SPECTRAL EFFICIENCY OPTIMIZATION OF MASSIVE MIMO NETWORK

DISSERTATION-II

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By

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CERTIFICATE

This is to certify that **Raabia Kausar** bearing Registration no.11601335 have completed objective formulation/Base Paper implementation of the thesis titled,**"Spectral Efficiency Optimization of Massive MIMO Network"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of thesis has ever been submitted for any other degree at any university.

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DECLARATION

I, Raabia Kausar, student of M. Tech under Department of Electronics and Communication of Lovely Professional University, Punjab, hereby declare that all the information furnished in this Dissertation-II report is based on my own intensive research and is genuine.

This report does not, to the best of our knowledge, contain part of my work which has been submitted for the award of my degree either of this University or any other University without proper citation.

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ABSTRACT

As per our interest & ability in the development of the 5G green networks, SS is the technique which is of prime importance. So for 5G providers the Massive MIMO serves as a backbone, in which BSs are provided with many number of antennas so as to provide the higher spectral & energy efficient gain than the present LTE networks we have. So we are acquainted with the ability to provide our views and discuss the methods which trigger those benefits provided by large MIMO. We initiate the process with the evolution and switching techniques required for flourishing 5G green network. Then we review famous SS maximization techniques for MM & observe some flaws associated with it. Then we deal with the certain changes which 5G demands for expanding capacity, enhancing data rate, diminishing latency for better QOS. To serve this, massive MIMO & hence the network requires certain changes. We examine SS under three different scenarios, urban area, sub-urban area & ruler area under many processing criteria. Furthermore we deal with optimization of the number of users, number of antennas and pilots for attaining maximum spectrum efficiency.

LIST OF ABBREVIATIONS

Abb.	Full form
TVWS	Television White Space
LTE	Long Term Evolution
DSA	Dynamic Range Access
RATs	Radio Access Technology
SDR	Software Define Radio
CDMA	Code Division Multiplexing Access
ITU	Indian Telecommunication Union
GSM	Global System of Mobiles
OFDM	Orthogonal Frequency Division Multiplexing Access
FER	Frame Error Rate
PIC	parallel interference cancellation
SIC	Successive interference cancellation
SRT	security-reliability trade off
PU	primary unit
SU	secondary unit
RJS	radio jammer selection
MAC	media access control
QOS	quality of service

FSU	Femto cell optical clients
MSU	Million service units
TNF	thermal Noise floor
FCC	Federal communication commission
RRM	joint radio resonance management
ASM	advanced spectrum management
OJS	optimal jammer selection
IOT	internet of things
MSUs	macro optical clients
DSL	Digital subscriber line
WCB	mm wave candidate limit
OOBE	out-of-band emission
OPSEC	Operations security
IUs	Inertial upper stage
CUS	Common user system
LSA	Local service area
SAS	Serial attaches (scsi) small computer system interface.
RFID	Radio frequency identification

SRD	Short range device/spectral recording digital.
UWB	Ultra wide band
M2M	Machine to machine
IMT	International mobile telecommunication .
QOS	Quality of service
PCAST	President's council of advisors on science
CEPT	Conference Europeans des postes etdes telecomm.(French).
BS	Base station
CR	Cognitive radio
SLA	Service Level Agreement
DEM	Device economic model
STP	Short Term priority
MIMO	Multiple input multiple output
MMW	Multi meter wave
CRN	Cognitive radio network
WRC	World radio communication conference

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CHAPTER 1

INTRODUCTION

1.1) Motivation

G. Marconi, an Italian inventor, opens the way from claiming present day wireless exchanges by conveying the letter `S' along a separation of 3Km as the form of three dot Morse code taking help from electromagnetic waves. Then afterward this inception, of wireless exchanges have got to be a critical piece to display in present scenario. Since satellite communication, TV furthermore radio transmission need propelled on pervasive portable telephone, remote interchanges have converted that style of society in which it is used to run. The advancement about remote starts here and will be indicated in fig. 1[1]. It indicates the evolving generations of remote innovations as far as information rate, mobility, scope plus spectral efficiency is concerned. Likewise the remote advances are growing, the information rate, mobility, and scope, also spectral efficiency expands. It likewise demonstrates that those 1G furthermore 2G advances utilize circuit switching/exchanging, 2.5G furthermore 3G employs both. But, other generations use packet switching only and these generations start with 3. 5G to recent generation i.e. 5G. Alongside these factors, it likewise separates between licensed also unlicensed ranges. Every last one of evolving generations utilize the authorized/licensed range but on the other hand those Wi-Fi, Bluetooth, WIMAX utilizes the unlicensed one [2].

Range imparting(spectrum sharing) might be characterized by Concerning illustration as when different range groups are available, range offering will be imperative with system limit for which different schemes are suggested to productive range imparting around separate system substances. The range assets need aid essentially imparted around clients with rise to likelihood. In the range offering system there will be a recommended view of multi-channel ALOHA protocol and the hypothesis of possibility gaming. In the writers contemplate range imparting around various cell division operate in the unlicensed range utilizing Stackelberg diversion. Clinched alongside range imparting is examined utilizing stable marriage gaming, which plans on discovering the majority stable pairings between those clients & frequency bands available. A clogging gaming methodology may be suggested which permits clients to autonomously select a range groups to expand & increase its identity or utility [2].

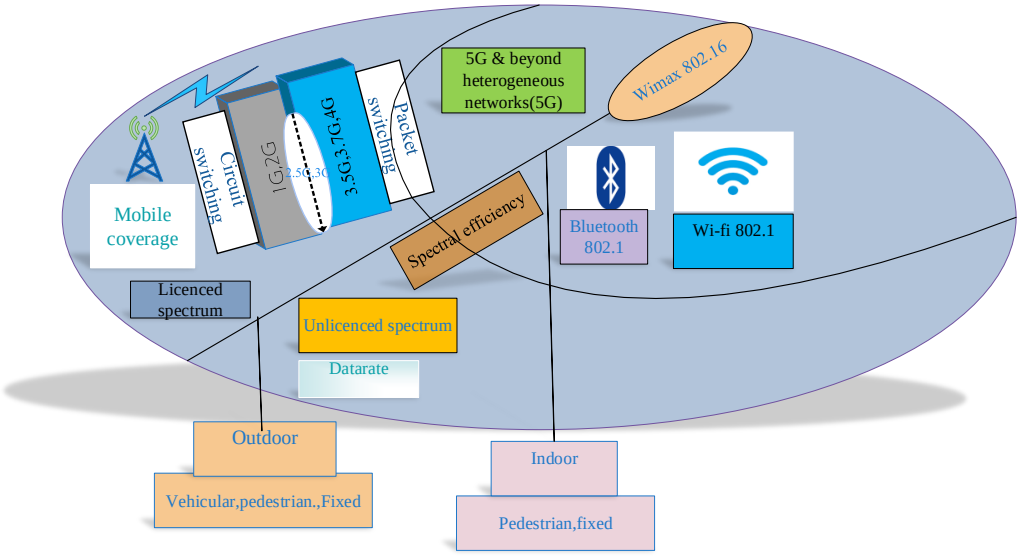


Fig.1.1 Evolution of wireless technology.

1.2) Overview of Study

Today cordless telecommunication networks has now become rather more prominent than any one might have thought of when the cell phone idea was 1st developed in 1960's and 1970's. Mobile wireless communication has come to the birth of creation and revolution, since early 1970's. From middle 1990's, the cellular communication business has seen extensive increase. Mobile cellular subscribers are increasing four-hundred folds per year. There is a tremendous growth in wireless and mobile networks from last twenty years. These days every cell phone have a wireless fidelity adapter. But there are also few cell phones that have Wi-MAX adapter, other than each of the 2G, 3G, WLAN, Bluetooth etc. adapters [2].

The arranged open wireless Network (OWN) is focused to create open baseband process modules with just a single interface parameter. The OWN focused on MAC/PHY layers of future (4G) wireless mobile terminals. The documented work higher than provides a ground to meaning of an arranged for on the far side 4G mobile networks referred during this paper as 5G mobile networks. Inside all the arranged origination the mobile client is on the most noteworthy among all. There is software bundle, illustrated radios and modulation theme in 5G terminals. Additionally, latest controlling of errors has plans of downloading to make them run from the web. The event is seen towards the user terminals as consideration of the 5G wireless networks the occasion is seen towards the client terminal. These terminals have an access to approach completely.

Diverse wireless innovation at consistent tine and furthermore the terminal should be prepared to consolidate distinctive streams from various advanced technologies.

Wireless technology is differentiated on the idea of their range. Some supply property among few feet's viz. Bluetooth and alternate cowl medium sized workplace area. The transportable covers whole continents. Wireless technology supply e-commerce additional versatile and in expensive ways in which to send and receive information. The four key advantages of wireless technology are as under:

- *Increasing efficiency:* High technology communication system transfer the information faster with in business and between customers.
- *Is rarely out of touch:* No need to be compelled to carry cables or adapters so as to access workspace Networks.
- *It provides Greater flexibility for users*: Wireless network within the workspace can be networked while not sitting at dedicated PC's.
- *It decreases Cost:* cordless networks are of less cost to maintain and install than wired networks.

In present the large scale MIMO procedure is perceived as a promising specialized possibility for future wireless communication systems due to its spectrum efficiency. In Fig.1.1 there is the concept of massive MIMO. By using large number of antennas at the transmitter and receiver side will bring large spatial diversity and multiplexing gains that promises a good improvement in performance [6]. Most of the research works on power allocation in large-scale MIMO systems are focused on expanding the capacity of the system. Be that as it may, because of the energy deficiency and furthermore the developing necessities of whenever and anyplace sight and sound applications innovation, there has been an enthusiasm on the energy utilization of tremendous scale MIMO system, uplink vitality productive resource distribution was considered in ghastly enormous multi-client MIMO networks. In [7] the author proposed the joint enhancement of antenna selection and energy assignment for extensive appropriated MIMO systems. A spectrum efficient augmentation drawback is created under limitations on per-client rate and per-transmit antenna energy to select conveyed antenna.

The commitments of this paper [8] are two overlay, these are listed underneath.

- Both of these up link and down link antennas are considered into account once designing the spectrum efficient resource allocation.
- This can be essential, wireless communication systems where a base QoS is required. The propose calculation program gives a QoS ensure. Just if the QoS is fulfilled, spectrum efficient designs become plainly valuable. And the propose algorithm gives guarantee to provide QoS.

Finally, the simulation results show that the number of antennas at transmit side plays an vital role in increasing the spectral efficiency and are able to get an optimal value of transmit antennas. It is conjointly discovered that the number of users and therefore QoS requirement have an impact on the energy efficiency.

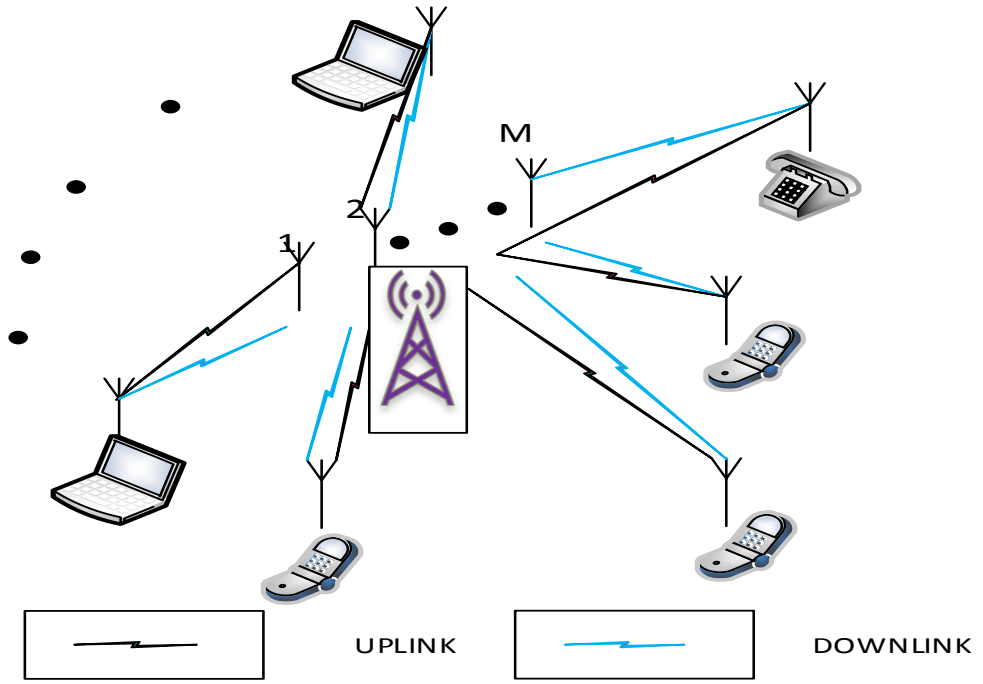


Fig.1.2 Massive MIMO network

1.3) Spectrum Sharing in 5G

5G green necessities should support limits fundamentally to suit a versatile movement surge plus other different benefits. [3]. Firstly, a greater amount of range will be required. But the authorized range will be exactly limited so, cell division networks are now growing by using the unlicensed band of spectrum (e.g. LTE-Unlicensed or LTE-U), for example, 5GHz also 60GHz [4]. Over the top deliberations starting with both industry and academia needs to commit to empower LTE on operation clinched alongside 5GHz band [5]. Besides, those under-utilized range from other frameworks for example, television white space (TVWS) could be reaped and used again in cell division frameworks to increment networks ability opportunistically, through propelled cognitive radio technologies.[6]Then, the cellular network will manage a heterogonous range pool as far as availability, bandwidth, etc. is concerned. Usage of the radio range is subject to recurrence, time, spatial area, and orthogonal flag detachment. Any sharing of the range should consider at least one of these four measurements. Sharing can be refined in a clear form when any two of these measurements are in like manner and the third or potentially fourth measurement contrasts by a degree adequate to guarantee that all the included administrations (at least two) can work palatably. Sharing can likewise be expert when administrations have every one of the four measurements in like manner. Eventually different little base stations (SBSs) are deployed to enhance the spatial range reuse over the system [7]. However, thickly deployed SBSs could fairly start with extreme inter-cell interference, which will corrupt both the system ability and also the client

experience. In order to adequately enhance the network limit also fulfil user's requirements, productive spectrum range imparting in cells is very important [8].

Allocating spectrum sharing range "effectively" obliges adjusting contending requests so that spectrum utilization is given to the privileged use (s) who value(s) them so much. Range directors must consider the sum of the real requests for range starting with government, commercial, also other non-business clients. These incorporate open safety, army protection, promotion of education, experimental research, furthermore impelling monetary development also thriving in the private division is included. On principle, when overseeing the trade-offs from contending demands, productive range management strategy ought to try to expand downright social and budgetary quality from claiming spectrum subject of the necessities situated toward policymakers. There are in any event two sorts of values that might be made eventually by range based administrations for policymakers by considering budgetary quality driven by the possibility benefits from deploying the spectrum. Also social esteem is made towards those non-business range built provisions. Both for these sorts of quality ought to be acknowledged when settling on range allotment choice.

Cases, offering will be finished toward applying specialized foul states which don't trade off the execution prerequisites of the benefits included. Some of the essential routines of range imparting are specified as:-. Computerized correspondence framework sharing which is known as digital communication sharing, dynamic pre-emptive time sharing, dynamic variable partitioning, geographic sharing, fleeting sharing, predictable, random, facilitated/coordinated sharing, clumsy/uncoordinated rule-based sharing,[9] regulatory methods(administrative), business sector methods (market method) & exchanging(trading method). [10].

To increase the SE of the mobile N/Ws massive MIMO is an efficient way where large no. of active antennas at the mobile towers are providing the efficient transmission processes. Here the number of antennas M, should be necessarily higher than no. of users (K) as the channels for users are orthogonal with M/K ratio greater than 10. Evaluating the optimization of no. of users depends on antenna no. and also on some other parameters as well. We have a new SE equation which efficiently analysis the systems for control of energy, pilot signals, reusing and selection of positions. This gives an idea of what happens if M has an infinite value while considering many situations with many pilots, different reuse factor and different schemes of processing.

Hence we realize form this that up to half the efficient spectrum block must be given to pilots and M/K should be less than 10 practically. It is not advisable to use similar K for comparing these schemes as K is dependent on processing schemes.

1.4) Methods of Spectrum Sharing

Some methods required for efficient spectrum sharing in 5G green network are classified as:-

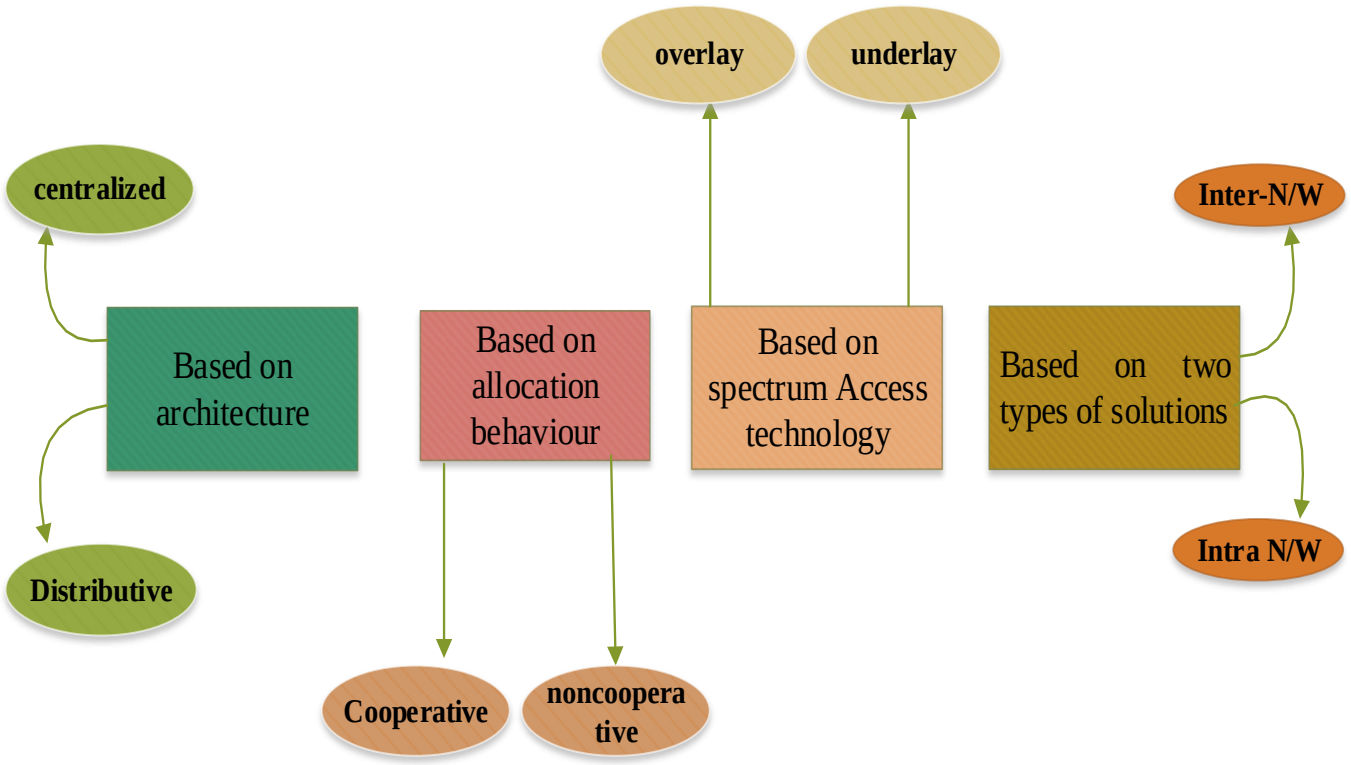


Fig. 1.3 Classification of Spectrum Sharing Methods

A) Based on architecture

a) Centralized spectrum sharing

central entity is used for handling the bandwidth allotments and accessing ways. Also, for the calculations of the bandwidth allotments there is sensing technique used to control it and then give it to the central controler so in this way a graph of bandwith allotment is created. Furthermore, the central body leases the bandwidth to clients in a perticular region only to specify the time required. Moreover, the bandwidth competition, user competition etc is also taken into consideration by a central spectrum policy server[42].

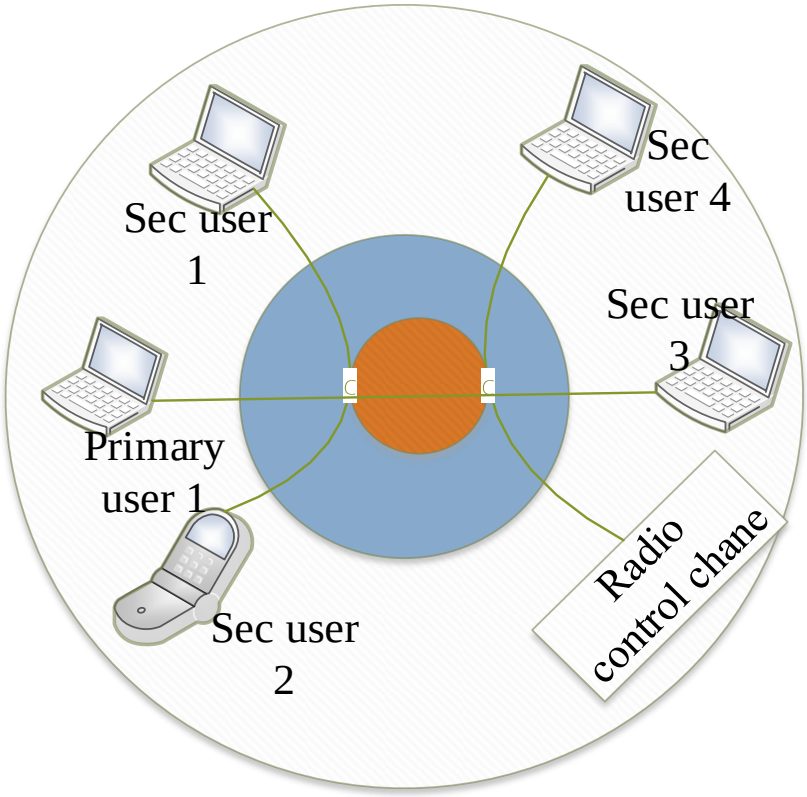


Fig.1.4 Centralized spectrum sharin

b) Distributed spectrum sharing.

Every node in a distributed fashion performs the processes and depends on the bandwidth allocation and access technique [43].These distributed wayouts need to be utilized in different networks so as to provide each base station (BS) a sort of competition with its neighbouring BSs as per the rule to get better quality of service requirements of its clients. Hence, these get a portion of the spectrum only for utilization. At the cost of the exchange of messages in between nodes, distributed solutions are used. These actually follow the centralized solutions[41].

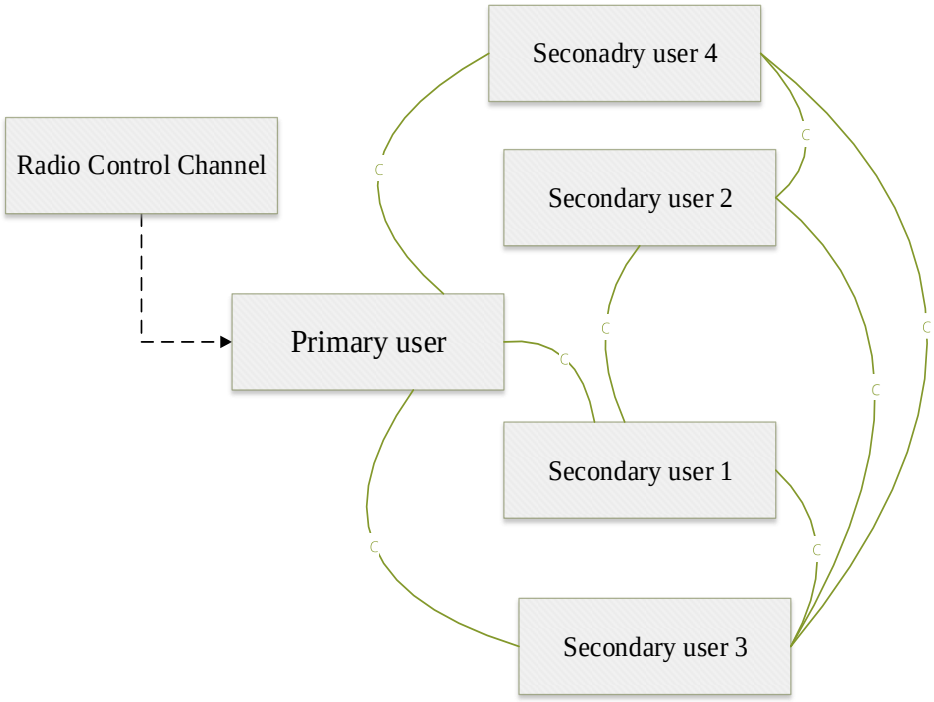


Fig.1.5 Distributive spectrum sharing

B) Based on allocation behaviour

a) Cooperative spectrum sharing

collaborative solution exploits the measuring of fading of each node which effects the communication of one cell on other cell is taken into account. In order to share interference information in local areas some common methods are used in these packages. An effective balance between a centralized and a distributive methods used in cooperte sharing is governed locally.

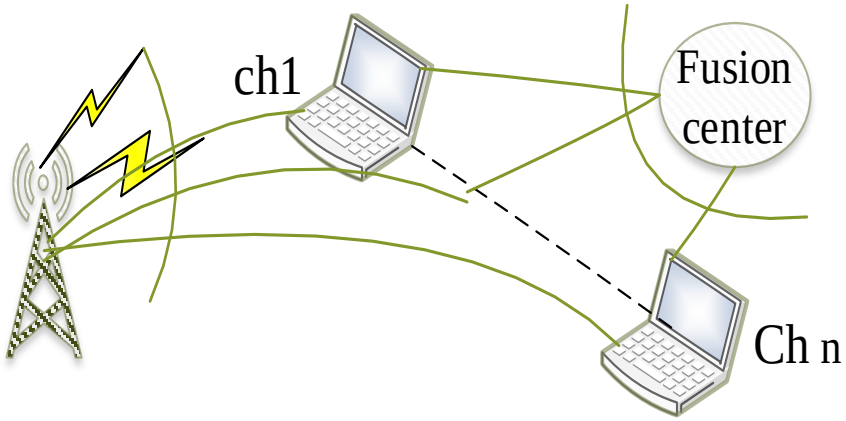


Fig.1.6 Cooperative spectrum sharing

b) Non-cooperative spectrum sharing

Non-cooperative(or non-collaborative, selfish) solutions are taken into account in single mode only [69]. Because inter- symbol interference is not considered in other nodes, non-cooperative solutions may cause reduced bandwidth utilization. But, these solutions do not require message exchanges between neighboring cells as in cooperative solutions. cooperative techniques provide a certain degree of fairness, as well as improved throughput. However, the performance degradation of non-cooperative approaches are generally disturbed by the significant low information exchanges leading to the power consumption[68].

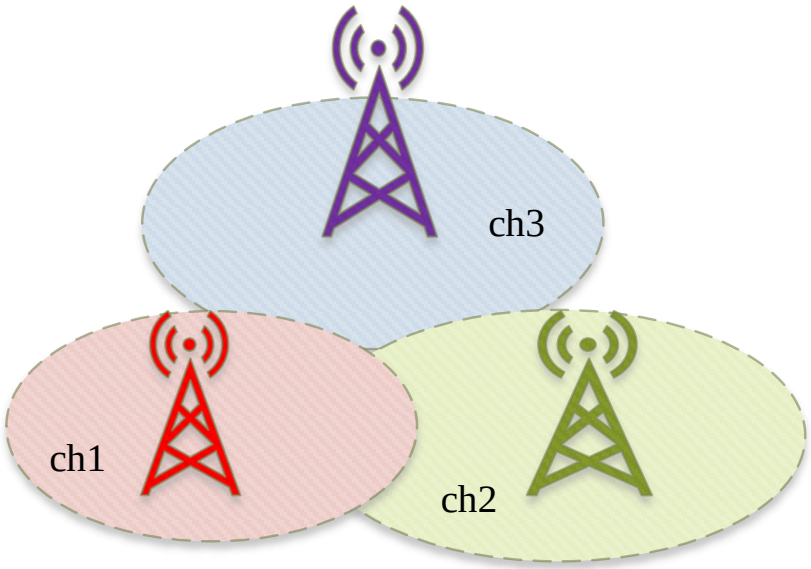


Fig.1.7 Non cooperative spectrum sharing

C) Based on spectrum Access technology

a) Overlay spectrum sharing

Nodes are accessed using the network with a portion of the spectrum that has not been used by any licensed user. Henc minimizing the interference to the primary network[40]Fig1.8(a)

b) Underlay spectrum sharing

The authorized clients exploits the spread sharing way outs for the propagation of CR node. Increasing the complexity to some extent only underlay technique makes use of higher bandwidth. Keeping in view these points, this compromize between combined techniques to be useful for the accessing of spectrum sharing technology in these networks.Fig.1.8(b).

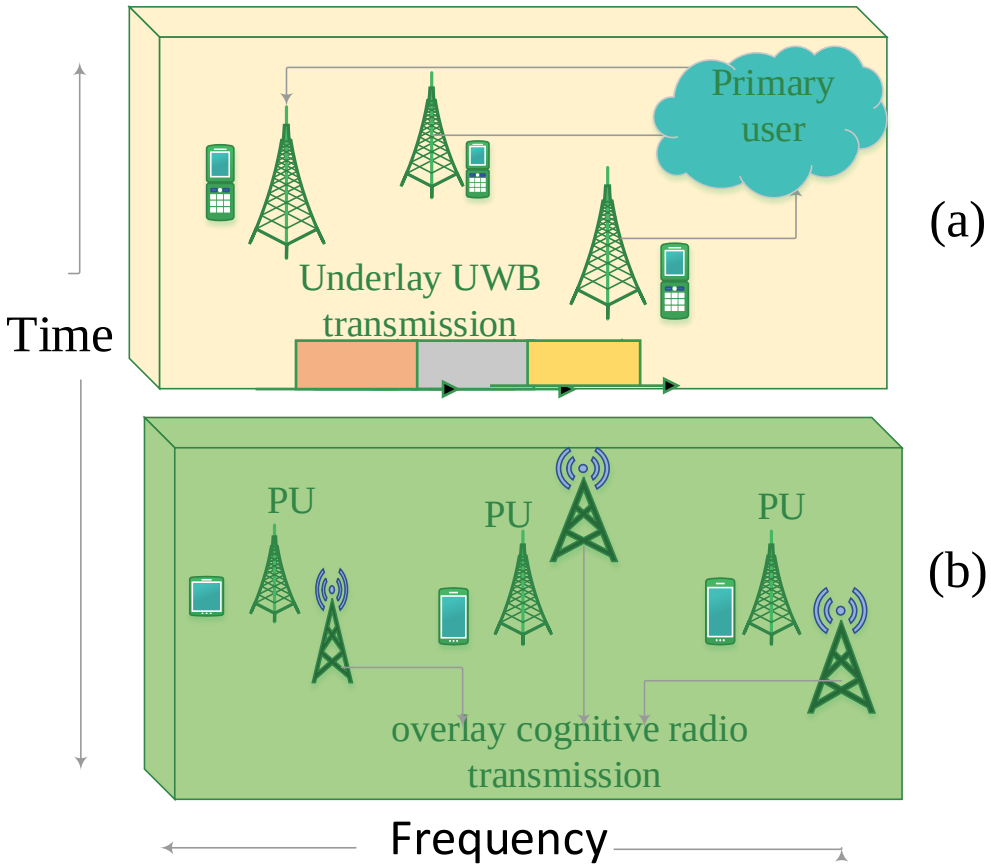


Fig.1.8 overlay & underlay transmission

D) Based on two types of solutions

a) Intra network spectrum sharing

This methods provides a solution for focussing on spectrum allocation in between the blocks of a CR frameworks. Therefore, keeping in view not to cause any interference to the primary users, the network utilizes the provided spectrum only. Previous wireless communication was not able to provide the unique challenege where as this typr of spectrum sharing has hold over it. [11].

b) Inter network spectrum sharing

The networks are allowed in CR to get used in mingled positions also bandwidths, as the inter-network spectrum sharing is considerd the wayout ,it provides plateform for large spectrum sharing systems by involving certain policies which operate it Fig.1.9 [11].

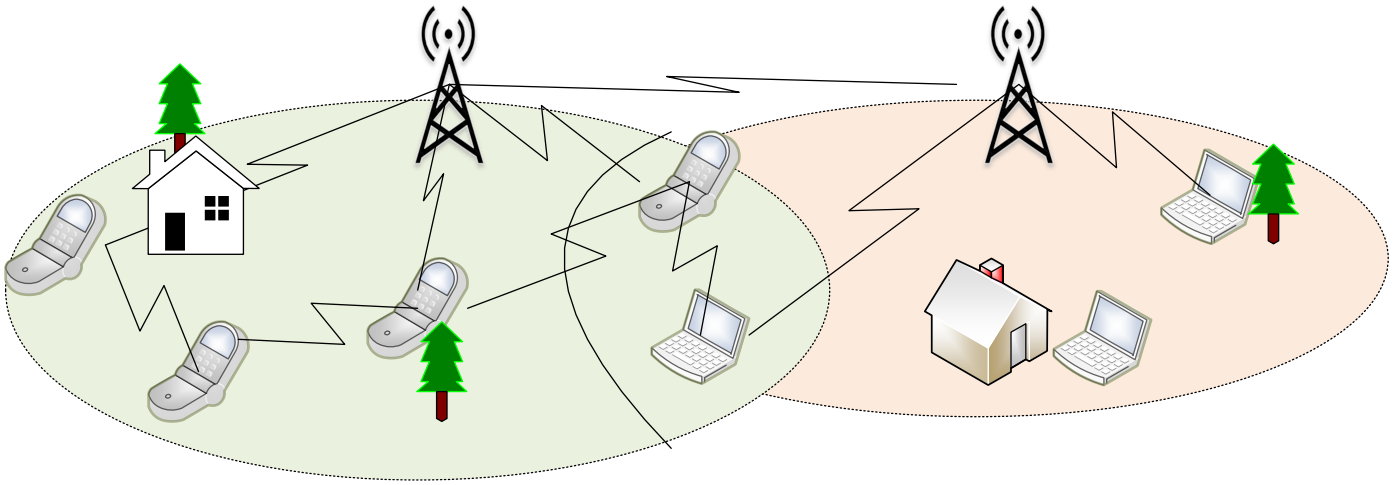


Fig.1.9 Intra and inter spectrum sharing

CHAPTER 2:

REVIEW OF LITERATURE

2.1 Literature Spectrum Sharing Methods

Akyildiz, Ian F., et al [11] in this paper author gives a brief description of need of spectrum sharing and classification of its methods based on architecture, based on allocation behaviour, based on spectrum Access technology and based on two types of solutions. These are further classified as centralized, distributive, cooperative, non-cooperative, overlay, underlay and inter, intra spectrum sharing respectively.

J. M. Peha, et al [12] in this paper author gives the classification of spectrum sharing methods on spectrum vs. time basis .It explains the universal method for taking care of range for cordless telephony large/remote area networks. The place two operators possess a certain parts of the range which may be once more subdivided under three other narrow frequency groups each allocated to one radio access technology (RAT). A pattern for more adaptable utilization of range is underpinned via novel developments to radio engineering organization. Starting of adaptable radio range use to a solitary driver is intra-operator range offering which incorporates the progressive allotment of RATs inside the range box of one driver and also the displacement of clients between these frequency ranges. Many European nations use the RATs with authorized range that will be permitted by those administrative forms empowering the adaptable provision for software defined radio (SDR) engineering organization [12].

Fitch, M in paper [14] classifies the spectrum sharing methods on spectrum vs time basis as:-
On orthogonal range imparting the clients can be moved again in range groups of both operators. However, one range band is at present only allotted to one person driver. No extra obstruction may be made by orthogonal range imparting fig 2-c.Thses operators have some part of band shown in fig c and d treated as protection bands (blue and orange labels bands respectively). Their function is to better QOS & to satisfy customer demands. Output of orthogonal inter-operator spectrum sharing is given in [13].

Ghosh, Gout am, et al [15] in this paper author explains Digital communication system sharing spectrum sharing using the two important methods of sharing overlay and underlay.There will be a pattern where transform should be computerized correspondence frameworks which regularly utilize lapse identification furthermore ahead slip revision calculations and might enhance framework execution in the vicinity from claiming obstruction sources. This probably enhances offering possibilities. Additionally, previously, numerous cases that advanced indicator structures utilized by varying imparting administrations are regularly indistinguishable twin or comparable.

One recent alternative method of sharing is based upon the principle of overlay. Those sharing systems are Spectrum and time overlay sharing (spread spectrum, packet radio, frequency agility).The principle of overlaying involves superimposing the operation of equipment's in a new service in such a manner that all primary allocated services can coexist. Several new technologies may have characteristics that may prove effective for overlay sharing. These are spread spectrum modulation (CDMA), intermittent packet communication and real-time spectrum occupancy measurements to find unused channels [15].

Y. Zhao, Z, et al [16] in the paper the author has explained few more types of sharing. As an additional usually acknowledged sort for offering/sharing may be Temporal. In this case, two clients might take the same band for range in the same geographic area, be that as in separate times. There would a few approaches over which a temporal sharing might be constructed. Such plans can be a chance to be isolated under two significant classes: predictable and irregular/random. Under a predictable transient offering regime, client agrees not to transmit throughout specific predefined times so as to accommodate the other user for that time. Such imparting may change eventually between the number of cycles and normality. The effect of predictable imparting on the worth provided for client depends on the timing, recurrence & assurance for when interruptions may happen. To instance, AM radio range will be imparted the middle of daytime also predominant 24-hour broadcasters. Huge numbers of the daytime broadcasters need aid required to decrease or turn off their administration. In night, permitting that prevailing 24-hour station will show a bigger foot shaped impression which shows its evening proliferation widened its foot shaped impression. Alternatively, a general client might bring a band of spectrum, but the point when it will get out of it. Of the degree that those predictable bandwidth sharing additionally make negotiated, now and again that are worthy with both parties, the quality lost might make significantly more level. Capricious or irregular offering happens. The point when the auxiliary client might prevent utilizing the particular range on short perceive alternately without cautioning. This sort of imparting might have been at first suggested for those 700 MHz square. Typically, the more terrific the span and more difficult to predict those sharing obligations, more will be the reduction for other user values [16].

Yiping Xing et al [17] author explains the Uncoordinated Rule-based sharing. It actually includes the scenario in which rule of utilization is planned to overcome the hazardous obstructions. Uncoordinated sharing normally happens through unlicensed range. Previously, those gadgets that help a specific set from claiming criteria would be permitted to transmit again with that range. This kind of offering may be rule-based, till every last bit client obeys the criteria of rule base, dissimilar to that of from claiming cognitive sharing, there may be no further compelling reason for coordination around the clients. Samples for this sort from claiming imparting incorporate low control devices, for example, baby screens also remote microphones, Wi-Fi, furthermore actually radio astro-chemistry. [17].

Y. Zhao, et al [25] in this paper author provides the detailed idea of Dynamic range/spectrum access is basically the recognition of claiming range gaps (a frequency spectrum range which may be spare sufficient to be used) alternately white spaces are furthermore utilized for communication purposes. [18] The technique of Dynamic spectrum range access may be the important & fundamental provision of cognitive radios. The PU groups need aid opportunistically accessed toward the SU networks such-and-such those obstruction created of the PUs may be unimportant. Fig. 5(b) below indicates the situation for dynamic range entry (DSA) the place different PUs plus SUs are existing together [19].

This may be a method toward which a radio framework adjusts with accessible range/spectrum gaps/holes for constrained range utilization privileges dynamically, because of the opposition with evolving condition furthermore objectives: those made obstruction transforms the radio's state for Ecological imperatives [20]. The fundamental errand/work of DSA will be that it should succeed two sorts about interference: i) hurtful impedance initiated by gadget malworking and ii) hurtful impedance initiated eventually by pernicious client [21]. Dynamic spectrum access aids in three different ways as shown in below figure 2 i) range awareness, ii) cognitive processing, furthermore iii) range (spectrum) access [22].

Qi, Lin, et al [34] in paper author explains spectrum utilization/sharing as methods an important methods in sharing spectrum among different users. It provides for those emulating anatomy/reality from claiming dynamic spectrum access system. The differing qualities of the imagined range change plans is showed in the amount of specialized foul terms coined till now :Dynamic spectrum access versus dynamic range commons, opportunistic spectrum access versus spectrum pooling, range underlay versus range overlay. Same time an alternate taxonomy: range underlay, range overlay furthermore range interweave is viewed. Regardless of which plot of perspective it has been thought as of those scientific classification from claiming dynamic spectrum access models, specialized foul implication inside remains same. Whatever remains in may be to make them realize to maximize the appropriate frequencies.

All the methods of spectrum sharing with applications and a brief description is summarized in Table 2.1.

Table 2.1. SUMMERY OF All SPECTRUM SHARING METHODS.

Reference	**Method**	**Applications**	**Description**
[35]	A .Digital communication system sharing	Used in real time spectrum occupancy. The best example can be cognitive radio. Which Intends to speed technological innovation and improve the efficiency of spectrum use.	Increase in demand of services like mobile telephones and many others has required changes in the philosophy of spectrum management.
[36]	B. GEOGRAPHICAL SHARING 1. Time & space sharing i) Dynamic pre-emptive time sharing ii) Dynamic variable partitioning 2.Temporal sharing, predictable and random 3.Coordinated sharing 4. Un coordinated rule based sharing	Geographic sharing is already very commonly used in the commercial and federal spectrum bands. i)It is used in public services to utilize a portion of the spectrum with the provision that in an emergency these users would vacate the spectrum for priority (government/non-government communications) ii) Used for establishment of a buffer of channels to respond immediately to requests 2.AM radio spectrum 3. Used to share the television bands with unlicensed devices. 4.Used in low power devices e.g.; baby monitors and wireless microphones,Wifi, and even radio astronomy	Geographic sharing is already very commonly used in the commercial and federal spectrum bands. i)It is used in public services to utilize a portion of the spectrum with the provision that in an emergency these users would vacate the spectrum for priority (government/non-government communications) ii) Used for establishment of a buffer of channels to respond immediately to requests 2.AM radio spectrum 3. Used to share the television bands with unlicensed devices. 4.Used in low power devices e.g.; baby monitors and wireless microphones,Wifi, and even radio astronomy
[39]	D. MARKET METHOD I. Spectrum Trading & Spectrum transfers II .Spectrum leasing III.Spectrum commons IV. Spectrum white spaces	Are being employed both at the primary issue of spectrum licences, when auctions are used, & more significantly, by allowing spectrum rights to be bought and sold in the lifetime of licence and allowing a change of use of the relevant spectrum. I. spectrum trading contributes to a more economically efficient use of frequencies. This is because a trade will only take place if the spectrum is worth	Market based approaches such as auctions and spectrum trading are viewed as superior ways of achieving economic efficiency over administered methods. In case where spectrum is a scarce resource, like all scarce resources in a competitive market, efficient allocation decisions are premised on prices. Well designed and properly managed auctions are appealing since they ensure that frequencies go to the firm which bids the most. In order for spectrum trading to be both transparent and efficient, it makes sense to

		more to the new user than it was to the older user, reflecting the great economical benefit the new user experts to derive from its user. And Spectrum transfers are generally understood to mean some form of lease or sublease arrangement, including features such as frequency assignment trans ability or divisibility. II. Spectrum leasing III. Spectrum commons used to transmit without licence IV. Spectrum white spaces are used to limit inference between active channels.	give all interested parties direct access to information. Spectrum common is a part of the spectrum that is free from centralized control where anyone can transmit without a license. That is why it is sometimes known as license-exempt or unlicensed.
[23] [39]	Dynamic spectrum Sharing	This allows users to access a particular piece of spectrum for a defined time period or in a defined area which they can't exceed without applying for the resource	It involves utilization of spectrum in terms of time slots and/or geographically. In its earlier stages of development, it is an advanced approach to a spectrum management techniques such as flexible spectrum management and spectrum trading.
[39] [11]	Technically enabled spectrum sharing I)Underlay technology a)ultra wide band b) spread spectrum II) Overlay technology a)Active overlay b)passive overlay	I) a) Due to extremely low emission levels currently allowed by regulatory agencies, UWB systems tend to be short-range and indoor applications. b) Used for signal transmission as CDMA is a digital cellular standard that uses wideband spread spectrum techniques for signal transmission. II) A major trial is currently taking place in Ireland involving several major manufactures of equipment and devices. a) b) Used for radio services that has shared spectrum with various govt. Users that require	Technically efficient use of spectrum, at a basic level, implies the fullest possible use of all available spectrum. It is of two types underlay and overlay. I) Spectrum underlay technique is a spectrum management principle by which signals with a very low spectral power density can coexist, as a secondary user, with the primary users of the frequency band(s). II) Active overlay technologies are beginning to emerge and be trailed. A major trial is currently taking place in Ireland involving several major manufactures of equipment and devices. There are several possible approaches being studied.

		the user to look for a CB radio channel that is free.	

Table2.2 indicates some of the systems which might be used to encourage sharing, assembled over columns in light of the four dimensions: frequency, time, spatial area and signal division.

Inside table 1 a few of the techniques are novel alternately the utilization of spectrum by them is more or gives acceptable adaptability. A number for these systems consequence starting with the presentation about new gear technologies, computerization from claiming dissection and new plans. A portion of the strategies may be complex, including ongoing computer regulated managing of spectrum. Often, the detail from claiming specific specialized parameters to gear up is important applying the spectrum sharing strategies indicated in Table 2.2.

TABLE 2.2 DIFFERENT METHODS THAT FACILITATE SPECTRUM SHARING

Frequency	Spatial Separation	Time Separation	Orthogonal Signal Separation
Channelling plans	Site Selection	DutyCycle Control	Code- Oriented Multiple access (CDMA)
Dynamic real-time frequency assignment	Anteena pattern discrimination	Dynamic real-time frequency assignment	Anteena polarization
Frequency-oriented multiple access schemes(FDMA)	Physical barriers Site sheilding	Time-oriented multiple access schemes(TDMA)	
Coding -error correction -compression	Interference power -dynamic transmitter level control -pdf limitation	Coding -error correction -compression	
Controlof emision spectral characteristics	-power spectral density limitation(energy dispersal)		
Dynamic-variable partitioning			
Frequency tolerance limitation			

Q. Zhao et al [39] in this paper author explains that Business sector routines need aid continuously be utilized in the starting issuance of a range license. When auctions need aid utilization and, a greater amount significantly, toward permitting range privileges. There is a purchase and sold in the lifetime of permitting a progress about utilization of important and accurate spectrum. Exchanging may include the transformation from claiming proprietorship of licenses. As much liberalization is given, more terrific adaptability range will be used by the client. We utilize term 'trading' which will involve both transformation from claiming proprietorship and also adaptability.

Spectrum trading is a phenomenon whereby privileges or any related commitments to utilize spectrum can be exchanged from person to another by using a method of market-based business to a certain cost. Over differentiating range re-assignment with range trading; clinched alongside a trade, the good to utilize those range will be exchanged voluntarily toward those display user, and whole is paid toward new client of the range which is retained. Market method of spectrum sharing provides two important concepts:-
Spectrum leasing and spectrum trading.

In order to remove some barriers & accelerate the spectrum approach we have made an initiative which is included in FCC secondary market as a part of spectrum leasing. Those licenses which have "exclusive use" can give the spectrum to others on lease by using two separate lease spectrum arrangements: 1) Spectrum Manager leasing and 2) *De Facto* Transfer leasing. Spectrum Trading is a mechanism whereby rights and any associated obligations to use spectrum can be transferred from one party to another by way of a market-based exchange for a certain price. In contrasting spectrum re-assignment with spectrum trading; in a trade, the right to use the spectrum is transferred voluntarily by the present user, and a sum is paid by the new user of the spectrum which is retained, either in full or in part, by the present (transferring) user[39].

Zheng Dou [34] in this paper author provides for those emulating anatomy/reality from claiming dynamic spectrum access system. The differing qualities of the imagined range change plans is showed in the amount of specialized foul terms coined till now :Dynamic spectrum access versus dynamic range commons, opportunistic spectrum access versus spectrum pooling, range underlay versus range overlay. Same time an alternate taxonomy: range underlay, range overlay furthermore range interweave is viewed. Regardless of which plot of perspective it has been thought as of those scientific classification from claiming dynamic spectrum access models, specialized foul implication inside remains same. Whatever remains in may be to make them realize to maximize the appropriate frequencies .Correlation about different access models & pros and cons of presently claiming different dynamic spectrum access models are indicated in Table 2.4.

Table 2.3 COMPARISON OF DIFFERENT MODELS

Access Model			
Comparison Terms	Spectrum underlay (Interference temperature)	Spectrum overlay (Network coding & channel coding)	Opportunistic Model
	A)both PUs & SUs can access B)Limitation on SUs' interference	A)both PUs & SUs can access B) Limitation on SUs' power	PUs have absolute priority
Advantages	SUs get higher Power	SINR & throughput improved	PUs tend to be much more stable
Disadvantages	Difficulty in measuring limitation	More energy & cost needed	Lower spectrum efficiency

2.2 Spectrum Sensing & Spectrum using cognitive radio.

Željko Tabaković [44] in this paper author explains that Cognitive radio (CR) permits low-priority auxiliary clients to temporarily make use of the unused authorized channel about high-priority essential users, thereby fundamentally moving forward generally range effectiveness. It provides conceptual detailed study of spectrum sensing technique including different types as Spectrum Management, analysis, Decision and Mobility.

Spectrum Sensing

The basic principle in range sensing determines if an essential client may be displayed around a band. The spectrum, the cognitive radio discusses its outcome about its identification with different cognitive radios following sensing. The objective about range sensing will focus range status and the authorized user's movement occasionally sensing the target recurrence band. In particular, a cognitive radio transceiver detects a range which is unused or range gap (i.e.; Band, location, time) and also determines the gaining entrance to system for it (i.e.; transmitting force and entry duration) without meddling of an authorized user's transmission. Range sensing might be possibly incorporated or conveyed. In the incorporated range sensing, a sensing controller (e. g. Right perspective or base station) faculties the target recurrence band, and the data gotten is imparted to different hubs in the framework. For example, the sensing controller might be unabated with identify an unlicensed client during the edge of the mobile. To conveyed range sharing, unlicensed clients feeling the range independently, and the range sensing is attained whichever utilized in distinctive cognitive

radios (non-cooperative sensing) or imparted to other clients (cooperative sensing). Despite the fact that agreeable sensing bargains for a correspondence and preparing overhead, the precision from claiming range sensing will be more stupendous over that about non-cooperative sensing [27]. Along these lines range sensing strategies might be arranged under three categories: Transmitter detection, helpful identification and obstruction band identification [28].

A) Spectrum Management

For the purpose of satisfying prerequisites of the clients range administration captures the best accessible frequencies. The CRs if choose the best band of the range for satisfying the quality of service (QOS) with all available recurrence bands; therefore, the capacities of the range administration are required for the CRs. Such type of management functions are explained as [29].

B). Spectrum analysis

The outcome of the range sensing about is evaluate to find out the range standard. Here problem to be corrected how should we measure the efficiency from range accessed by SU. This efficiency could be make portrayed by signal to noise ratio (SNR), the Normal relationship and the white spaces accessibility. Data on the accessible range personal satisfaction for a cognitive radio client might be erroneous & loud.

C). Spectrum Decision

Range entry obliges a choice model. The multifaceted nature from claiming this model is depended on the parameters viewed as in the range examination. The choice model gets to be additional mind boggling at an auxiliary client & need various destinations. To example, an SU might need to boost execution same time minimizing annoying influence brought about of the PU. A stochastic streamlining system may be an intriguing apparatus that will model also unravel the issue for range right in a cognitive radio. The point when clients (both grades) are in the system, inclination offered will impact the choice of accessing the range. These clients could make agreeable or non-cooperative to get range. Each client need its identity or reason for existing in a non-cooperative surroundings. An agreeable one, every client operates jointly to fulfill the aim .An agreeable environment, CRs participate with each other, settle on a choice for gaining entrance to the range and expanding the target work recognizing the regular imperatives. In this type of scenario, a vital controller coordinates the range management [29].

D). Spectrum Mobility

Range portability will be a work identified with the variety of operating recurrence band from claiming CR clients. As an authorized client starts on entry in a radio channel which will be presently constantly utilized by an unlicensed user, the unlicensed client could transform unmoving range to an animated range band. This change in a working recurrence band will be known as spectrum/range handoff. The protocol parameters during

the spectrum handoff in the protocol stacks must be balanced so as to match the new operating recurrence band throughout range handoff. Range handoff must attempt to guarantee that the unlicensed client could keep on going the information transmission in the new range band [30].

E). Spectrum Sharing

Since many optional clients need an access to the utilization of range holes, cognitive radio need will administer offset between its self-goal from claiming majority of the data transferring effectively also selfless objective of sharing the accessible range with other cognitive also non-cognitive clients. This will be carried out toward approach standards deciding self-destructive considerations and conduct from claiming cognitive radio for radio surrounds. The reasonable range planning method, open range use in the range offering will be a standout amongst the major tests. Previously existing systems, it views comparable with generic media access control MAC issues.

CHAPTER 3

ENERGY EFFICIENT SPECTRUM SHARING

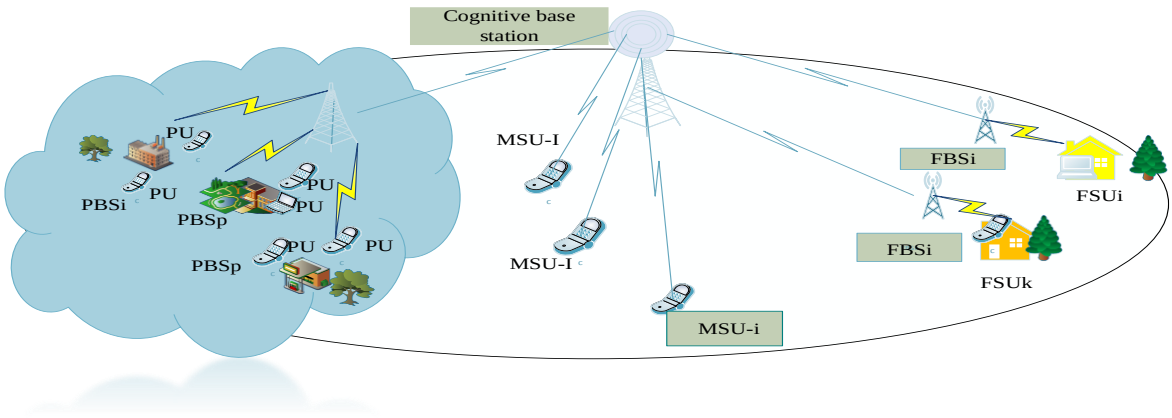
Xie, Renchao ,et al (46) in this paper the author concentrate on those vitality proficiency (energy efficiency) angle from claiming range imparting also control allotment for heterogeneous cognitive radio networks for femto cells(explained in appendix). Since both cognitive radio 2012 incidents IEEE INFOCOM 978-1-4673-0775-8/12/$31. 00 ©2012 IEEE 1665 and femto cell would guaranteeing advances should empower vitality proficiency in remote networks. The transaction in the middle of them benefits further investigation for utilizing bits/Hz for every joule [37] to measure the execution of vitality proficiency. For full exploitation of the cognitive capability, a remote system structural engineering for which both those microcell and the femto cell bring the cognitive ability is ultilized. This system structural engineering is to begin with suggested previously, [38], which will be of essentialness over useful cell division femto cell networks, the place the macro cell base stations might sense those television band. We plan the Vitality productive asset allotment issue to heterogeneous cognitive radio networks for femtocells as a Stackelberg diversion. Then a gradient built cycle algorithm is recommended on get the Stackelberg harmony of the Vitality productive asset allotment issue.

A).System Model

We think as of a correspondence framework that comprises about grade networks also a femtocell-based heterogeneous cognitive radio network, similarly as demonstrated to fig. 11. An essential organize could offer and only range asset of the heterogeneous cognitive radio organize for femtocells to win extra benefit. In the heterogeneous cognitive radio network, there would be various macro optional clients (MSUs), a cognitive build station, various femtocells, & various femtocell optional clients (FSUs).

The cognitive base station allocates those range asset purchased from the elementary networks with femtocells or MSUs specifically dependent upon those channel personal satisfaction with amplify its income. Every femtocell, contains a femtocell build station (FBS) & will give administration on FSUs, the place the FBS is associated with those cognitive base station. In a broadband connection, for example, link modem alternately digital subscriber line (DSL) [44]. Those entirety framework is worked on a time-slotted manner, and the essential networks and the femtocell-based cognitive radio organize expected will be superbly synchronized. On rearrange those examination of the problem, without reduction generality, we expect that there may be. Special case FSU that is overhauled toward the FBS for every chance slot, which will be usually accepted in the writing because of those entrepreneurial planning operation clinched alongside act [45].

Under this framework, we expect that there would be p elementary networks also known as primary networks. Every essential organize p may be eager to offer a range offering cost cp also offers its component range asset wp of aggregate spectrum of the heterogeneous cognitive radio organize to amplify its benefit. The cognitive build station might purchase that range asset WP starting with elementary system relying upon those range value. Afterward those cognitive base station allocates the range WP of the femtocells or MSUs straightforwardly to get its income. Here, we expect that the range asset WP purchased starting with a specific grade system is best allocated to one femtocell or MSU. Expect there would be Ktot femtocells also ItotMSUs specifically served with the help of the cognitive base station in the heterogeneous cognitive radio system. Normally the downright number for femtocells and MSUs requesting will unite with the cognitive base station will be large, that is, (Ktot + Itot) ≥ p. Because of the set resource, there need aid at most p about (Ktot + Itot) femtocells & MSUs that could get of the cognitive base station in every period slot, which could make acknowledged planning also gets control. Here, without reduction generality, we expect k femtocells furthermore MSUs get the cognitive build station, the place K+I = p. To every run through slot, the point when a range WP may be utilized with the femtocell, the point of the femtocell may be on expand its energy efficient interchanges by allocating its force. Similarly, the point when those range may be utilized by MSUs, the cognitive build station performs the energy efficient power allotment. In view of the talk above, we could define the issue for asset allotment for vitality productive (energy efficient) interchanges in the heterogeneous cognitive radio system similarly as a three-stage Stackelberg amusement problem, concerning illustration depicted in the accompanying subsection [46]



3.1 System model for femtocell-based cognitive radio networks (PBS: primary base station

CHAPTER 4: OBJECTIVES OF RESEARCH

3.1 Effect of Spectrum sharing methods in different deployment scenario's using different processing schemes.

(1) Urban macro cell scenario

In urban macro-cells units, propagation in case of non-line of sight and the static mobile stations are considered to be on top of the close structure heights as a result of the road level is often faces one optical phenomenon over the top side. In these typical urban environments, the mobile station is found outside at street level but the building area units either forming a typical structure of grid, or have some further irregularities with position with a height of over four floors. Such typical urban macro cell state of affairs have got homogeneous peak and density of the building area unit largely.

(2) Sub-urban macro cell scenario

In suburban macro-cell units, to get the wide space coverage, the bottom station area units are positioned well on top of the rooftops however, the base stations units are outside at street level. In these situations, the houses or some other structural area units are somewhat aside from one another and have less floors. They need a lot of open areas in the form of of parks or playgrounds. Vegetation in these areas is modest, moreover, the streets don't obey to go in the regular strict grid structure way like that of urban ones.

3.2 Optimizing the number of users for maintaining Spectral efficiency in these scenarios.

The main insight is making the system power efficient while increasing the number of user equipment's under each antennas at each small cell access point (SCA) in all three scenarios

3.3 Optimizing the number of antennas for maintaining energy efficiency in these scenarios.

Increasing the number of antennas at each small cell access point (SCA) and optimizing the number of pilots in all three scenarios

.

CHAPTER 5: EXPECTED RESEARCH OUTCOME

- Optimizing the number of transmitter and receiver antennas in Massive MIMO for attaining maximum spectral efficiency in three different scenarios.

  To increase the SE of the mobile N/Ws massive MIMO is an efficient way where large no. of active antennas at the mobile towers are providing the efficient transmission processes. Here the number of antennas M, should be necessarily higher than no. of users (K) as the channels for users are orthogonal with M/K ratio greater than 10.

- Optimizing the number of users and pilots per cell to maximize the spectral efficiency in massive MIMO under three different scenarios.

Evaluating the optimization of no. of users depends on antenna no. and also on some other parameters as well. We have a new SE equation which efficiently analysis the systems for control of energy, pilot signals, reusing and selection of positions. This gives an idea of what happens if M has an infinite value while considering many situations with many pilots, different reuse factor and different schemes of processing.

Hence we realize form this that up to half the efficient spectrum block must be given to pilots and M/K should be less than 10 practically. It is not advisable to use similar K for comparing these schemes as K is dependent on processing schemes.

CHAPTER 6: PROPOSED RESEARCH METHODOLOGY

5.1 Mathematical analysis for maximum spectral efficiency for massive MIMO.

The massive MIMO scheme relays on providing mobile stations with large no. of antennas. Due to this gain and accuracy of no. of users included in MIMO communications increases the no. of users in each cell. Moreover, this increase in no. of antennas helps in increasing the efficiency of the systems. However, the point of discussion is the number of user equipment's in each cell to make it more efficient.

This resultant SE equation is applicable to both (UL) and (DL) transmission, where indefinite user positions and energy conservation which gives same UE output. If we take the traditional scenarios of working methodologies such as maximum ration (MR) combining/transmission and zero-forcing (ZF), and a new full – pilot zero-forcing (p-ZF) which actively overcome the cellular interferences in the beam forming way of distribution signal.

General expression for spectral efficiency achieved is

$$SE_j = SE_j^{(ul)} + SE_j^{(dl)}$$

$$= K\left(1-\frac{B}{S}\right) \log_2\left(1 + \frac{1}{I_j^{scheme}}\right) \text{ [bits/s/Hz/cell]}$$

Where; $SE_j^{(ul)}$=uplink spectral efficiency.

$SE_j^{(dl)}$=downlink spectral efficiency.

A) FOR Uplink

$$SE_j^{(ul)} = K\zeta^{(ul)}\left(1-\frac{B}{S}\right) \log_2\left(1 + \frac{1}{I_j^{scheme}}\right) \text{ [bits/s/Hz/cell]}$$

Where the interference term

$$I_j^{scheme} = \sum_{l \epsilon L_j(\beta)\{j\}} \left(\mu_{jl}^2 + \frac{\mu_{jl}^2 - (\mu_{jl}^1)^2}{G^{scheme}}\right) + \frac{\left(\sum_{l \epsilon L} \mu_{jl}^1 Z_{jl}^{scheme} + \frac{\sigma^2}{\rho}\right)\left(\sum_{l \epsilon L_j(\beta)} \mu_{jl}^1 + \frac{\sigma^2}{B\rho}\right)}{G^{scheme}}$$

Where; $G^{scheme} = array\ gain$

Z_{jl}^{scheme} = Interference

$\mu_{jl}^{2}, (\mu_{jl}^{1})^{2}$ = Propagation parameters

$$\frac{\sigma^2}{\rho} = \frac{varience}{design\ parameter} = SNR$$

$$I_j^{scheme} = interference\ scheme$$

$$I_j^{scheme} = positive\ fraction$$

$$K = no.of\ users$$

$$\boldsymbol{L_j(\beta) = subset}$$

B) FOR Downlink

$SE_j^{(dl)} = \zeta^{(ul)}(1 - \frac{B}{S})E_{\{z\}}\ \{\log_2(1 + SINR_{jk}^{(dl)})\}$ [bits/s/Hz]

With the effective SINR, $SINR_{jk}^{(dl)}$, given by

$$\text{Effective SINR} = \frac{q_{jk}\frac{|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\}|^2}{E_{\{h\}\{|}|g_{jk}|^{2}\}}}{\sum_{l\epsilon Lm=1}^{K} q_{lm}\frac{|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\}|^2}{E_{\{h\}\{|}|g_{jk}|^{2}\}} - q_{jk}\frac{|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\}|^2}{E_{\{h\}\{|}|g_{jk}|^{2}\}} + \sigma^2}$$

Where; SINR= signal to noise interference ratio.

$$|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\} = effective\ channel\ mean$$

q_{jk}= power control coefficient

$$\frac{|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\}|^2}{E_{\{h\}\{|}|g_{jk}||^{2}\}} - q_{jk}\frac{\left|E_{\{h\}}\{g_{jk}^{H}h_{jjk}\}\right|^2}{E_{\{h\}\{|}|g_{jk}||^{2}\}} = uncorelated\ channels$$

$$\sigma^2 = variance$$

$$E_{\{h]}\{\left|\left|g_{jk}\right|\right|\}^2 = tractability$$

CHAPTER 7

RESEARCH CHALLENGES & CONCLUSION

TABLE 7.1RESEARCH CHALLENGES

Category	Open Problems and Research Challenges
1. Spectrum allocation/assignment and spectrum management	• New access paradigms and protocols for efficient spectrum use. • Models that incentivize incumbents to share their licensed spectrum or to relocate to other bands. • Sharing between commercial and non-commercial users (e.g., federal-commercial sharing). • Models and techniques, including dynamic spectrum markets/auctions, for assignment of spectrum. • Frameworks for defining dynamic and flexible incumbent protection zones. • Approaches for incorporating real-time sensing results with database-driven spectrum sharing.
2. Metrics to quantify spectrum usage	• Quantifying spectrum efficiency, value of spectrum and fair access to the spectrum. • Defining techniques and standards for spectrum measurement. • Quantitative definition of harmful interference, and its applications. • Quantifying receiver performance in real-world spectrum sharing environment. • Tools for evaluating the economic and technical trade-offs in spectrum sharing.
3. Interference management and coexistence	• Techniques for enabling harmonious coexistence between heterogeneous wireless technologies. • Adaptive modulation schemes to enable coexistence and interference mitigation. • Realistic propagation models for frequencies that are being considered for new applications. • Mathematical models of interference and techniques for mitigating interference. • Models for radio system performance with trade-off assessment capabilities. • Interference-tolerant waveforms and protocols. • Techniques and policies for protecting passive IUs.
4. Security and enforcement	• Vulnerability studies of flexible spectrum access systems and development of countermeasures. • Investigating the trade-off between OPSEC and implementation complexity in spectrum sharing. • Hardware and software technologies for enforcing spectrum sharing rules. • Techniques and policies for identifying, adjudicating and punishing non-compliant radio devices. • Defining property rights, and mechanisms to enforce those rights. • Automated enforcement mechanisms and compliance certification methods.
5. Radio hardware and software	• Reconfigurable radio hardware, including antennas, amplifiers, filters, tuners, etc. • Improvements in smart radio architectures that support high dynamic range for wideband operation. • Radio hardware that supports operation in the millimeter wave band. • Designing low-power or energy-harvesting devices for sustainability. • Hardware that provide improved geolocation, direction-finding and interference nulling capabilities. • Clearly defined metrics for quantifying advances in radio hardware and software.
6. Protocols and standards	• Frequency-, space-, and time-cognizant protocols that dynamically leverage multi-functional radio hardware and software. • Standards that support pre-emptive spectrum access for emergency services. • Protocols and standards for carrier aggregation. • Database-access-protocols for database-driven sharing. • Standards for radio propagation measurement for different bands.
7. Experimentation, testing and standardization	• Development of advanced and adaptable test beds using advances in hardware, software and policy. • Virtual test beds, including the use of computer simulations, to model and assess coexistence techniques in large-scale spectrum sharing scenario. • Proofs-of-concept demonstrations covering a variety of bands, applications and geographical areas. • Standardization of current/future test beds.
8. Policy, regulatory and economic issues	• Service level agreements for negotiated sharing. • Understanding the possible impact of new radio technologies on health and environment. • Risk assessment techniques for evaluating when and how to share the spectrum between users. • Strategies for designing dynamic spectrum auctions and markets. • Assessment of economic trade-offs in incentivizing spectrum sharing under multiple scenarios. • Strategies to inventivize spectrum sensing. • Devising economic models and processes that can operate on huge datasets of wireless feedback, rapidly assess spectrum usage, and adjust spectrum sharing parameters in real-time.

CONCLUSION

This thesis report explains the number of user equipment's K which must be used in massive MIMO. So as to increase the spectral efficiency in each cell for the limited no. of antennas M. Usually it is the user equipment's position which affects the equations so decision of selecting the no. of users becomes difficult. But on the other hand, an equation has been generated in this thesis where user equipment position do not affect it all. Because of the controlled energy finding out the approximate location equation for user equipment. Actually the equation we have derived is similar for uplink and downlink, so we take into consideration both the user equipment's together. Such equations can be fruitful in providing the direct wide N/W opportunity if given to the networks which are sharing symmetry. Also every cell should become the identity of every other cell. But, with this equation we have to use the Monte-Carlo expressions. Here we are using the MR and ZF processes and also the newly term P-ZF. So as to overcome the inter symbol interference in nearby cells on using the pilot transmitted signal.

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