \leq G_j$$

Where

$$G_j = \begin{cases} 0 & PU_j isdetected \\ \eta(d_j - r_p^j)^{\beta_j} & PU_j isnotdetected \end{cases}$$

Where Pj is the allocated power for SUs in subchannel j and ŋ is the threshold. For simplicity, the threshold in all sub channels is assumed to be the same. Gj is the interference constraint for sub channel j, dj is the distance between the SU transmitter and the PUj transmitter, and$r_p^j$is the radius of theprotection region in sub channel j, β_j denotes the path attenuation factor. One scenario which we simulated in Matlab is given below. Red boxes are SU's with their protection ring and Green ones are PU's with their reliable detection ring.

The OFDM communication model is of the form

$$y_n[m] = h_n x_n[m] + w[m]$$

$$n = 0,1, \dots, N-1$$

Where is the input, is the output, is AWGN and $h_n$is the channel gain. The normal water filling problem consist of optimizing capacity in the by allocating the power such that

$$C_n = \max_{P_0,\dots P_{N-1}} \sum_{n=0}^{N-1} \log\left(1 + \frac{P_n |h_n|^2}{N_0}\right)$$

Under the constraint $\sum_{k=0}^{N-1} P_n = P_{total}$

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$$P_n \geq 0, n = 0,1,\ldots,N-1$$

The above conditions are solved using Lagrangian multipliers using the Kuhn- tucker condition to get the optimum solution such that

$$P_n = \begin{cases} 0 & if\ \frac{1}{\lambda} < \frac{N_0}{(|h_n|)^2} \\ \frac{1}{\lambda} - \frac{N_0}{(|h_n|)^2} & otherwise \end{cases}$$

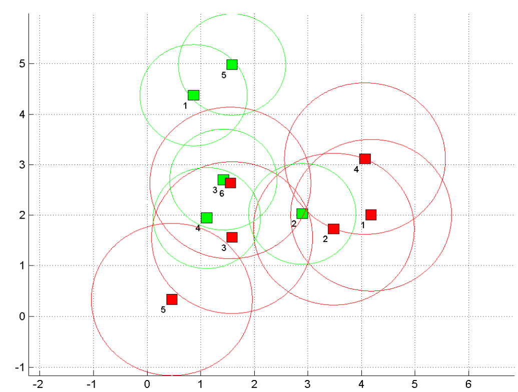

Fig 3: Heterogeneous Network

The model is modified to suit an OFDM based cognitive radio system described above by adding a following constraint of maximum power i.e. $\sum_{i\epsilon I\_i} P_i = F_j \leq G_j$ where P_i is the power allocated to that subcarrier and G_j is the maximum power transmission capacity of that particular sub channel.

One method to solve this problem is such as stated by the algorithm given as follows:

I. Initialization:

A={j|j=1,2,...,M},B=ø,C=A, Ř=R_t.

II.Iteration:

1) Perform the conventional water-filling on the subcarriers in all the

Sub channels that belong to the set A with the target rate Ř.

2) $F_j = \sum_{i=mj}^{mj+1-1} Pi$ where j€ A,C={j|F_j≥G_jj€A};

3)A=A\C,B=B∪C;

4) Perform the traditional water-filling on the subcarriers in each sub channel j that

j€C individually with the corresponding sub channel transmit power constraint

G_j ;

5) $Rj = \sum_{i=mj}^{mj+1-1} log\,(1 + |hi|^2 P_i)$ where j€C,Ř=Ř-$\sum_{J\epsilon C} R_j$.

III.End

VI.Results:

The simulated result shows how was the primary user and secondary users are arranged in a heterogeneous network and corresponding power allocation to the licensed and unlicensed users in the network. Hence the proposed system also increases throughput.

PU's and SU's Allocation

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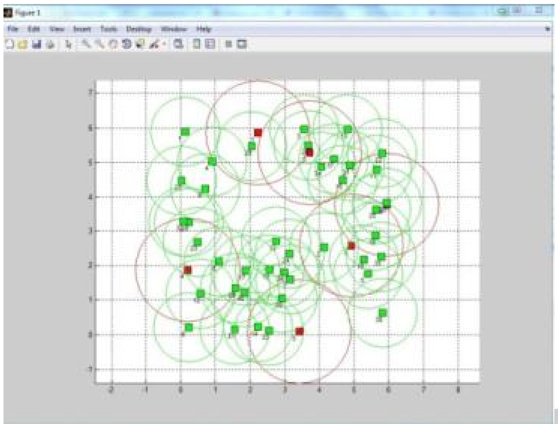
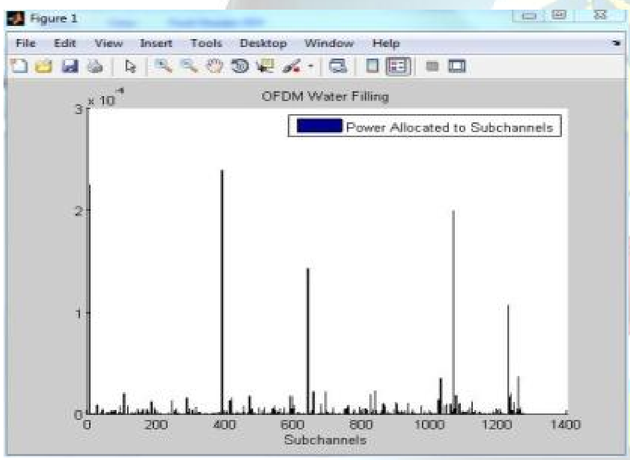
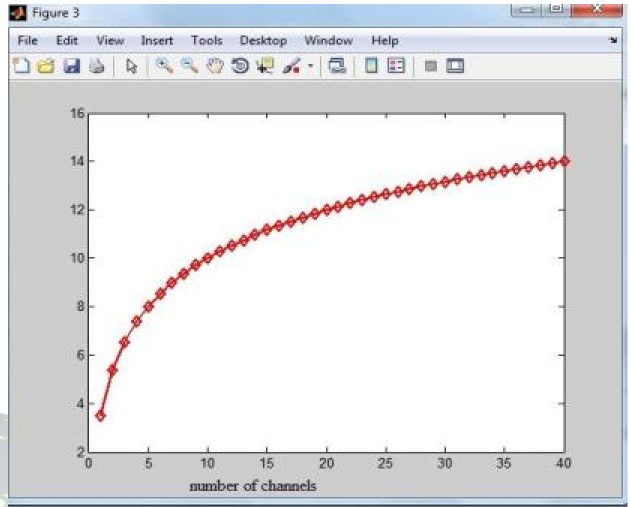


Equal power allocation



Throughput result



I.CONCLUSION

From the result the power allocated to the Primary and secondary users in a cognitive heterogeneous network have been equally allocated to all users and throughput also increased. Hence water-filling algorithm provides enhanced equal power allocation among a heterogeneous network, which is also improves throughput. Therefore water-filling5G outdoor to indoor, water-filling algorithm performs better power allocation to the licensed and unlicensed spectrum.

VIII. ACKNOWLEDGMENT

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