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Cooperative Communication For 5G Networks: A Green Communication Based Survey

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ABSTRACT

This paper provides an in-depth review on the technologies being considered for recent and future wireless cellular networks based on cooperative communication with reduction in energy. Initially, the evolution from fourth generation (4G) to fifth generation (5G) is described in terms of performance characteristics and major requirements. The technology developed by the 3GPP community, which supports the integration of current and future services. The fifth generation (5G) cellular networks will require a major paradigm shift to satisfy the increasing demand for higher data rates, reduced latencies, better energy efficiency, and reliable connectivity through femto-cell based relays. These relay nodes are equipped with energy harvesting technique in cooperative networks for the improvement in energy efficiency. Unlike conventional energy source, the fluctuation in energy flow causes performance degradation. To overcome the above drawbacks, energy harvesting technique and other methodologies are explained together with possible improvements, challenges and few approaches that have been considered in this paper.

Keywords: Cooperative communication, energy efficiency, capacity, coverage, 5G networks, femto-relay

Over the last decade, cellular systems have experienced exponential growth and worldwide there are currently about two billion users. Demand for increased data rate services has forced the telecommunication operators to improve their cellular system's capacity, coverage and reliability. The sudden growth of cellular industry from 2nd generation narrow band time-division multiple-access (TDMA) and frequency-division multiple-access (FDMA) based Global System for Mobile communications (GSM) network to 3rd Generation wide band code-division multiple-access (WCDMA) based Universal Mobile Telecommunications Systems (UMTS). With the implementation of multi carrier modulated CDMA from single carrier, extension of UMTS system called High Speed Packet Access (HSPA) techniques and HSPA+ are evolved which improved uplink and downlink performance over existing cellular system at a minimum expense. To meet even more data rate and traffic requirements, migration to 4th Generation standard defined with potential and current applications including improved mobile web access, IP telephony, online gaming services, HD mobile TV, video conferencing, 3D television was required. A variation of 4th Generation operational network rolled out worldwide are LTE (Long Term Evolution) or LTE-Advanced developed by Third Generation Partnership Project's (3GPP) and is standard for improved high-speed wireless communication for mobile and data terminals[1].

Fig. 1 forecast the increment in global IP traffic requirement which is nearly triple from 2015 to 2020[2]. In order to support this predicted increase of traffic data requirement, cellular operators are moving beyond 4th Generation to 5th Generation standard which is packed with benefits of improved coverage, reliability, data rate, green communication and lesser latency for a faster, safer, and smarter wireless network that can revolutionize the production, automotive, health care, and energy sectors[1]-[6].

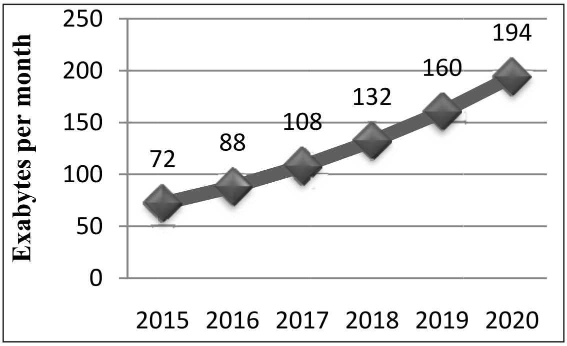

Fig. 1: Global IP traffic requirement forecast, 2015 - 2020

"Zero latency gigabit experience" is the expectation of users from 5G[2]. Increase of data rates as well as reduction of latency is equally important factor when a system migrates from 4G cellular network to 5G. 5G cellular network is envisioned to support devices and applications like smart watches, sensor networks, industrial and vehicular automations, autonomous vehicles, Internet of Things (IoT) / Internet of Experience (IoE), smart-city cameras etc. This various type of application and device scenarios need more intricate networks that cannot only support high throughput or data rate, but also provide very low latency in data delivery, energy efficient consumption, high scalability to accommodate a large number of devices, and higher reliable connectivity for users. In this section, the requirements and its potential solutions met have been discussed.

Data rate is an important factor for evaluating performance in wireless communications. Currently, the maximum data rates of 8-15 Mbps supported for high definition streaming applications[1]. But 5G networks are aiming to provide a peak data rate of 10 Gbps. With the help of new techniques, the data rate can be improved 100 times over fourth generation (4G) networks[4].

The end-to-end delay for data delivery in the 4G system (LTE-Advanced) is around 15 ms and it is expected to reduce to 1 ms for 5G[1],[4].

Cost and energy consumption are very critical in a 5G. 5G requires sensor with less power and supports when required, the devices not connected to the central base stations[1]. As the numbers of smart devices are getting increased, the number of base stations (BSs) required supporting these devices also increases. Therefore, small cells could be deployed which is cheaper and power efficient compared to macro cells. This lead to BS densification and increased bandwidth, hence small saving in energy could lead to huge energy efficiency in large-scale. Major cost consideration is in backhaul which connect the network edge to the core[1],[4].

Network scalability is an important factor in fifth generation wireless communication network design to accommodate more number of mobile devices that connect to the network. 5G must also be capable of supporting larger and more diverse set of devices. The number of devices connected to cellular network is expected to be nearly 30 billion by 2020[7].

Some of the use cases and requirements of 5G such as Mobile broadband, traffic volume, automotive sector, smart society, smart grids, health and industrial sectors and logistics are discussed in[2]. Fig. 2 forecast the growth in number of device connected to the cellular network from 2015 to 2020. Growth rate in M2M communication, smart phone and connected TV devices is high and is to be supported in future cellular network.

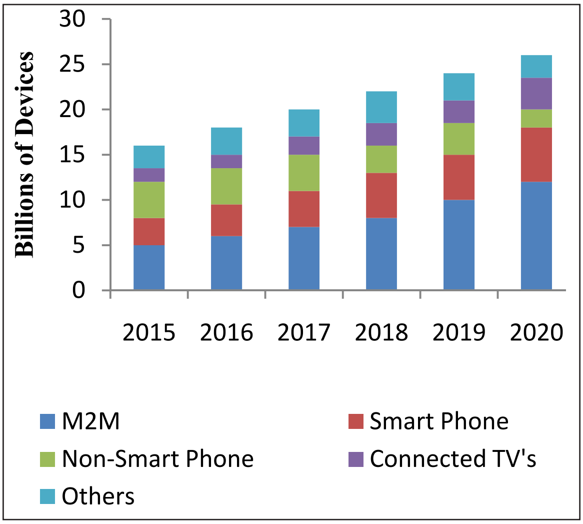

Fig. 2: Device connection to cellular network forecast

Scalability require upgrade in physical layer, control plane and network management relative. There are huge amount of radio resources available in a physical layer to for connecting more number of devices. Network layer is capable of controlling the transmit power and also to reduce the interference level. It also influences the design of medium access control (MAC) protocols to occupy huge amount of devices. Further, transport layer, transports the data from source to the destination and efficient routing algorithm is required at core side network layer for routing the data[1].

Improved connectivity and reliability should be guaranteed whenever the network move towards fifth generation wireless network. For better connectivity, coverage and handover efficiency must be improved. Due to densification of BS and number of devices connected are large, number of handovers that to be handled by a BS increases. So handover algorithms should be optimum to handle large handovers request at high rate. Another factor which is to be considered is authentication and privacy concerned with handover. If there is any delay in contacting the authentication server for each handover around 100 milliseconds will be intolerable for 5G applications. Using millimeter wave and femto-cell reduces the coverage or transmission range of signal in BS[1],[8]. So connectivity and reliability are great challenges to be looked in.

Security is the mostly looked and expected facility in 5G wireless network. It plays an important role in electronic payments, digital wallets, etc. and it is also responsible to address on AAA (Authentication, Authorization and Accounting), encryption protocol for user data integrity while on transmission, safe guarding of cloud computations and core databases and management activities. Device which are interconnected should provide authentication and authorization and accounting with fine grained and

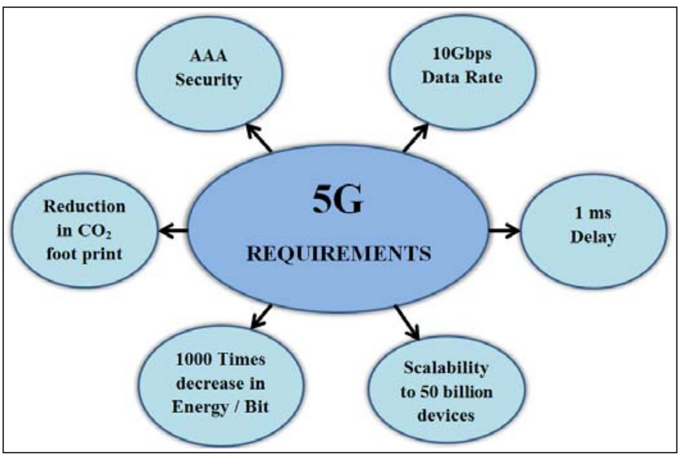

Fig. 3: 5G Requirements

secure mechanism. To attain high level security network operator, device manufactures and also standardization bodies should work together on designing the types of services to be supported, protocol for the services and devices standard to make service available at user end. Fig. 3 illustrates the structure for the requirements of fifth generation networks, discussed in this section.

To meet the above requirements, cooperative communication is essential for providing better coverage[9].

A virtual full-duplex relaying scheme was proposed in[10].[11] analyzed the energy harvesting relay-aided cooperative protocol under slow Rayleigh fading channels from outage behavior. An efficient relay-destination selection scheme for multiuser multi-relay networks was used in[12]. A joint relay-and-antenna selection scheme (JRAS) was proposed through decode-and-forward relay protocol using energy harvesting technique for the reduction in outage probability[13].[14] utilized a robust cooperation scheme to update the channel state information for better improvement in capacity as well as coverage. This scenario can also be analyzed mathematically to overcome the outage loss and feedback method was incorporated in[15]. The techniques are now being discussed can be done through cooperative relaying strategy and it plays a vital role in different channels like Rayleigh, Rician, Nakagami and fading types[16] studied efficient communication protocol for full-duplex relaying scheme over Nakagami—m fading channels. Further, the performance in terms of coverage for the above channels with the optimized relay placement was analyzed in[17]. The authors in[18] analyzed the performance of hybrid decode-amplify-and-forward (HDAF) relaying protocol with the help of incremental relaying scheme to reduce the error rate and outage probability. In[19], the diversity order was improved through space-shift keying (SSK) technique in order to achieve better connectivity. Authors in[20]-[25] studied and proposed techniques to minimize errors in order to get better capacity and coverage[26]-[30].

In this paper, cooperative communication techniques are explored for an improvement in capacity, coverage and green communication for 5th generation technology.

The rest of the paper is organized as follows: Section II explains the basic features of 5G networks. Major challenges of 5G standard are briefly explained in Section III. Section IV describes cooperative communication and its protocols. Section V concludes the paper.

FEATURES OF 5G NETWORKS

In the last section, key requirements to meet the challenges in fifth generation networks have been discussed. Therefore, fifth generation networks are capable to support massive number of connections efficiently. With the anticipated increase of techniques such as device-to-device communication, machine-to-machine communication, a cell needs to occupy more number of users and provide coverage for all the users along with high rate. The conventional macrocell network architecture has been taken as the basic network architecture in fourth generation systems. Evaluations from the literature have shown that the periodical mobile traffic around the globe will be approximately more than 15 exabytes in the year of 2018. A remarkable growth in bandwidth demand arrives from the rapid development of electronic gadgets like smartphones and electronic devices that requires accessing the network and needs better connectivity for data, voice and video streaming applications. With reference to the unprecedented diversity of mobile devices and services, the fifth generation network terms for high flexibility in all layers present in a network. In order to improve the capacity and offload the traffic density in existing base stations, the features such as spatial ultra densification and spectral aggregation are considered[1].

(a) Ultra Densification

Ultra densification is a simple and efficient way to increase system capacity which can reuse the set of frequencies which makes cells smaller. From the literature, size of the cells can be reduced for an extent. However, with this extreme densification technique, some of the challenges like installation cost, back-hauling, maintenance and signaling overhead have to be considered. It is possible to meet this challenge with the utilization of femto-based systems. But the research work is required to meet the existing requirements.

(b) Energy Efficiency

Energy efficiency still remains an important design issue while developing for 5G. Today, Information and Communication Technology (ICT) consumes as much as 5% of the electricity produced around the globe and is responsible for approximately 2% of global greenhouse gas emissions – nearly equivalent to the emissions created by the aviation industry. Hence, it is necessary to pursue energy-efficient design approaches from Radio Access Networks (RAN) and backhaul links to the User Equipments (UEs)[11], [29].

The main advantage of energy-efficient based system design is manifold. Initially, it plays a vital role in sustainable development by reducing the carbon footprint of the mobile industry itself. Then, ICT as the core enabling technology of the future smart cities can also play a fundamental role in reducing the carbon footprint of other sectors especially in transportation. Further, it can increase the revenue of mobile operators by reducing their operational expenditure (Opex) through saving on their electricity bills. Therefore, reducing the 'Joule per bit' cost can keep mobile services affordable for the users, allowing flat rate pricing in spite of the 10 to 100x data rate improvement expected by 2020. Last but not least, it can extend the battery life of the UEs. Energy harvesting technique can be used in cooperative relay networks which helps to improve better performance with minimal power[29], [30].

(c) Self-Organization Network

A network which is capable of self-organization is one of the components of 5G. As the growth of population for small cells are getting increased, then the self-organizing network gains more effectively. Most of the wireless traffic is generated indoors. In order to carry this heavy traffic, ultra dense small-cell deployments in indoors is needed and to be maintained by the users alone. The indoor small cells need to be self-configurable, which has to be installed in a plug and play manner. Furthermore, they need to have a capability of self-organization by adapting themselves to the neighboring small cells intelligently and also to minimize inter-cell interference.

(d) Antenna Diversity

Antenna diversity can be employed either at the transmitter or receiver side for the achievement of performance in terms of gain. This configuration is common in most of the base station and it is very essential and effective technique to incorporate multiple antennas for multi-users. Multiple-Input-Multiple-Output (MIMO) plays a vital role in wireless cellular networks and utilizes spatial multiplexing to achieve better performance. In addition to the above, massive MIMO is proposed as key enabling solution for fifth generation networks. It includes more number of antennas and placed in arrays. Further, massive MIMO designs hundreds of antennas at the base stations to increase the system capacity as well as throughput[1]. Other benefits of massive MIMO includes high data rate, better spectral efficiency with reduced latency.

(e) mm Wave (Millimeter Wave)

According to the Federal Communications Commission (FCC) and the outcomes from academic and industry professionals, millimeter wave plays an important role and shows interest for providing gigabit per second (Gbps) throughput with its enormous bandwidth. It prefers the frequency band of 30-300 GHz, but researchers also interested to include the nearby frequency bands of 24 GHz to 28 GHz. Therefore, this technique can be considered as an important technique for 5G networks to provide greater amount of frequency bandwidth and is also capable to support high data rate and seamless connectivity for more number of users[1].

(f) Device-to-device Communications (D2D)

In traditional cellular networks, the communication occurs between base stations and user equipments. The communication between two links has to be established through base stations and it is not efficient for recent requirements. In order to improve spectral efficiency, D2D communication was introduced[1]. This technique will provide better quality of service (QoS) with public safety and security.

(g) Machine-to-machine Communications (M2M)

Machine-to-machine communication refers to an emerging application that allows devices to connect with other devices in wired as well as in wireless environments. It utilizes sensing device to detect an event, it is further relayed through a wired or wireless network to a specific application. This specific information translates the detection information into useful information. M2M plays a vital role; still some of the challenges need to be addressed such as seamless integration with mobile computing, cost mechanism, security related issues and energy management. Most of the M2M devices are designed to operate with very less power, making them amenable for powering with batteries. In addition to that, few M2M networks are expected to operate over longer duration of time. The concept of M2M also referred to as Internet of Things (IoT), which enables devices to access Internet on its own and this access shall be some kind of a wireless link headed for gateway, connected to a mobile network. Several studies have been addressed on energy efficiency in M2M networks by considering energy-efficient access control, energy-efficient relaying and routing for the aggregation of M2M devices with weak link quality, energy efficiency for securing M2M networks, scheduling devices and energy harvesting techniques[29].

(h) Backhaul

Backhaul has been considered as a challenging task in 5G networks. The ultra-densed cells with high traffic density cells have to be connected to the core network through backhauling. The backhaul can be deployed in different topologies like point-to-point, tree, mesh and star networks. Basically, backhaul networks are mainly built with fiber optic and microwave links. In recent years, the work shown in the literature addressed challenges by employing recent techniques, but backhaul has emerged a bottleneck for fifth generation networks[26].

TECHNIQUES AND THEIR CHALLENGES IN GREEN COMMUNICATION

In this section, some important ongoing researches will be discussed, in which could assist in achieving the requirements of 5G cellular networks as discussed in previous sections. Table 1 shows the main research challenges and areas to be considered for future wireless networks.

Table 1: Research Areas

Research Area	Key Achievements & Challenges
Cooperative Communication	❒ Deployment of multiple femto-relay and femto based cells ❒ Improvement in capacity & coverage
mmWave Communication	❒ Improvement in bandwidth and data rate ❒ Pathloss and propagation Mechanism issues. ❒ Link blockage
Massive MIMO	❒ Implementation challenges for smaller environment. ❒ Electromagnetic radiation. ❒ High scalability.
Energy Efficient Communication	❒ Energy efficiency with minimal power ❒ Ultra-densification
Device-to -Device Communication	❒ Reduction in latency. ❒ Better connectivity to cell edge user.

COOPERATIVE COMMUNICATION

The idea of cooperative communication was first proposed by van der Meulen (1971). It is a fastest growing research area and is emerging as an important area in wireless communication network for efficient spectrum usage. It allows effective utilization of communication resources by allowing relays to cooperate each other[5]. The key idea in this type of communication technique scheme is resource sharing between multiple nodes in a network. In cooperative communication a relay station in deployed which is neither data source nor destination to introduce a relay channel which is an auxiliary to direct channel between the source and destination. Techniques like spatial diversity, time and frequency diversity concepts can also be achieved to mitigate the effect of fading. Fig. 4 explains how a cooperative relaying can help in extending the coverage and capacity for a cellular network. Cooperative relay in wireless network is capable of amplifying a weak signal due to fading or path-loss effect in channel and hence extend the coverage[10],[16],[28]. Cooperative communication helps in achieving following benefits:

- Improved energy/power efficiency.
- Increasing the attainable system throughput.
- Cell-edge coverage extension.
- Guaranteeing a given QoS.
- Less expensive infrastructure by use of relay and femto cells.
- Network deployment
- Throughput

- ❖ Improvement in data rate
- ❖ Mobility

The above improvements can be assembled for enhancing better coverage and throughput. In addition to that, the use of cooperative relays brings the features like reduction in cost and power.

Relaying, a scheme which helps to transport information from one node to other or several nodes to meet existing demands in cellular wireless networks. In general, the deployment of relay nodes has shown a great interest for the improvement of coverage. The relay channel, in which a source point communicates with a destination point with an utilization of relay. The relay which is capable to operate either in half-duplex or in full-duplex mode. If a relay is said to be full-duplex, it transmits and receives information simultaneously in the same frequency band whereas half-duplex relaying is not in simultaneous mode.

There are variants of processing scheme that a relay node (RN) / relay station (RS) employs to process the signal that relay receives from the source which could be macro cell base station (MBS) and results in different cooperative communication protocol. The communication between relay node and base station occurs in two ways such as inband and outband. In inband, the communication link utilizes the same band that the source uses to communicate with destination within the donor cell, while in the case of outband, it uses different band. In this section, some popular relaying schemes will be discussed in detail.

1. Fixed and Adaptive relaying schemes

In fixed relaying schemes, the channel resources between the source and relay are divided in a fixed or deterministic manner. According to the protocol, the processing of signal at relay differs. Most common fixed cooperative protocol are *amplify and forward* (AF) protocol and *decode and forward* (DF) protocol. Fixed relaying scheme has advantage of easy implementation but have disadvantage of low bandwidth efficiency as half of resources are dedicated for relaying which reduce the data rate of the network. This case is true when the direct link between source and destination are very good.

In adaptive relaying scheme, the scheme is adaptive in nature with respect to the received signal from source. It improves the inefficiency of fixed relaying scheme. Two common strategies are *selective decode and forward relaying* and *incremental relaying.*

2. Cooperative Relay Protocols

A typical cooperation strategy can be modeled by two orthogonal phases avoiding interference between the two phases of transmission. In phase 1, source sends information to destination and RS also receive the information at same time. In second phase, RS help source by forwarding or retransmitting the information to destination.

In *fixed amplify and forward* protocol, RS scales the received version of signal along with noise from source, then amplifies and retransmits to the destination. In *fixed decode and forward* protocol RS involves in decoding the source transmission at the relay. RS retransmit the decoded signal after re-encoding them (possibly compressing or adding redundancy). The decoded signal can be incorrect due to poor SNR condition of the channel. So forwarding the incorrect signal to destination in meaningless. Here *selective decode and forward scheme* comes into picture which transmit the decoded information to destination only when the source relay link SNR in above a threshold value. When source relay channel suffers severe fading and channel SNR falls below threshold, RS remain idle whereas fixed DF scheme forward information even though it is not correct. In *compressed and forward* (CF) *scheme*, relay transmits a compressed and quantized version of received signal i.e. an estimate of the source transmission to the destination. Reception function at destination is done by combining the source transmission and estimate from the relay node. In *coded cooperation relaying scheme*, RS send incremental redundancy, which when combined at destination with codeword send by source results in a codeword with higher redundancy. Another relaying scheme is *incremental relaying* and is assumed that there is feedback channel from destination to relay. Destination will send acknowledgement to RS if it is able to receive information from source correctly so that relay don't have to send same information to the destination, hence radio resource can be used efficiently.

In Table 2, some methodologies which are used in optimizing the network and its corresponding performance analysis in terms of reduction in outage probability have been sited with minimal power and better coverage expansion. Some of the existing schemes have been discussed in Table 2. The forthcoming paragraph will be discussing the concepts mentioned in Table 2 with respect to the utilization of energy.

In Jia *et al.*[23] focused on max link selection algorithm over independent and non-identically distributed Nakagami-m fading channels for the performance measurement of outage probability with minimum latency. In[25], two-way decode-and-forward with signal space diversity scheme has been proposed and studied different schemes for the optimization and power utilization for relay nodes. Further, better spectral efficiency has been achieved with optimal power using Monte-Carlo simulations.

A Role Selection (ROSE) mechanism with energy harvesting technique is utilized in[21] for the achievement of better transmission reliability with minimum power.

Li and Letaief[11] used stochastic based energy harvesting technique for the minimization of outage probability and multiplicative gain. Bai *et al.*[18] proposed hybrid decode-and-amplify forward relaying scheme with incremental based concept and it outperforms other cooperation relaying schemes because it works better at lower power allocation factor.

Table 2: Summary of existing methodology and its performance analysis

Authors	Algorithm	Relaying Protocol	Contribution
Jia *et al.*[23]	Max. Link selection schemes	Buffer aided relay	Analysed outage performance for cooperative relaying system over non-identical Nakagami-m fading channel.
Ajmal Khan, Raveendra and Wang[25]	Signal space diversity	DF	Studied different schemes for the optimization relay position and power allocation using Monte Carlo simulation.
Chadi and Noun[22]	Optical Communication System	DF	Introduced the optimal solution for the performance of FSO systems using multi relay.
Som and Chockalingam[19]	Signal Shift Keying	DF	SSK outperforms PSK and predicted the achievable diversity as a function of system parameters.
Ding *et al.*[21]	Role selection (ROSE)	Energy Harvesting relay	Analysed performance in terms of outage probability, energy harvesting, role selection and diversity order
Li *et al.*[10]	Multi path relay channel (MPRC) and inter relay interference (IRI)	Full-Duplex DF relay	Demonstrated the performance gain with an existing system.

Marco Antonio Beserra de Melo and Daniel Benevides da Costa[12]	Low complexity relay destination selection scheme	DF & AF	Increased outage performance with Monte Carlo simulations
Li and Letaief[11]	Energy harvesting technique	Energy Harvesting relay	Improvement of system performance in terms of multiplicative gain and minimization of outage probability.
Hui, Li and Wang[15]	Limited feedback with channel state information (CSI)	Selective DF & AF	Diversity analysis and outage performance of opportunistic relaying
Khafagy *et al.*[16]	Cooperative diversity with loop back interference	Incremental selective DF	Outage performance and diversity gain for full duplex relaying over Nakagami-m fading channels.
Jiang, Kaiser and Han Vinck[14]	Opportunistic space time coding (OSTC)	DF	Achievement of capacity and multiplexing-diversity trade off.
Men, Ge and Zhang[13]	Joint relay and antenna selection (JRAS)	MIMO DF	Analysed the probability of outage
Bai *et al.*[18]	Three node cooperative relaying scheme	Incremental HDAF	Investigated the performance of outage probability, bit error rate, SNR threshold power allocation.
Han *et al.*[17]	Optimal relay placement and power allocation	DF	Analysed the performance of DF relaying protocol over log-normal shadowed rayleigh fading channel.
Elkourdi and Simeone[20]	Femto based relaying schemes	Femto-relay	Studied the performance of diversity multiplexing trade off and outage probability for the improvement in capacity and coverage.

3. Cooperative Relaying Topologies

Two relay assisted topologies are *single dedicated relay (SDR)* and *single shared relay (SSR)*. In SDR each relay is dedicated to a single user while in SSR single relay assists multiple users.

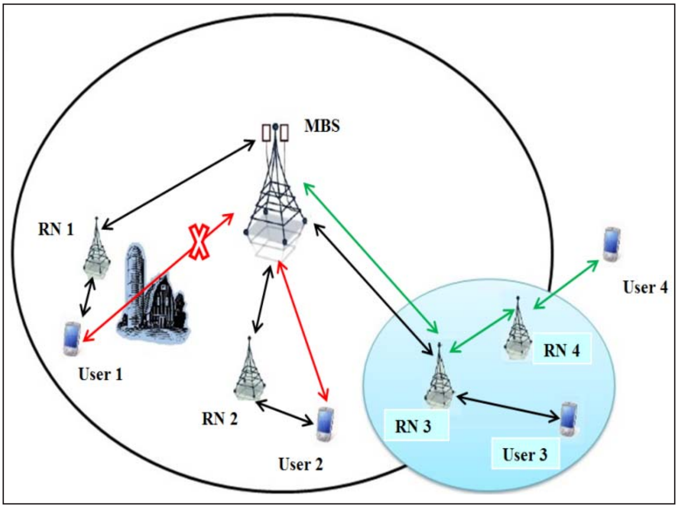

Fig. 4: Cooperative relay in cellular network

When multiple relay exists, the resultant relaying topologies can be classified into three types: *Serial multi-relaying, Parallel multi-relaying* and *Generalized multi-relaying*. In serial multi relaying, source signal are forwarded to destination by help of multi-hop relaying depending on cooperative diversity combining at each hop. In parallel multi relaying, signals from source are forwarded to destination by using multi branch parallel cooperation technique for sake of achieving maximum diversity order. In generalized multi relaying, a combination of multi-hop and multi-branch relaying is used aiming at attaining diversity order and relay aided path loss reduction.

4. Femto-cell

Latest study shows that most of the voice calls and data traffic originate from indoor environment. In addition to that, number of device connected to cellular network is increasing drastically. So cellular network now face challenges of proving larger capacity and wide cellular coverage. For the increase in more device connecting to the cellular network and increasing capacity requirement, smaller cell are regarded as a viable option over the macro cells. Small cell deployment such as femto cell is considered as means to meet the capacity of modern wireless network application. Femto cell can be used as an easy fix for increasing network coverage due to the availability of cheap backhaul connections between home base stations (HBS) installed by network operators and operator's core network side. HBS are operated in two modes: *open access* where all users has same privilege to connect to network and *closed access* where only subscribers device are allowed to connect whereas service to public are dropped[8].

Femto cells HBS act as an independent BS and during uplink each HBS are required to decode intended user and pass decoded information along with necessary control signaling overhead to the mobile operator via backhaul link. Intended user can be subscriber's device located indoor or possibly outdoor located macro-cell users. Indoor radio propagations are mostly affected by indoor clutters, walls and also moving human bodies. A small scale issue can lead to large scale effect on wireless network due to densification of BS. HBS also faces challenges like cross-interference, co-interference, backhaul, mobility issues[4]. Cross-interference occurs when small cell user and nearby macro-cell user can interfere with each other when they operate in same licensed frequency band and this issue is mainly seen in a closed access environment. Co-interference is interference between neighboring small cell user and cell mainly in an environment where many femto-cells are densely deployed in a building. Backhaul may suffer network congestion at some times due to which network fails to provide consistent and required QoS. Small coverage can leads to more increase in handoff request rate at core network which should be handled precisely without delay. Cooperative diversity technique can be utilized with femto-cell to confront these indoor effects[8].

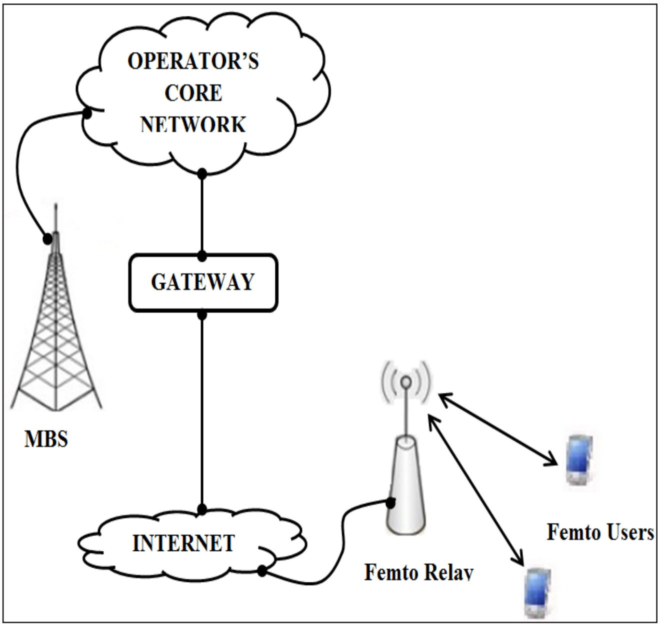

Fig. 5: Femto Relay architecture

5. Femto-relays

Femto relay technology is introduced to mitigate the small cell challenges. Femto relay technology is a novel, cost effective small cell solution offer better performance than that exist currently. This femto relay technology results in cross-tier and co-interference cancellation, dynamic backhaul switching, co-tier coexistence optimization through multi-relay coordination technique and improved mobility technique. Careful radio frequency planning and dedicated backhaul connection to network core is not required for a femto-relay, hence reduction in capital expenditure and operating expense obtained when compared to traditional BS and small cell deployments. Femto-relay with minimal power also provides the benefits of a normal small cell deployment like improved cell coverage, enhancement of system capacity, easy scalability and guaranteed QoS[3],[4]. Fig. 5 shows the basic architecture how femto relays can be installed for advancing the cellular network performance.

Initially, relaying strategy shown in Fig. 4 provides better coverage in rural and less densely populated areas. It also helps to overcome link blockage. Femto relay can be connected to macrocell base station (MBS) via backhaul connectivity, which provides an added advantage of cost effectiveness, reliability and green communication when compared to connecting relay to MBS via radio resources.

CONCLUSION

This paper presents an in depth overview of the technologies being considered for future cellular networks. Particularly, the utilization of cooperative relaying based femto-cell concepts with energy harvesting technique have been discussed. Further, the techniques for improving capacity, coverage and diversity techniques have been reviewed. Moreover, the current issues and challenges have been discussed in detail.

Other open research areas are using more relays for forwarding the signal to destination in a given cell and hence the requirement of an efficient routing algorithm, power allocation algorithms and scheduling algorithms is essential.

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