International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Integrated Power and Subcarrierassignmentby Cooperative Communications in LTE-A Networks

R.RajaKumar, R.Pandian, P.Indumathi, Jyotirmayee Subudhi

Abstract- The major enhancement of LongTerm Evolution (LTE), namely, LTE-Advanced aims at larger capacity for the users. The specifications of LTE-A include, Downlink(DL) at 3Gbps, Uplink(UL) at 1.5 Gbps spectral efficiency at 30 bps/Hz and Type II relay station. The relay station and the eNodeB (eNB) make use of the same In-Band channel to maximize the available resources. This paper deals with optimal allocation of the Multicarrier scheme, namely, OFDM's power and subcarrier to maximize DL communication efficiency of multiuser. Sub-carriers are assigned to users having the highest channel quality and using water-filling strategy, the power is allocated. This allocation scheme is assessed against existing schemes and found to be effective. Thus our work aims at introducing power and resource allocation schemes in a LTE-A network.

Keywords—LTE-A, cooperative communication, spectrum efficiency, relay channel, water-filling algorithm, resource allocation, user fairness.

I.INTRODUCTION

Worldwide Third-Generation (3G) systems are employed to improve DL and UL transmissions. Anyway, because of the advancements in technology and higher demands of Service quality and Service experience requirement, future wireless systems face challenges such as higher data rates and efficient multimedia services. Hence 3GPP has released the LTE standard for wireless systems with the goal of higher speed data transmissions compared to current radio access technologies [1], [2].

DL uses OFDM and UL uses different subbands with single carrier in LTE-A to increase the spectral efficiency. These choices make LTE-A support larger peak rates, throughput, coverage and reduced latencies improving QoE of user [3].Driven by the user'sclaiming extremely highrateconnections, maximizing the network efficiency through resource and power allocation fuelslot of research work. By cooperative communications among base stations and the relays, cell-edge throughput and coverage are enhanced. A Type II relay is bidirectional and has transparency to every UE within its coverage, not needing any resource.This paper aims atpartitioning. In our work we deal with Type II relays as they provide multipath diversity and UE gains. Among the cooperative protocols, Decode and Forward protocol has anadvantage, as relay and source use the same channel increasing spectral efficiency.

- The optimal assignment of power between the eNB and the RS can improve data rate on every subcarrier. By this technique, the eNB and the RS cooperate so as to increase transmission efficiency.
- The optimal resource allocation scheme to increase the throughput on each subcarrier.

Our paper is arranged as below. The Section II provides system model. The maximization of the achievable rate of relay channel in a subcarrier is provided in Section III. The optimum power allocation among eNB and RS as well as the throughput maximization are contained in Section IV. Results of Simulation and concluding remarks are presented in Section V and Section VI respectively.

II. SYSTEM MODEL

The system model of our work is shown below. An eNB is deployed in every LTE-A cell at the center to provide service to many UEs. Relay Stations(RS) with minimal area of coverage are present near edges of the cell, so as to increase throughput of edge users. If there were no cooperation among neighbouring RS, users get service from their assigned eNB and RS if feasible. In DL, serving eNB sends signals to users. Suppose the user's location is within range of coverage of RS, eNB reaches the user via both the direct link and the link via the relay, just as that is modeled by the cooperative relay channel with three nodes. DL communication is aided by the assigned RS as it captures signals transmitted from eNB and direct to user. Upon reception, RS retrieves the original message and sends again in its specific codes, while further transmission block occurs. From practical reality, Two-hop transmissions are dealt in this work. As hops increase, the complexity of decoding increases [19]. OFDM is the DL transmission scheme in LTE-A, where the available band B is orthogonally shared into n sub channels at various subcarriers, with each one having bandwidth 1/n of the total B Hz.. The subcarriers can be assigned time to time so as the users can make use of both diversities of multiuser and frequency at a very fine level.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
Dr.R.RajaKumar*, Mathematics Department, Sathyabama Institute of Science and Technology ,Chennai,India,e-mail:,rrkmird@gmail.com.
Dr.R.Pandian, Electronics and Instrumentation Engineering, SathyabamaInstitute of Science and Technology,Chennai,India. rpandianme@rediffmail.com
Dr.P.Indumathi,Electronics Engineering Department, MIT Campus Anna University Chennai, India.indu@mitindia.edu
JyotirmayeeSubudhi, Electronics Engineering Department, MIT Campus Anna University Chennai,India jyotirmayee.subudhi@gmail.com.

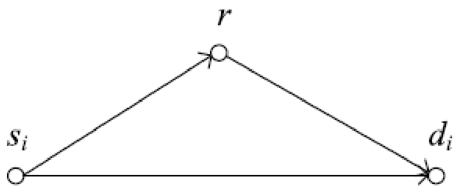

Fig 1. System model

Let the user sets be denoted as M= {1,…m} and sub-channel sets be denoted as and N= {1,…,n} respectively. When a transmission block starts, eNB assigns the suchannels and the transmitted power is attuned flexibly at evolved Node B and Relay Stationmaximizing efficiency of transmission. If all the wireless channels are assumed Gaussian, and the RS does not cover a user, the channel gain coefficient is just$h_{sd}^{(k,l)}$. If Transmit and Receive endshave Channel State Information (CSI), specific power and subchannel can be allocated by eNB optimally..

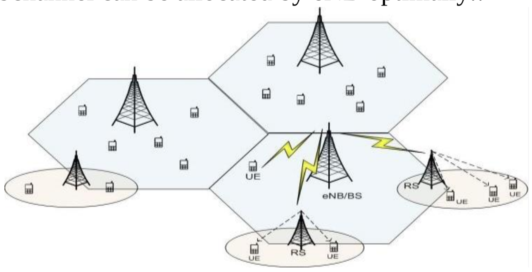

Fig.2. LTE-Advanced cellular network and RelayStations.

III. SINGLE USER RELAY CHANNEL ANDPOWER ASSIGNMENT

The transmit-end node is assumed to have power restriction as

$$\frac{1}{T}\sum_{t=1}^{T} x_{s_i}^2(t) \le P_i,$$

The relay node is considered to have power constraint as below while link i is active.

$$\frac{1}{T}\sum_{t=1}^{T} x_r^2(t) \le P_r^{(i)}.$$

Hence, the signals obtainedby the nodes at relay and sink are, respectively

$$y_r(t) = \frac{x_{s_i}(t)}{\sqrt{l_{s_i r}^{\alpha}}} + z_r(t),$$

$$y_{d_i}(t) = \frac{x_{s_i}(t)}{\sqrt{l_{s_i d_i}^{\alpha}}} + \frac{x_r(t)}{\sqrt{l_{r d_i}^{\alpha}}} + z_{d_i}(t),$$

here$z_r(t)$ and $z_{di}(t)$ are AWGN obtained at node of relayr and at the node of sink $d_i$with σ^2variance. Let l_{pq}representp toq distance. Path loss parameterα has a range 2 ~ 8, for all links.Let$P_r^{(i)}$ bedenote relay node's powerwhile transmitting in link i. While a blockis transmitted, the node r atrelay just transmits the present message's code with its maximumtransmit power$P_r^{(i)}$. In the case of node at sources$_i$, the overall transmission power Pi is divided into two parts, $P_i^{(1)}$ and $P_2^{(i)}$ for various purposes. $P_i^{(1)}$ is employed for the next message and $P_2^{(i)}$ is that of the relay for sending the present message to the sink. The two codes are combined andtransmitted by s_i.Hence, , the rate achieved for link iwith this relaying strategy is as below,

$$R_i = \max_{p(x_{s_i},x_r)} \min\{I(X_{s_i};Y_r|X_r), I(X_{s_i},X_r;Y_{d_i})\}$$
$$= \max_{P_i^{(1)},P_i^{(2)}} \min\left\{\frac{1}{2}\log\left(1+\frac{P_i^{(1)}/l_{s_i r}^{\alpha}}{\sigma^2}\right), \frac{1}{2}\log\left(1+\frac{P_i^{(1)}/l_{s_i d_i}^{\alpha}+\left(\sqrt{P_i^{(2)}/l_{s_i d_i}^{\alpha}}+\sqrt{P_r^{(i)}/l_{r d_i}^{\alpha}}\right)^2}{\sigma^2}\right)\right\}.$$

We can observe that R_i the rate achievable is dependent on $P_i^{(1)}$, $P_2^{(i)}$,$P_r^{(i)}$ and relay location. Our goal is to maximize throughput by joint assignment of power subject to constrained total power consumption and optimally locate the relay. This is the following optimization problem:

$$\max \sum_{i=1}^{n} R_i$$
$$\text{subject to } P_i^{(1)} + P_i^{(2)} + P_r^{(i)} \le P^{(i)}, \quad \forall i = 1,\ldots,n.$$

here $P^{(i)}$is the maximum power consumed while the active link is i.The first term $I(Xs_i; Yr|Xr)$ is the decoding rate achieved by the relay, and the second term $I(Xs_i , Xr; Yd_i)$ is the rate successfully decoded by the sink.Given a relay's transmission power $P^{(i)}$, the maximum rate obtained is through the optimum assignment of $P_i^{(1)}$ and $P_2^{(i)}$ at the source. That is , the source node tries balancing the rates at which relay and sink decode and the ideal strategy is to have both the rates equal.

Based on the constraint rate, there are two choices available for the source code for power allocation:

- When the rate atwhich sink node decodes is the constraint, the node at source can enhance$P_2^{(i)}$ anddecrease $P_i^{(1)}$ to make the two rates equal. This is synchronous case.
- When the rate at which relay decodes is the constarint, the source node sets$P_i^{(1)}$= P^i and $P_2^{(i)}$ = 0. While$P_2^{(i)}$ = 0, the source and the relay communicate independently. This is asynchronous case..

In our optimization method, we will consider joint allocation of $P_r^{(i)}$,$P_2^{(i)}$ and $P_i^{(1)}$ for the two strategies.

A. Synchronous Scenario

In this case, as the sink receivesthe combined strength, initially we maximize the rate at the decoder of sinkwith fixed $P_0^{(i)}$, $P_0^{(i)}$, = $P_i^{(2)}$+$P_r^{(i)}$. Later, we can distribute$P_i^{(1)}$and $P_0^{(i)}$ with overall power constraint. The rate at which sinkdecodes is

$$\max_{P_i, P_r^{(i)}} R_i$$

subject to $P_i + P_r^{(i)} = P^{(i)}$.

$$I(X_{s_i}, X_r; Y_{d_i}) = \frac{1}{2}\log\left(1 + \frac{\frac{P_i^{(1)}}{l^{\alpha}_{s_i d_i}} + \left(\sqrt{\frac{P_i^{(2)}}{l^{\alpha}_{s_i d_i}}} + \sqrt{\frac{P_0^{(i)} - P_i^{(2)}}{l^{\alpha}_{rd_i}}}\right)^2}{\sigma^2}\right).$$

from [19].

Thus, the optimal distribution between $P_i^{(2)}$ and $P_r^{(i)}$ is

$$P_i^{(2)} = \frac{l^{\alpha}_{s_i d_i}}{l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}} P_0^{(i)},$$

$$P_r^{(i)} = \frac{l^{\alpha}_{rd_i}}{l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}} P_0^{(i)},$$

The decoder rate at sink becomes:

$$I(X_{s_i}, X_r; Y_{d_i}) = \frac{1}{2}\log\left(1 + \frac{4P_0^{(i)}/(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}) + P_i^{(1)}/l^{\alpha}_{s_i d_i}}{\sigma^2}\right).$$

The optimal rate Ri is achieved while $P_i^{(2)}+P_r^{(i)}+P_i^{(1)}= P^{(i)}$ and the two rates are same:

$$I(X_{s_i}; Y_r | X_r) = I(X_{s_i}, X_r; Y_{d_i}).$$

This is sameas

$$\frac{1}{2}\log\left(1 + \frac{P_i^{(1)}}{l^{\alpha}_{s_i r}\sigma^2}\right) = \frac{1}{2}\log\left(1 + \frac{4P_0^{(i)}}{(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i})\sigma^2} + \frac{P_i^{(1)}}{l^{\alpha}_{s_i d_i}\sigma^2}\right)$$

Rewriting the optimization problem as

$$\max \frac{1}{2}\log\left(1 + \frac{P_i^{(1)}}{l^{\alpha}_{s_i r}\sigma^2}\right)$$

with constraint $Pi^{(1)}+ P_0^{(i)} = P^{(i)}$

$$\frac{P_i^{(1)}}{l^{\alpha}_{s_i r}} = \frac{4P_0^{(i)}}{l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}} + \frac{P_i^{(1)}}{l^{\alpha}_{s_i d_i}}.$$

If $l_{sidi} \geq l_{sir}$ i.e., a relay is employed between the sourceand the sink to enablepassing on the traffic, the optimal power allocation then is:

$$P_i^{(1)} = \frac{4 l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}}{(l^{\alpha}_{s_i d_i} - l^{\alpha}_{s_i r})(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}) + 4 l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} P^{(i)},$$

$$P_0^{(i)} = \frac{(l^{\alpha}_{s_i d_i} - l^{\alpha}_{s_i r})(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i})}{(l^{\alpha}_{s_i d_i} - l^{\alpha}_{s_i r})(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}) + 4 l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} P^{(i)},$$

from [19]

The maximum rate achieved is:

$$R_i^{sync} = \frac{1}{2}\log\left(1 + \frac{4 l^{\alpha}_{s_i d_i}}{(l^{\alpha}_{s_i d_i} - l^{\alpha}_{s_i r})(l^{\alpha}_{s_i d_i} + l^{\alpha}_{rd_i}) + 4 l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} \cdot \frac{P^{(i)}}{\sigma^2}\right)$$

If $\beta(k,l)$ €{0, 1}is theparameterthe transmit end employs, to finetune the part of power transmitted that is used to cooperate with the relay so as to attain the highest raterate and $\beta(k,l) = 1-\beta(k,l)$. We can also write

$$R^{(k,l)} = \frac{1}{n}\log\left(1 + \frac{|h_{sr}^{(k,l)}|^2(|h_{sd}^{(k,l)}|^2 + |h_{rd}^{(k,l)}|^2)}{|h_{sr}^{(k,l)}|^2 + |h_{rd}^{(k,l)}|^2} \cdot \frac{P^{(k,l)}}{B/n}\right).$$

from [19].

B. Asynchronous Scenario

In asynchronous ($l_{sidi} \geq l_{sir}$) case, $P_i^{(2)}= 0$ and $P_i^{(2)}= P_i$, the optimization problem becomes

Similarly, the obtained rate is maximum when,

$$\frac{P_i}{l^{\alpha}_{s_i r}} = \frac{P_i}{l^{\alpha}_{s_i d_i}} + \frac{P_r^{(i)}}{l^{\alpha}_{rd_i}}.$$

From [20]

Hence, the optimal power sharinghere is

$$P_i = \frac{l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}}{l^{\alpha}_{s_i d_i} l^{\alpha}_{rd_i} - l^{\alpha}_{s_i r} l^{\alpha}_{rd_i} + l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} P^{(i)},$$

$$P_r^{(i)} = \frac{l^{\alpha}_{s_i d_i} l^{\alpha}_{rd_i} - l^{\alpha}_{s_i r} l^{\alpha}_{rd_i}}{l^{\alpha}_{s_i d_i} l^{\alpha}_{rd_i} - l^{\alpha}_{s_i r} l^{\alpha}_{rd_i} + l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} P^{(i)},$$

The highest achievable rate is:

$$R_i^{(asyn)} = \frac{1}{2}\log\left(1 + \frac{l^{\alpha}_{s_i d_i}}{l^{\alpha}_{s_i d_i} l^{\alpha}_{rd_i} - l^{\alpha}_{s_i r} l^{\alpha}_{rd_i} + l^{\alpha}_{s_i r} l^{\alpha}_{s_i d_i}} \cdot \frac{P^{(i)}}{\sigma^2}\right).$$

Or

$$R^{(k,l)} = \frac{1}{n}\log\left(1 + \frac{|h_{sr}^{(k,l)}|^2 |h_{rd}^{(k,l)}|^2}{|h_{sr}^{(k,l)}|^2 - |h_{sd}^{(k,l)}|^2 + |h_{rd}^{(k,l)}|^2} \cdot \frac{P^{(k,l)}}{B/n}\right)$$

From [20]

C. Non-cooperative case

If $l_{sidi} < l_{sir}$, then $P_i^{(1)}/l_{sir}$ is at all times smaller than $P^{(i)}/l_{sidi}$, implying that the rate at which relay decodes is the bottleneck in all scenarios of power allocation. Thus, the distribution in optimum manner can be obtained when $P_i^{(1)} = P_{(i)}$. This is the case wherein the relay is not utilized for source-sink transmission and the maximum rate is given by

$$R_i^{dir} = \frac{1}{2}\log\left(1 + \frac{P_i}{l^{\alpha}_{s_i d_i}\sigma^2}\right).$$

Or

$$R^{(k,l)} = \frac{1}{n}\log\left(1 + \frac{|h_{sd}^{(k,l)}|^2 P_s^{(k,l)}}{B/n}\right).$$

D. Equal power allocation

In this scheme the eNB sends with the same power as the RS. .

IV. JOINT POWER AND SUBCARRIER ALLOCATION FORTHROUGHPUT MAXIMIZATION

A. Existing Scheme – Scheme 1

Statement: To increase the data rate of a given subcarrierin a DL multiuser OFDM scheme, is that the subcarrier should be allotted to a single user with the highest channel gain in that subcarrier.

Hence, a subcarrier is used by only one user and never by multiple users in a given time.After the allocation of subcarriers, the total transmit power is evenlyassignedto the subcarriers.

S_{km} =S/M for m=1,2,…M. Here S is the power transmitted and M is the total number of sub channels.

B. Existing Scheme – Scheme 2

The power and subchannels are equally distributed for all the users, unmindful of each user'schannel conditions. There are K users overall consuming N sub channels, while transmitted power is constrained to P.

C. Algorithm for Optimal Resource Assignment

The goalhere is to increase the overall throughput.

$$\max_{P^{(k,l)},\rho^{(k,l)}} \sum_{k\in\mathcal{M},l\in\mathcal{N}} R^{(k,l)}$$

given,

$P^{(k,l)} \leq P_{total}$

$P^{(k,l)} \geq 0$, for all k, l

$\rho^{(k,l)} \in \{0, 1\}$, for all k, l

Optimally allocating the resources jointly,amountsto increase the overall throughput byassigningthe subcarrier to the user with best channel and allottingpower by water-filling strategy.

- Given, $l = 1, ... , n$, find a $k(l)$ fulfilling the condition $H^{(k(l),l)} \geq H^{(k,l)}$ for every $k \in M$. Allot sub channel l to specific user k(l), i.e., set $\rho^{(k(l),l)} = 1$.
- Assign$P^{(k(l),l)} = (\lambda - 1/H^{(k(l),l)})^{+}$ as the power transmitted for the user k(l) in sub channel l. λ is the level of water-filling process that is chosen to fulfill the total power restriction**.**

D. Water filling process.

To sum it up in a nutshell, as power of signal is raised from zero, we allocate the power for the channel with lowermost noise.

V. NUMERICAL RESULTS

To understand our joint resource assignment scheme, the results of simulation are stated as two parts.

A.Power Assignment and Single-User Relay Channel

The rates attainable for an individual user are obtainedby optimally dividing power for both synchronous and asynchronous cases. We compare it with equal power division where both evolved Node B and the Relay Stationhaveequal power. To understand the improvementdue to employing relay station, we keep capacity of transmission without cooperation as a baseline to compare, as shown in Fig. 3. We deduct that cooperative transmission with relay outperforms the relay-less noncooperative strategythrough achievable rate of data.Also, higher rate can be achieved in synchronous scenario than asynchronous scenariomost often, since the former one makes use of the cooperation between the eNB and RS while coding. It is also observed that equal power division is inferior to our scheme of optimum power division.

B. Resource Assignment for Throughput Maximization

Fig. 4 compares the throughput of the three schemes of synchronous scenario and Fig. 5 shows the behaviour when asynchronous relay is considered. From these figures, it can be observed that the highest throughput isattained by optimal resource assignmentin both synchronous and asynchronous cases. Moreover, scheme 1 beats scheme 2,as it uses the channel variance.Also, we can infer from both the figures,that the achievable throughputof the optimal resourceallotment and the one attained by scheme 1 increases as users increase.

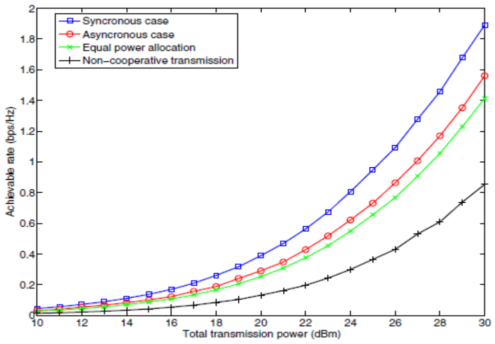

Fig 3. Comparison of achievable rates.

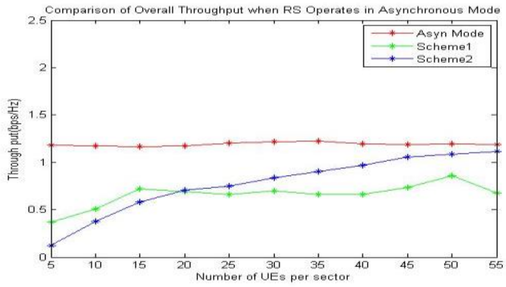

Fig 4. Comparison of achieved Throughput for relay in asynchronous scenario .

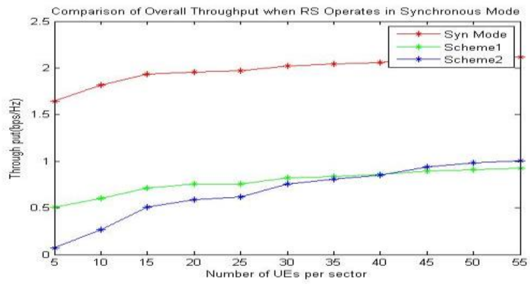

Fig 5. Comparison of achieved Throughput for relay in synchronous scenario.

VI. CONCLUSION

We have studied the DL resource allocation for maximizing the communication efficiency in an LTE A systemby deploying relays. Contrary to just amplify and forward the signal received, coding abilityis required by relays to achievemaximum data rates.Same channel occupancy of source and relays is the property of In-Band Type II decode and-forward relays employed in our work. Anoptimumjoint assignment of subcarriers and power is employed herefor increasingachieved throughput. Simulation results confirm that our algorithm increases the minimum rate of each user. Relay installation with cooperation for DL-COMP can be a future work.

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

REFERENCES

1. 3GPP, "Requirements for Evolved UTRA and Evolved UTRAN," vol.TR 25.913. Available: www.3gpp.org.
2. H. Ekstrom, A. Furuskar, J. Karlsson, M. Meyer, S. Parkvall, J. Torsner, and M. Wahlqvist, "Technical solutions for the 3G long-term evolution,"IEEE Commun. Mag., vol. 44, no. 3, pp. 38–45, 2006.
3. A. Ghosh, R. Ratasuk, B. Mondal, N. Mangalvedhe, and T. Thomas, "LTE-Advanced: next-generation wireless broadband technology," IEEETrans. Wireless Commun., vol. 17, no. 3, pp. 10–22, 2010.
4. Y. Yang, H. Hu, J. Xu, and G. Mao, "Relay technologies for WiMAX and LTE-Advanced mobile systems," IEEE Commun. Mag., vol. 47, no. 10, pp. 100–105, 2009.
5. X. Tao, X. Xu, and Q. Cui, "An overview of cooperative communications,"IEEECommun. Mag., vol. 50, no. 6, p. 65, 2012.
6. P. Bhat, S. Nagata, L. Campoy, I. Berberana, T. Derham, G. Liu, X. Shen, P. Zong, and J. Yang, "LTE-Advanced: an operator perspective,"IEEECommun. Mag., vol. 50, no. 2, pp. 104–114, 2012.
7. S. Peters, A. Panah, K. Truong, and R. Heath, "Relay architectures for 3GPP LTE-Advanced," EURASIP J. Wireless Commun. Netw., vol. 2009.
8. C. Hoymann, W. Chen, J. Montojo, A. Golitschek, C. Koutsimanis, and X. Shen, "Relaying operation in 3GPP LTE: challenges and solutions,"IEEECommun. Mag., vol. 50, no. 2, pp. 156–162, 2012.
9. L. Lei, Z. Zhong, C. Lin, and X. Shen, "Operator controlled deviceto-device communications in LTE-Advanced networks," IEEE WirelessCommun., vol. 19, no. 3, pp. 96–104, 2012.
10. Y. Li, P. Wang, D. Niyato, and W. Zhuang, "A dynamic relay selection scheme for mobile users in wireless relay networks," in Proc. 2011 IEEE INFOCOM, pp. 256–260
11. Y. Liang and V. Veeravalli, "Gaussian orthogonal relay channels: optimal resource allocation and capacity," IEEE Trans. Inf. Theory, vol. 51, no. 9, pp. 3284–3289, 2005.
12. T. C.-Y. Ng and W. Yu, "Joint optimization of relay strategies and resource allocations in cooperative cellular networks," IEEE J. Sel. AreasCommun., vol. 25, no. 2, pp. 328–339, 2007.
13. J. Jang and K. Lee, "Transmit power adaptation for multiuser OFDM systems," IEEE J. Sel. Areas Commun., vol. 21, no. 2, pp. 171–178, 2003.
14. W. Rhee and J. Cioffi, "Increase in capacity of multiuser OFDM system using dynamic subchannel allocation," in Proc. 2000 IEEE VTC, vol. 2, pp. 1085–1089.
15. Z. Shen, J. Andrews, and B. Evans, "Adaptive resource allocation in multiuser OFDM systems with proportional rate constraints," IEEETrans. Wireless Commun., vol. 4, no. 6, pp. 2726–2737, 2005.
16. G. Song and Y. Li, "Cross-layer optimization for OFDM wireless networks—part I: theoretical framework," IEEE Trans. Wireless Commun., vol. 4, no. 2, pp. 614–624, 2005.
17. "Cross-layer optimization for OFDM wireless networks—part II: algorithm development," IEEE Trans. Wireless Commun., vol. 4, no. 2, pp. 625–634, 2005.
18. M. Mehrjoo, S. Moazeni, and X. Shen, "Resource allocation in OFDMA networks based on interior point methods," Wireless Commun. MobileComput., vol. 10, no. 11, pp. 1493–1508, 2010.
19. L.-L. Xie and P. Kumar, "An achievable rate for the multiple-level relay channel," IEEE Trans. Inf. Theory, vol. 51, no. 4, pp. 1348–1358, 2005.
20. X. Zhang, Z. Zheng, J. Liu, X. Shen, and L.-L. Xie, "Optimal power allocation and AP deployment in green wireless cooperative communications," in Proc. 2012 IEEE Globecom.
21. T. Cover and J. Thomas, Elements of Information Theory. John Wiley& Sons, 2006.

AUTHORS PROFILE

Dr.R.Raja Kumar completed his post-graduation in Mathematics in 1991 from ManonmaniamSundaranar University. He received his Ph.D from Sathyabama University in the interdisciplinary domain of Chaotic Communications in 2013. He is working as a Professor in Sathyabama Institute of Science and Technology (formerly Sathyabama University) from 2013 onwards. He has a total of 28 years of teaching experience.

Dr.R.Pandian is currently working as an Associate Professor in the Department of Electronics and Instrumentation Engineering at Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India. He has graduated from Madras University, Chennai in 1999 with Bachelor's Degree in Electrical and Electronics Engineering. He has obtained his M.E Degree in Applied Electronics from Anna University, Chennai2007. He has obtained his Ph.D from Sathyabama Institute of Science and Technology, Chennai, Tamil Nadu, India. He has gained a teaching experience of more than 16 years. His research interests are Image Processing and Neural Network. He has published papers more than twenty five papers in SCI and Scopus Journals.

Dr.P.Indumathi obtained her Bachelor of Engineering degree in Electronics and Communication Engineering in 1989 from Anna University. She completed her Master of Engineering in Communication Systems in 1994 from Anna University. She obtained her Ph.D from Anna university in 2007 from Asynchronous Transfer Mode Networks. She is passionate about Communications. Currently she is a Professor in Electronics Engineering in MIT Campus of Anna University. As of now, she has 23 years of teaching experience.

JyotirmayeeSubudhi obtained her BTechin ECE and MTechin VLSI Design in 2012 and 2015 respectively. She is currently pursuing the Ph.D. degree in information and communication engineering with Anna University. Her current research interests include 5G, non-orthogonal multiple access and MIMO. She has special interest on Mathematics behind many communication principles.