A Survey Of Spectrum Sharing Techniques In 5g Communication Network

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Abstract: Now a days, spectrum has become under the basic commodities of life due to communication and data usage. For any type of communication, spectrum is an important factor to create a channel to pass the information. It becomes a scare resource due to increasing demand and new technology development. In order to satisfy the demands and incorporate the new technology, spectrum sharing concept is used. Spectrum sharing gives an advantage of increasing the spectrum efficiency and revenue for the licensed spectrum holders. In this paper, spectrum sharing in 5G communication network is discussed by analysing various techniques. The basic approach of spectrum sharing is based on improving the sensing of the channel for transmission. Sensing schemes can be classified as random sensing, compressed sensing, channel assignment schemes like greedy channel assignment etc., The techniques for spectrum sharing is broadly classified into four types namely Graph based access, auction based access, game theory based access and carrier aggregation based access. Mostly, the spectrum sharing scheme is evaluated in terms of throughput, blocking probability and sensing time. In this, the throughput of the system is considered for comparing the different spectrum sharing approaches. Among theses, the virtual coalition formation game theory is best for the spectrum sharing in 5G network which can provide the throughput of 11.5 Gbps for 100 users.

Keywords: Spectrum sharing, 5G technology, schemes, Cognitive Radio Network, game theory, throughput, sensing schemes, channel assignment

I. Introduction

The developments in the mobile and wireless communication is ever increasing day by day in accommodating new users and including new technologies like Internet of Things (IoT). All these services are solely dependent on the spectrum which led to the massive capacity demand. To provide a solution for these demands, the 5G wireless communication is introduced. [1].

The main purpose of 5G network is to reduce the latency and provide higher data rate to all users along with the other purposes like Internet of things. But, with current spectrum policies and scheme, the need of spectrum has to be increased for both the mobile users and IoT. To overcome this problem, the spectrum sharing concept is introduced which helps to improve the efficiency of licensed bands [1]. For 5G deployment, the bandwidth range will be from hundreds of MHZ to few GHZ. But this ranges are already in use by the non-mobile sectors like Military, Television and medical field etc.,[2].

The Sub 6 GHZ band is already accessed by the mobile operators. This band is divided into smaller fragments for the contiguous bandwidth usage in the mobile networks and it is done by the regulators.

The Mobile networks use the contiguous bandwidth for carrier guided services and wider bandwidth for the video calling, wireless network services and internet of things. The 100 MHZ band is now accessed with the help of Long term Evolution schemes A and B by using carrier aggregation and Multiple Input Multiple output system (MIMO) and relaying techniques [3].

The Interband carrier aggregation is a difficult process because the bands are the fragmented and it is belonged to different frequency bands. It can be achieved only if the Adjacent channel leakage power ratio of the physical link layer is high [4]. The wider band services in carrier aggregation is also a challenging one.

In MIMO system also, the wider bandwidth services is a difficult one because the signal quality is relay on the signal to noise interference ratio at the receiver side [5]. The users with the lower SINR will not able to receive the higher data rate. So, the deployment of 5G using MIMO will be a challenging one to provide higher data lower SINR users. To overcome this problem, the deployment of millimetre wave antenna at higher frequencies helps to increase the capacity of network in wireless communication system. [6].

Another solution for this problem is deploying the small cells with minimum power requirements for the higher data rate. But, this type of allocating limited frequencies to the small cells increase the cost and reduction in the spectrum efficiency [7].

Spectrum reframing is a process in which the non- mobile spectrum users access with the other frequencies to provide their frequency slot to the mobile users. But this is also not a possible solution in terms of long time and it also require more financial expenses to allocate the slots [8].

Another solution for improving the spectrum efficiency combined with the higher data rate for the user is the spectrum sharing. It also increases the user's capacity. The spectrum sharing is done between the licensed and

non- licensed user to provide various carrier guided services. It should abide the regulations and techniques provided by the regulator for sharing.
The spectrum in 5G network can be well utilised using cognitive radio technology. In cognitive radio networks, the idle spectrum of licensed users can be used by the unlicensed or the secondary users. It helps to improve the quality of service in 5G [9]. But in the CR networks, the energy requirement is higher as it spends its energy on spectrum sensing and sharing mechanism. Hence, an energy harvesting procedure is also needed to implement the spectrum sharing by cognitive radio network in 5G communication [10].
The paper is arranged by describing various research works in spectrum sharing in 5G network in section II. Section III describes about the benefits and drawbacks of the methodologies. Section IV describes about the comparison of method with its results and it is concluded in the section V.

II. Literature Survey:

In this, the spectrum sharing approaches in 5G network is discussed based on co-operative, cognitive and multi-level or multi-tier combinations. The co-operative based sharing and cognitive radio based sharing is the most suitable solution for spectrum sharing which able to improve the energy and spectrum efficiency. [11].

a. Co-operative based spectrum sharing:

The term co-operative spectrum sharing refers to sharing the same spectrum pool between the small cells and backhaul networks or between the wired and wireless networks. The below figure shows the diagram for the heterogeneous network.

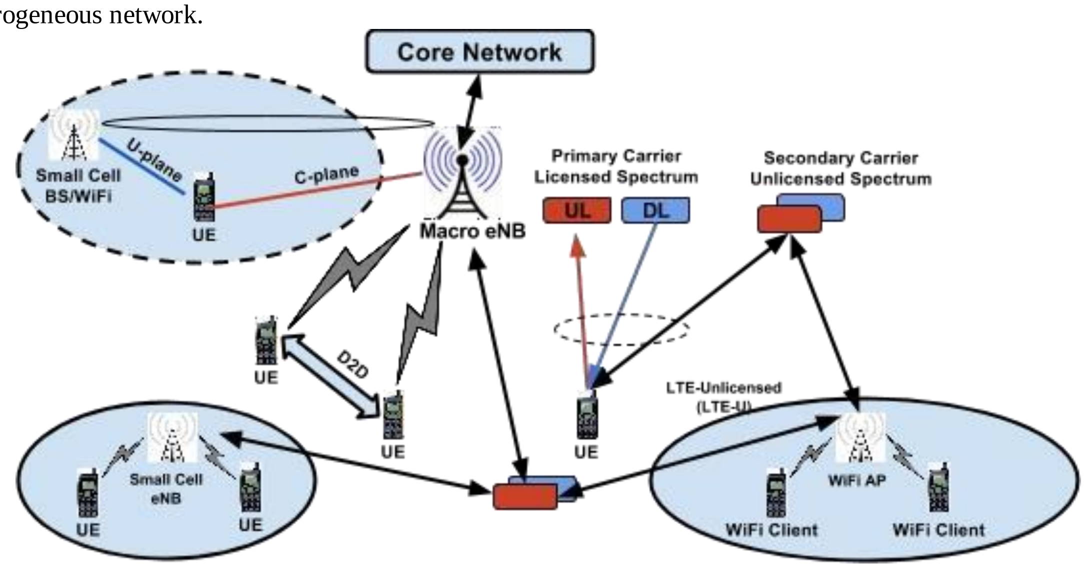


Fig 2. Heterogeneous 5G network

In [12], the spectrum sharing is performed in the in band full duplex mode. IBFD helps to operate the small cells in FD mode and able to establish the communication between the back-haul network. Due to this, the bandwidth is divided between the Small cell and back-haul for uploading and downloading the data. The bandwidth in the back- haul network is further divided between the back- haul networks and access communications. Due to the FD mode, the coverage area of spectrum is small. It also experiences the interference due to leakage of signal from the transmitter to the receiver.
A two tier and multi-tier approach is proposed in
[13] for spectrum sharing. In two-tier network, the macro cell is considered for back-haul network and small cell as one tier. The partition of spectrum between these tiers is performed based on active and silent mode. In silent mode, the backhaul network will be shut and small cell will be used for communicating and sharing the load. This approach limited the usage of small cells.
For the multi-tier network, two approaches were proposed in [13] for partitioning and utilization of resource. The first approach is to determine the all combinations of UE-AP associations in heterogeneous 5G network and allocate the frequency based on that. But this process is practically involve lot of computational time and cost. The second approach is probabilistic analytical approach which is based on assumptions and distributions for sharing. Both this approaches are practically not possible with the backhaul and small cells.
[14] Described a new optimal partitioning scheme between the small cell and back haul networks in heterogeneous 5g network. The optimal partitioning is performed using three types of approaches 1. Out band full duplex mode. 2. IBFD and hybrid. In OBFD the spectrum of small cell is orthogonally split between the access and back haul links. In IBFD mode, the same spectrum is used for access and back haul link of the small cells. In hybrid mode, the small cell bandwidth is divided into one IBFD mode and two OBFD mode. The two OBFD modes were used for back haul and access transmissions.

Eight different approaches were implemented on the sharing between macro-cell, small cell and back-haul networks in [15]. The first approach consider the equal bandwidth for both the macro and small cells. The second approach uses 50% of bandwidth for the small cell and remaining for the direct links. The small cell band width is further partitioned for the other purposes. It reduces the interference problem as compared to first approach.

In third approach the band is divided between the SC and direct links. The band in the SC are in-band mode which creates interference between each other. The fourth approach divides the band into two parts one for small cell and the other for all the links in the systems. Due to this, the interference is reduced. The fifth approach is similar to the third approach but the small cell uses the out of band mode which reduces the interference between them but the interference between the links is increased.

The other three approaches are access aware approaches of second to five approaches. In which, the bandwidth is divided as 80% for small cell and 20% for macro cell. Due to this concept, the throughput and fairness is increased in the system as compared to the other five approaches. But, it faces a bottle neck which can overcome by implementing MIMO system. But, this bottle neck problem in larger dimensions will increase the implementation cost.

b. Cognitive Radio Network based sharing

In CRN, the spectrum sharing is carried out in terms of dynamic spectrum access and opportunistic spectrum access.

a. Opportunistic spectrum access.

The OSA operates in three stages observation, decision and reconfiguration. In observation stage, it observes all the necessary parameter for the sharing that is bandwidth, traffic, no of user, no of free slots and network. The decision makes a wise decision for sharing by identifying the spectrum hole and communication between the users. In reconfiguration, all the parameters of the network are reconfigured based on the decision. [16].

[17] Described about the different spectrum sharing approaches in OSA models of cognitive radio network. The approaches were Game theory based, Markov decision process, optimal stopping priority and Multi-armed bandit model. Among this four models, the optimal stopping priority is the best one for OSA based sharing because it performs the parallel sensing to accommodate more users and increase the spectrum efficiency.

The two channel sensing mechanism in OSA system is proposed and evaluated using throughput in [18]. In this, at a single slot a secondary user can able to sense two channel and make use of the unused spectrum using Markov-chain based greedy channel assignment. In this, the secondary user can exploit more resources for data transmission and it achieves a maximum throughput of 0.45 Mbps with the minimum sensing time of 1.2 seconds for 10 users. But, due to multiple channel sensing, the channel assignment and decision need to be properly taken.

The throughput of the cognitive radio network is analysed based on the random sensing, accessing, and energy queue capacity for multi secondary users in [19]. The sensing and accessing for the multi users is in random manner and it is based on the probabilities of sensing and accessing. The throughput is solely dependent on the sensing probability because a better sensing in multi-user can only access the spectrum efficiently. The drawback of this approach it consider the sources are saturated one and the traffic of the primary users are not considered.

The spectrum sharing of cognitive radio network is based on the Medium access control protocol which uses the OSA model in [20]. The paper briefly explained about the OSA MAC protocol in terms of architecture, all types of spectrum process like sensing, sharing and access strategies, channel allocation, access methods and effect of front ends. The performance is evaluated using the throughput. The throughput for 10 secondary users using MAC OSA is 10 Mbps.

The opportunistic game theory approach is proposed for sharing between LTEs and also between the LTEs and WIFI [22]. This process done with the help of multiple mobile network operators. The spectrum sharing between the operators is realized through process namely1. Opportunistic carrier aggregation 2. Markov chain model for the realization of mobile operators. 3. Coalitional game for sharing between the multiple operators.

Opportunistic carrier aggregation which defines about the primary access and secondary access. In primary access the LTE operators with highest priority will access the unlicensed spectrum and it starts communication using listen and Talk approach to avoid the interferences. In secondary access the LTE operators sense the unlicensed spectrum for idle channel and then start transmission.

The game theory for LTE-U is realized through the Markov chain model (i,j). The i represents the horizontal dimension for the unlicensed spectrum. The term j denotes the number of users actively using the spectrum. The coalitional game theory uses the shapley value for accessing the spectrum. Initially, the shapley value will be equal for all the spectrum. Later, it will be based on the access and its payoff. Higher payoff will use complete allocated spectrum. Lower payoff will access lesser spectrum.

b. Dynamic spectrum access

The DSA is a method able to determine the spectrum hole quickly and start communication in it by reducing the interference of harmful users and device malfunctioning. The DSA performs its function in three stages 1. Spectrum Awareness knowledge about the unused spectrum for re-use. 2. Cognitive actions to make decision on it for unlicensed users.3. Spectrum access for sharing the network and update its information [23].

DSA models can be classified into three types namely Dynamic exclusive model, open-access and hierarchical model. The Dynamic Exclusive model uses two types of approaches. One is spectrum property right in this the unused spectrum is traded for the other access and the other is the dynamic spectrum approach which allows the allocated spectrum to be used when it is free.

In open-access model, all the users can access the spectrum freely based on the uncommon, managed uncommon and private uncommon. In the hierarchical model, it allows the interference to the primary user at lower level. The three approaches used in this model are the inter-weave, underlay and overlay.

The models used for dynamic spectrum access are game theory, markov chain based, fuzzy logic based and Network coded cognitive radio channel is elaborately described in [23].

The all stages and types for sharing the spectrum in 5G communication is discussed in [24]. The procedures discussed in [24] are spectrum sensing, spectrum allocation, and spectrum access and spectrum handoff. The spectrum allocation describes the techniques of graph based approach, auction based approach, game theory and carrier aggregation. Among these four approaches the game theory and carrier aggregation is the best approach for the spectrum sharing.

The game theory approach helps to promote the competition and co-operation between the primary and secondary users. The six game models are stackelberg, cournot, Bertrand, repeated, evolutionary and auction game model.

The dynamic pricing stackelberg and evolutionary game model is used for the spectrum allocation in 5G vehicular Ad-hoc networks [25]. The replicator dynamics is used for selecting the modes of VANET in the evolutionary game. The model is selected in such a manner which payoff is higher than the actual payoff.

A virtual coalition formation game theory (VCFG) is proposed for the spectrum sharing in LTE-U [26]. Along with the VCFG KALAI-SMORODINSKY bargaining solution and Q-LEARNING is used. The time sharing problem between LTE-U and WIFI is solved using Kalai Smorodinsky. The Q- Learning approach is used to allocate the resources in LTE-U. The VCFG approach outperformed other approaches with higher MOS and fairness value in LTE-U network.

The co-operative bandwidth sharing is proposed for the three layer heterogeneous networks in 5G communication [27]. In this, the load for the macro cell is reduced based on the user stream. The term user stream denotes how the user flows from upstream to downstream like a river. The upstream here is the femtocell and downstream is the macro cell. The users are transferred from femtocell into a downstream cells like pico cell or macro cell only its maximum bound is reached. The switching is done based on the RSRP of the cells.

The stackelberg game theory approach is discussed for sharing the spectrum in a single heterogeneous network [28]. The compressed sensing scheme is preferred over the normal sensing scheme in cognitive radio network to improve the identification of spectrum holes. The stackelberg game theory is used for spectrum sharing which is based on higher data rate with minimum cost. The interference will occur when the SNR of the primary users become higher.

The solution for the spectrum sharing problem in the device to device communication for the ultra- denser region of 5g network is proposed in [29]. In this, the auction based model is proposed for sharing the spectrum with an objective of maximizing the sum rate and co-ordinate the interferences between them. The base station announce the spectrum slot to the device and the device will bid for it. The highest bidder will get the slot and its information is updated to all the network. The maximum throughput for the 100 users is 4.1 and 4.2 for device to device link and cellular link.

A combined decision tree and repeated game model is proposed for sharing the spectrum between LTE-U and wifi in [30]. The rank-order tournament model is used to realize the game theory between the LTE-U and WIFI. They build up their own strategies to occupy the spectrum slot. The decision tree decides its operation on each stage of the game.

c. Different methods of spectrum sharing

This sections describes about some other methods which are used for sharing the spectrum in unlicensed band or within the operators of 5G communications.

Various spectrum sharing schemes such as IDFB, LTE-U, NOMA schemes and integrated sharing schemes were described in [31]. The working of IDFB and LTE-U schemes are similar to other research works. NOMA is a scheme which is based on the spectrum gain, multiplexing, power mode, coding gain and channel mode. It promotes the self- interference cancellation. But, an imperfect SIC has to be added to improve SIC which may lead to interference. Integrated sharing is the combination of multiple sharing schemes.

The efficient use of unused spectrum between the mobile operators is improved by using the many to one stable matching game and Q-learning in [32]. The Q-learning is to improve the power allocation for the mobile operators. The many to one stable matching algorithm is to allocate the unused spectrum between the mobile

operators.
A stackelberg and potential theory based approach is proposed for the spectrum sharing of two- tier heterogeneous network which consists of macro cell and large number of small cells in [33]. First the power of the cell is optimized with the help of potential theory. Next, the stackelberg game theory based on pricing is used for sharing the unused spectrum. Throughput of the system is improved and transmit power is reduced.
A coordination protocol is introduced in the small cell deployment for improving the spectrum utilization between the operators in [34]. A protocol which maintains the requirement and usage details of additional spectrum by the operators. To speed up and determine the optimal way for sharing the repeated game theory is used. The whole process is realized through the indoor scenario using small cell deployment. The quality of service for the operator is improved as compared to the non-sharing spectrum operators.
An improved stackelberg game theory is used for sharing the spectrum with increasing revenue between the cellular and unlicensed users in an unlicensed spectrum [35]. The game theory is based on the pricing scheme to increase the revenue for the operators by sharing the spectrum. But while sharing, the interference will occur which overcome by using the Kalai-Smorodinsky bargaining game among the leaders for proper selecting of frequency allocation. The interference is reduced as compared to the traditional game theory.
The antenna is designed in such a way that it carries the 5G signal which is suitable for enhancing the spectrum sharing in [37]. The antenna is designed based on the beam forming pattern in the shared spectrum whose gain is more and interference is less. Such a beam forming pattern based antenna is used for propagating the signal.
[38] described about the combination of the Non- orthogonal multiple access and cognitive radio network for improving the spectrum utilization in mmwave antenna transmission. The key concept in NOMA is the power domain multiplexing. This concept is added to the CRN design in three formats. The three forms of NOMA-CRN are Interweave, under relay and over relay.
This NOMA_CRN design able to achieve all the requirements of 5G transmission like high spectrum utilization, massive operations, better fairness, low latency. But it faces some difficulties in the interference cancellation and energy efficient due to power domain multiplexing approach.
[39] describes about the spectrum sharing approaches based on three aspects namely economic, technical and heterogeneous networks. Based on economic it is classified as spectrum trading and spectrum leasing. The technical aspects classifies the spectrum as mobility, relaying, routing and harvesting.
The spectrum sharing using the optimization techniques based on multiple objectives of the cognitive radio network is discussed in [40]. The multiple objectives were throughput maximization, minimizing outage and power consumption etc. The programming used were solving these problems are Linear programming types, convex optimization, SDP.

III. Summary of different spectrum sharing techniques in 5G communication system

This section describes about the various spectrum sharing approaches in the 5G communication with their merits and demerits in the tabular column.
In General the spectrum sharing is based on mainly four approaches . They are as follows.

- Graph cut based approach
- Auction based approac0068
- Game theory Based approach
- Carrier aggregation Based approach.

Based on these approaches, several research works and analysis have been carried out in different forms. Those forms are

- 5G network
- Single heterogeneous network
- Device to device link connection
- Protocol layers
- Cognitive radio network.
- Small cell installation
- Enhanced spectrum sensing operation with minimal sharing approaches.

Tab I. Summarization of Different approaches of spectrum sharing

Paper	Method	working	Merits	Demerits
[12]	IBFD	Same spectrum is used for receiving and transmission for a node	Self-Interference cancellation	Realization of system in practical involve more circuits
[13]	Multi-tier approach	Backhaul and small cell used for communication transmission	Load is shared. Power is saved	Practical realization is less due to the assumptions.
[14]	Hybrid mode	The small cell bandwidth is divided into one IBFD mode and two OBFD mode. The two OBFD modes were used for back haul and access transmissions.	Self-Interference cancellation	Realization of system in practical involve more circuits. Combining backhaul and small cell requires more circuits in practical
[18]	Markov-chain based greedy channel assignment	In single time slot, two channel is sensed for the spectrum sharing	Throughput is improved	The channel assignment and decision need to be properly taken for multiple channel sensing.
[19]	Random sensing and energy queue capacity	The energy queue capacity of the node is increased	Throughput is improved by energy queue	Perfect sensing is needed otherwise throughput will be affected
[20]	OSA based MAC protocol for cognitive radio sharing	A complete MAC protocol structure	Throughput is improved to 10 Mbps for 10 users	Design is only opportunisitic spectrum access
[21]	Sequential fixing LP channel	Channel assignment along	Throughput is improved as	Complexity is high
	assignment for cognitive radio networks	with the MAC protocol	compared to the greedy	
[22]	Coalitional game theory and shapley value	For sharing between LTEs as well as between LTE and WIFI	Throughput is improved as compared to greedy and SFLP	It is purely based on the payoff matrix and shapely value
[24]	Graph based	Based on the network topology structure	Spectrum utility is maximized	Higher throughput system occupy more bandwidth as compared to the lower throughput system.
[24]	Auction based	Based on bidding of users	Primary user qualities is preserved	The highest bidder only get the benefits.

[24]	Game based	Easing competitions between the primary and secondary users	Spectrum and fairness is improved	Convergence need to be speed up
[24]	Carrier aggregation base	Wider spectrum is created by aggregating multiple spectrum	Fragmentation and spectrum is utilized well	Promising one but the multiple carriers and frequency should be maintained properly
[25]	Dynamic pricing stackelberg and evolutionary game model	5G VANET	Spectrum is well utilized	Mode selection is important which is based on the replicator dynamics
[26]	VCFG KALAI-SMORODINSKY bargaining solution Q-LEARNING	Sharing Between LTE-U and Wi-fi	VCFG approach outperformed other approaches with higher MOS and fairness value in LTE-U network	Assumption is made in calculating the payoff.
[27]	Co-operative bandwidth sharing	Heterogeneous network	Load is rarely transferred to the macro cell	Assumed femto cell is available for all time.
[28]	Compressed sensing scheme and stackelberg game theory	Cognitive radio network	Provide higher data rate with minimum cost	The interference will occur when the SNR of the primary users become higher.
[29]	Auction based Model	Device to device link	Spectrum efficiency and throughput is improved	Bidding is the main factor for getting spectrum
[30]	Combined decision tree and repeated game	Between LTE-U and WIFI	Spectrum is utilized in LTE-U	A failure in decision tree results in a bad spectrum sharing.
[31]	Different NOMA	For 5G communication	Self-interference cancellation. Gain is improved	Imperfect SIC affects the SIC-NOMA
[31]	Integrated spectrum sharing	Combining Multiple spectrum sharing	Individual user performance is improved.	Design complexity is high
[32]	Many to one matching game and Q-learning	It is based for increasing the unused spectrum between mobile operators	Spectrum can be reused and power allocation is improved	Theoretically only described
[33]	Stackelberg game	Heterogeneous network	Transmit power is reduced Throughput is improved	Based on the power transfer of the small cells.
[34]	Co-ordination protocol Repeated Game	Small cell deployment	Quality of service is improved	Suitable for indoor scenarios

[35]	Stackelberg game theory Kalai-Smorodinsky bargaining game	Sharing between the operators in the unlicensed spectrum	Interference is avoided	Computational time and assumptions may differ from practical scenario
[36]	One shot game	Closely located RAN	Minimal exchange of operators information	Suitable for smaller environment
[37]	Antenna design	Based on beam forming pattern	Gain is more Interference is less	Practical implementations differ from the proposed one due to the assumptions used for calculating the gain and beam forming pattern
[38]	NOMA-CRN	A cognitive radio network is designed using NOMA principle	Low Latency Massive communication	Interference cancellation Energy efficient is less
[40]	Optimization method	Multiple objectives of CRN	Minimization of outage and power consumption	Assumptions and iterations are used to reach the desired solution

The below table is the brief explanation of the different schemes like Game theory model, Markov decision process based model, opportunistic spectrum access and multi-armed bandit models for cognitive radio network in [17].

Tab II. Various spectrum sharing approaches in OSA models

Method	Merits	Demerits
Static game	Interference avoided Throughput is maximized Global utility is maximized	Depends on single user nature and static behaviour
Repeated game	It can be applied both static and dynamic	Perfect learning is required
Graphical Game	Congestion and collision is minimized	Learning of topology is important
Evolutionary Game	Throughput improved	Position updation is need to be proper
Coalitional game	Improved spectrum access alongwith sensing	The payoff matrix decides the best solution
Discrete time Markov Decision models	Sequential sensing with improved throughput	Suitable for single secondary user
Continuous time Markov decision model	Perfect sensing with maximized throughput	Channel quality is poor
Slotted markov decision model	Battery lifetime improved	Imperfect sensing Collision occurs
No Recall- optimal stopping priority	Power minimization and throughput maximization	Channel quality and sensing is poor
Recall-optimal stopping priority	Energy conserved	Primary user is mostly occupied due to poor sensing

Multi-armed bandit models both LLD and Restless	Can access multiple channels at a time	Perfect learning is required

The below table is the brief explanation of the different schemes like Game theory model, Measurement based model, fuzzy control, spatio temporal spectrum management model and Network coded cognitive model for cognitive radio network in [23].

Tab III. Various spectrum sharing approaches

Method	Merits	Demerits
Game theory model	Create a completion between secondary and primary users	Assumptions are made to make more reliable
Measurement based (semi-markovian)	Compromise between accuracy and computational complexity is made	Frequent update of system is important
Network coded cognitive radio channel	Best for OSA access	Degradation occurs due to frequent exploitation of resources
Fuzzy logic	Different parameters can be analysed	It mainly focus on the distance between the primary and secondary user.
Spatio temporal management	Spectrum is utilized well	The spectrum remain idle if there is no request for more spectrum

A brief explanation of the spectrum sharing approaches based on three aspects namely economic, technical and heterogeneous networks [39] is given in the below table.

Tab IV. Various spectrum sharing approaches

Method	**procedure**	**Demerits**
Spectrum trading	Promotes the spectrum utilization by selling for different purposes by a broker	The spectrum can be utilized only when the spectrum is sell or buy
Spectrum leasing	Primary users will be benefited more as compared to the secondary users by renting the licensed spectrum	Stackelberg game approach is followed for sharing
Spectrum mobility	By performing handoff and spectrum access	Interference occurs when proper handoff does not takes place
Spectrum Routing	Utilized in the white spaces of the TV	Congestion occur when proper routing for multiple channel access
Spectrum harvesting	Trading of the licensed band to the unlicensed users	Primary users may face interference when the users capacity of the network is increased

IV. Performance comparison

Most of the research works analysed the spectrum sharing in 5G communication network is based on the system throughput using their model for spectrum sharing process.

Throughput:

Throughput is a measure that how much data can be transfer from source to destination in a given span of time. The throughput for the different spectrum sharing model is shown in the below table.

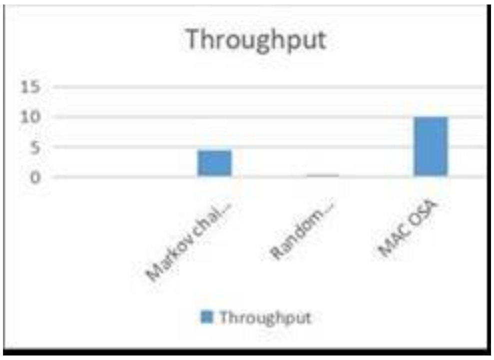
Tab V Throughput comparison of different approaches

Method	**Throughput (Mbps)**

Markov chain Greedy algorithm [18]	4.5
Random Sensing [19]	0.35
MAC OSA	10

The pictorial representation of the above table is shown in the below figure.

Fig 2. Comparison of approaches in CRN



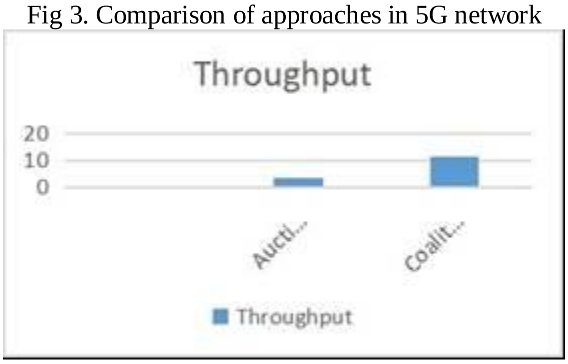
The above figure 2 depicted the throughput comparison of a cognitive radio network in 5G communication network. From the table it is observed that the for an opportunistic spectrum access mechanism, the medium access control based spectrum sharing is suitable for better sharing of spectrum as compared to the sensing and markov chain model.

The overall system throughput for spectrum sharing in 5G communication network using game theory approach is shown the below table.

Tab VI. Overall System throughput comparison

Method	**Throughput (Gbps)**
Auction based game theory	3.2
virtual coalition formation game theory [26]	11.5

Fig 3. Comparison of approaches in 5G network



The figure 3 shows that the coalitional game theory based spectrum sharing is suitable for 5G heterogeneous network. Because, the VCFG is able to achieve the throughput of 11.5 Gbps more than 50 users as compared to the auction based approach.

V. Conclusion

The paper discussed about the various approaches for improving the spectrum efficiency and reduce the spectrum scarcity problem in 5G communication network. Most of the research works improved the spectrum efficiency by varying the sensing, sharing and accessing approaches. Fewer research works were discussed about the spectrum handoff techniques. The most promising solution for spectrum utilization in LTE-U is improving the spectrum sharing. The spectrum sharing technique also has different approaches like Graph based model, auction model, Game based model and carrier aggregation. Among these techniques, the game based and carrier aggregation model is the best for spectrum sharing in the 5G communication system. The virtual coalition formation game theory is the best approach for the spectrum sharing in 5G communication. Multi-hop communication increases spectrum efficiency but has a high switching delay. Interference management is also needed for cognitive NOMA to handle inter-network interference, which degrades reception reliability. This comprehensive survey is expected to aid researchers in addressing important issues in achieving successful 5G applications.

VI. Future work:

In future, a development in a game theory with less assumptions for practical realization of spectrum sharing in 5G communication and beyond.

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