ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 13, March 2016

Mitigation of Channel Interference for Femtocell Architectured Wireless Mesh Network

J.Monica Steffy
Department of Electronics and Communication Engineering
Karunya University
Coimbatore, India
monicasteffy1993@gmail.com

E.Lilli Malarvizhi
Department of Electronics and Communication Engineering
Karunya University
Coimbatore, India
lilly@karunya.edu

Abstract—**To mitigate the femtocell channel interference in the mesh network, OFDM-Reservation random access(OFDM-RR) protocol is used. During channel allocation in a network, a tie on the highest index is treated as a collision and is resolved by repeating the collision resolution process. In this process, collision is avoided and throughput gets increased. Although the OFDM-RR can improve the throughput, it suffers from the fairness issue. This problem can be overcome by Selective Packet Discarding (SPD) method, which is taken as a future work.**

Keywords—**OFDM-RR protocol, Multiple access interface, Collision resolution process.**

I. Introduction

Wireless mesh networks, an upcoming technology, which brings the idea of a logically connected world into a realistic one. Wireless mesh networks can energetically connect the full cities using low-priced and available technology.

The major advantage of wireless mesh networks which differs from wired or the fixed wireless networks is that they are wireless in truth. Most popular “wireless” access points still have to be wired to the internet to broadcast their signal. For vast wireless networks, Ethernet cables have to be hidden in ceilings and walls and throughout public areas.

A. FEMTOCELL

The requirement for greater data rates and expanded spectral efficiencies is urging the future generation broadband access networks towards extending smaller cell structures known as femtocells with orthogonal frequency division multiple access (OFDMA)[1]. Femtocells are connected indoors for example, company and homes, and use the small spectrum and approach technology as macro-cells (long established cell towers), while bridging to the root network through cable or DSR backhaul. The low cellular signal problem indoors, experienced by many users nowadays, can easily be overthrown by femtocells. Furthermore, with the help of femtocells, we can save the energy and high data rates by transmitting to a neighbor femtocell rather than a far cell towers, using the 4G enabled mobile phones. In addition the limited area of femtocells increases the cellular network capacity along increased spatial reuse. These merits grant mobile broadband service providers to: 1) increase coverage and service quality, and 2) misguide the traffic from macro-cells to femtocells in a cost-efficient manner.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 13, March 2016

To harness the aforementioned benefits in practice, one first needs to mitigate the interference that occurs in femtocell networks.Althoughpreviousstudies(e.g.,[2])haveproposed solutions to alleviate the interference between macrocells and femtocells, interference mitigation between collocated femtocells has not drawn considerable attention and thus forms the focus of this work. However, the design of a resource management solution for femtocells is complicated by the fact that the femtocells have to interoperate with the cellular standards that they inheritfrommacrocells.Thereareseveralotherkeyaspectsthat make the resource management problem both challenging and unique.

1) Operating mode

Femtocells are provided by a wireless service providers to their customers. A femtocell is mostly the size of a residential gateway or tinier and connects to the users broadband line. Unified femtocells which consists both a DSL router and femtocells also survive. Once connected, the femtocell bridges to the MNO's mobile network and affords extra coverage. From a user's aspect, it is plug and play, there is no individual installation or specific knowledge needed, anybody can install a femtocell at home.Various technical challenges towards mass deployment of femtocells have been addressed. Interference mitigation between neighboring femtocells and between the femtocell and macro- cell is considered to be one of the major challenges in femtocell networks because femtocells share the same licensed frequency spectrum with macrocell. We provide a survey of the different state-of-the-art approaches for interference and resource management in orthogonal frequency division multiple access (OFDMA) based femtocell networks. A qualitative comparison among the different approaches is provided[3]. Thus, femtocells could be viewed as a promising option for next generation wireless communication networks such as OFDMA-based LTE-Advanced and WiMAX networks.With efficient interference management schemes, the network capacity and coverage can be increased that benefit both the subscribers and the operators.

2) Air Interface

Although much of the commercial focus seems to have been on UMTS, the concept is equally applicable to all air-interfaces. Indeed, the first commercial deployment was the cdma 2000 Airave in 2007 by Sprint.Femtocells are also under development or commercially available for GSM, TD-SCDMA, WiMAX and LTE. [4]To mitigate the interference, they proposed a distributed and self-organizing femtocell management architecture, called the Complementary TRi-control Loops (CTRL), that consists of three control loops to determine (1) maximum transmit power of femtocell users based on the fed- back macrocell load margin for protection of the macrocell uplink communications; (2) target signal to interference plus noise ratios (SINRs) of femtocell users to reach a Nash equilibrium; and (3) instantaneous transmit power of femtocell users to achieve the target SINRs against bursty interference from other nearby users. Also, CTRL guarantees convergence in the presence of environmental changes and delayed feedback.

3) Issues

Femtocells are a complicated technology and there have been a number of issues and concerns, although as deployments have increased these have largely been addressed.

4) Interference

The placement of a femtocell has a critical effect on the performance of the wider network, and this is the key issue to be addressed for successful deployment. Because femtocells can use the same frequency bands as the conventional cellular network, there has been the worry that rather than improving the situation they could potentially cause problems.Femtocells incorporate interference mitigation techniques detecting macrocells, adjusting powerand scrambling codes accordingly.

B. OFDM-Reservation Random (OFDM-RR)

The frequency-domain back-off idea is generalized into a robust Reservation Random Access (OFDM-RR) protocol. The key extension consists of allowing a variable number of contention rounds for reservation which guarantee subsequent collision-free data transmission. Although it is applicable to any slotted OFDM wireless system, we propose the OFDM-RR protocol for resolving inter-cell interference in a dense network of OFDMA femtocells with bursty traffic patterns.

II. PROPOSED METHOD

A. Random Access Protocol

The proposed OFDM-based Reservation Random Access (OFDM-RR) MAC protocol is suitable for any

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 13, March 2016

synchronized OFDM wireless network that provides a reliable feedback con- trol channel from the receiver to the transmitter. Specifically, it can be used to mitigate inter-cell interference in dense networks of OFDMA femtocells such as 3GPP LTE home base stations (Home eNB) [2]. In the following, we will describe our proposed random access algorithm in a generic OFDMA-based femtocell network.

1) Protocol Description

Considered a cluster of co-located OFDMA femtocells each serving a single User Equipment (UE).

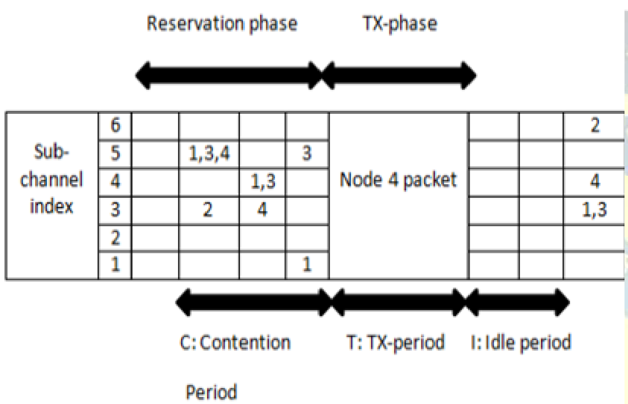

Fig: 1 OFDM-RR Protocol

The channel is divided into K sub-channels and time is divided into equal slots. Fig. 1 illustrates an example of OFDM-RR with N = 4 femtocells and K = 6 sub-channels. In the first attempt, the random values of the sub-channel index k picked by femtocells 1 to 4 is (5, 3, 5, 5) respectively. In this round, the highest occupied sub-channel index (kmax = 5) was selected by femtocells 1, 3, and 4, hence a collision occur and the three femtocells continue to the next round while femtocell 2 quits. In the second round, femtocells 1 and 3 collide on the highest occupied sub-channel index so they proceed to a third round. In the third round, the highest occupied sub-channel index (kmax = 5) was selected by exactly one femtocell, thus the reservation is successfully established for femtocell 3. After the transmission of femtocell 3's packet, the reservation process restarts again and we see that femtocell 2 was able to reserve the channel from the first attempt. Clearly, the number of rounds needed to resolve the conflict is a random variable that depends on the network load and the degree of channelization K.

B. Project Flow Diagram

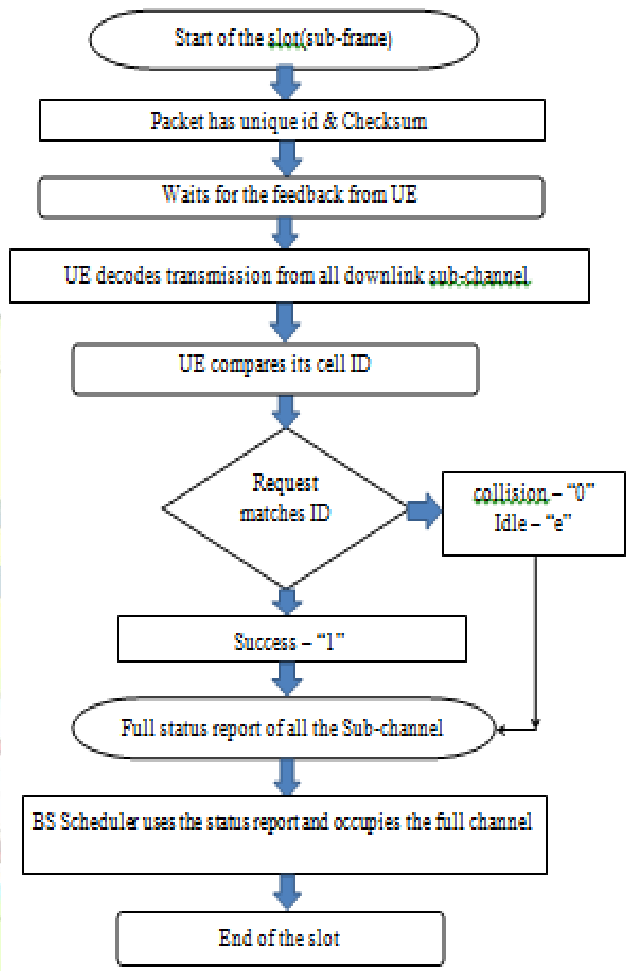

Fig: 2 Flow Diagram for Channel Allocation

At the start of the slot (sub-frame), the BS scheduler creates and transmits a reservation request containing a unique cell ID and a checksum on one of the K sub-channels and awaits for the feedback from the UE on the PUCCH. The UE tries to decode any transmission on all K downlink sub-channels. If a sub-channel contains a valid reservation request (i.e., with a correct checksum), the UE compares the cell ID in the request with its locally stored cell ID. If the request matches its cell ID, then the status of this sub-channel is "success." Otherwise, if the checksum fails or the request is valid but contains another Cell's ID, then the sub-channel status is "error." If nothing is detected on the sub- channel, the status is reported as "idle." The UE then transmits the full status report of all K sub-channels to its BS using the PUCCH. The BS scheduler then uses the status report to determine the result of the reservation attempt by comparing its rank with other nodes as explained above. If this BS wins the reservation, it then occupies the full channel for a fixed number of slots (data transmission phase).

III. THROUGHPUT ANALYSIS

We will now analyze the performance of the proposed OFDM-RR protocol in terms of the maximum MAC throughput.

A. System Model

We model the femtocell cluster in a group of N wireless links belonging to a single collision domain, which means all transmissions in the group interfere with each other. Each link consists of a transmit-receive pair, i.e., a BS serving a single user.A single wireless channel of bandwidth W is shared among all cells, where channel access is determined using the reservation-based random access protocol. Each transmitting node first attempts to reserve the channel by sending a short reservation packet of size m bits; the successful node then transmits the data packet for T seconds without any collision. The data packet size M is fixed and is assumed to be an integer multiple of the reservation packet size. Time is slotted and we assume all transmissions are synchronized to the beginning of each slot. The slot size is taken to be the transmission time of the reservation packet over the whole channel.

In extending this "canonical" scheme to the case of OFDM-RR where the channel is divided into many sub-channels, we require that each node receives a ternary feedback {0, 1, e} report per sub-channel at the end of the slot. This is necessary for the node to determine its "rank" among contending nodes. If the sub-channel chosen by the node has a "success" (1) status and all higher order sub-channels have an "idle" (0) status, then the reservation is successful. If the chosen sub-channel has a "collision" (e) status and all higher-order sub-channels are idle, then the node can retry the reservation request in the next slot. In all other cases, the node stops the reservation attempt, but continues to monitor the channel until it becomes idle, indicating the end of a packet transmission and the start of a new reservation cycle.

B. Throughput of OFDM-RR

In OFDM-RR, the channel time can also be viewed as a sequence of reservation and transmission cycles. Since nodes transmit their reservation requests with probability p, some slots may remain idle if no requests are transmitted. Once a request or more is transmitted, the channel becomes busy until contention is resolved and a data packet is transmitted. Therefore, the reservation cycle consists of two periods: an Idle period followed by a Contention period. Let I = 0,1,... and C = 1,2,... be the number of slots in the Idle period and the Contention period respectively. The random variable I is geometrically distributed with mean (1−q)/q where q is the probability of at least one reservation attempt in a slot. In terms of the slot size τ, we have:

$$E[I]=1-q\ q\times\tau$$

$$=(1-p)N\ 1-(1-p)N\times\tau.$$

IV. RESULT ANALYSIS

In this section, we evaluate the performance of the proposed OFDM-RR technique based on the aforementioned performance metrics. For this purpose, simulation experiments have been conducted using NS-2(Network Simulator-2).

A. Packet delivery ratio :

The ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

∑ Number of packet receive / ∑ Number of packet send

The greater value of packet delivery ratio means the better performance of the protocol.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 13, March 2016

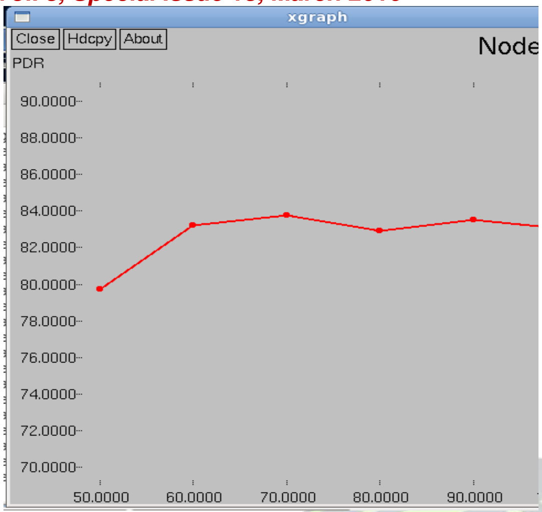

Fig: 3 Analysis of Packet Delivery Ratio

B. Delay

The average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

$\sum$ (arrive time – send time) / $\sum$ Number of connections

The lower value of end to end delay means the better performance of the protocol.

Packet Lost : the total number of packets dropped during the simulation.

Packet lost = Number of packet send – Number of packet received .

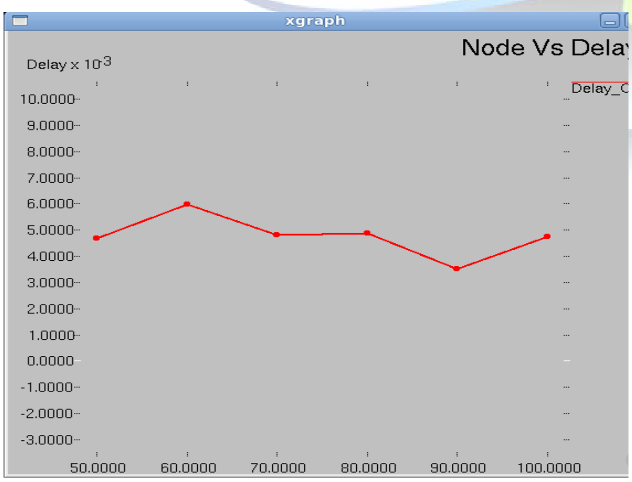

Fig: 4 Analysis of Delay

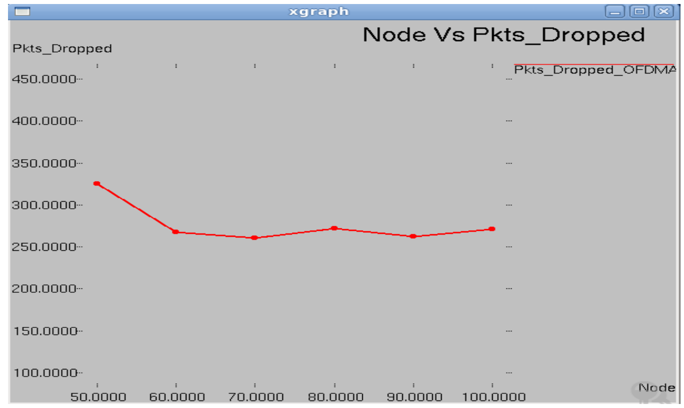

Fig: 5 Analysis of Packets Dropped

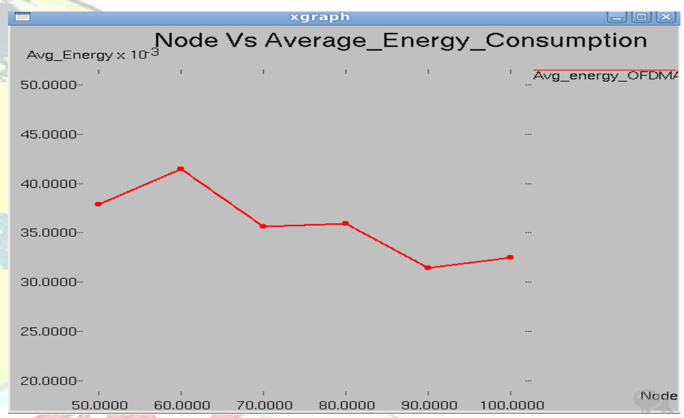

Fig:6 Analysis of Average Energy Consumption

C. Throughput

Throughput is the number of successfully received packets in a unit time and it is represented in bps. Throughput is calculated using awk script which processes the trace file and produces the result.

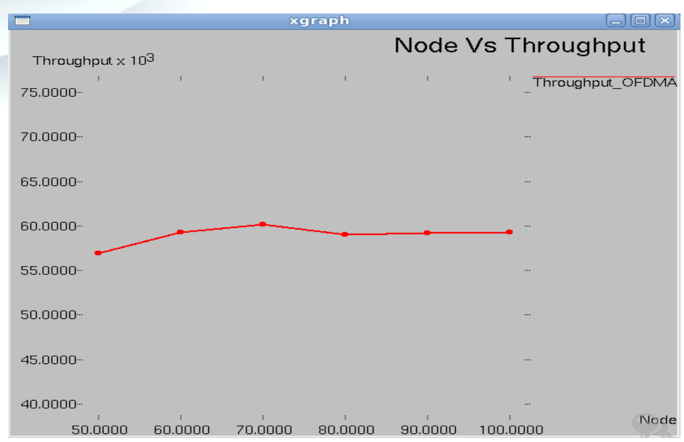

Fig: 7 Analysis of Throughput

V. CONCLUSION

Frequency-domain backoff is a novel idea proposed to replace the time-based backoff procedure in the IEEE 802.11 random access protocol with the goal of reducing channel access delay. We extended this idea into a more general OFDM based Reservation Random access (OFDM-RR) protocol and described how it can be used to mitigate inter-cell interference in dense networks of OFDMA femtocells such as LTE Home eNBs. Then, we derived its throughput in terms of the network load, packet size and the number of sub-channels. Channelization increases the transmission time of the reservation packet in OFDM-RR (due to the smaller sub- channel bandwidth), the collision resolution mechanism which reduces the collision rate sharply helps improve the throughput especially in the high load region. We proved that OFDM-RR is superior to the other techniques and derived the critical value of the network load beyond which the proposed protocol significantly improves the system throughput.The fairness issue can be overcome by the Selective Discarding Packet method which is enhanced for the future work.

VI. REFERENCES

[1] R. V. Nee and R. Prasad, OFDM for Wireless Multimedia Communi- cations. Norwood, MA: Artech House, 2000.

[2] D. Lopez-Perez, G. Roche, A. Valcarce, A. Juttner, and J. Zhang, “In- terference avoidance and dynamic frequency planning for WiMAX femtocells networks,” in Proc. IEEE ICCS, 2008, pp. 1579–1584.

[3] Nazmus Saquib, Ekram Hossain, Long Bao Le, and Dong In Kim for “Interference Management in OFDMA Femtocell Networks: Issues and Approaches,”in IEEE Wireless Communication, July2012.

[4] J.Weitzen, M.Li, E.Anderland, and V.Eyuboglu, “Large-scale deployment of residential small cells,” Proc. IEEE, vol. 101, no. 11, pp. 2367– 2380, Nov. 2013.

[5] N. Saquib, E. Hossain, L. B. Le, and D. I. Kim, “Interference management in OFDMA femtocell networks: Issues and approaches,” IEEE Wireless Commun., vol. 19, no. 3, pp. 86–95, Jun. 2012.

[6] T. Zahir, K. Arshad, A. Nakata, and K. Moessner, “Interference manage- ment in femtocells,” IEEE Commun. Surveys Tuts., vol. 15, no. 1, pp. 293– 311, 2013.

[7] J. G. Andrews, H. Claussen, M. Dohler, S. Rangan, and M. C. Reed, “Femtocells: Past, Present, and Future,” IEEE J. Sel. Areas Commun., vol. 30, no. 3, pp. 497–508, Apr. 2012

[8] A. Mutairi and S. Roy, “The Case for Random Access in OFDMA Fem- tocells,” IEEE Wireless Commun., vol. 20, no. 5, pp. 4–4, Oct. 2013.

[9] W. Crowther, R. Rettberg, D. Walden, S. Ornstein, and F. Heart, “A system for broadcast communication: Reservation-ALOHA,” in Proc. 6th Hawaii Int. Conf. Syst. Sci., Jan. 1973, pp. 596–603.

[10] S. Sen, R. R. Choudhury, and S. Nelakuditi, “No time to countdown: Migrating backoff to the frequency domain,” in Proc. 17th Ann. Int. Conf. MobiCom, 2011, pp. 241–252.

[11] E. Dahlman, S. Parkval, J. Skold, and P. Beming, 4G: LTE/LTE-Advanced for Mobile Broadband, 2nd ed. London, U.K.: Academic,2014.