ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 2, February 2013

Energy - Effectual Strategies for Conjunctive Multichannel MAC Protocols

B. Sunil Kumar[1], P. SivaChandrika[2], A. Shiva Kumar[3], K. Srinivasulu[4]

Assistant Professor, IT, GPCET, Kurnool, India[1]

IV B.Tech II Sem, IT, GPCET, Kurnool, India [2, 3, 4]

ABSTRACT - **This paper presents the energy efficient strategies and the importance of Altruistic approach in the absence of nearest neighboring nodes to the receiver. Two energy-efficient strategies are proposed: in-situ energy conscious DISH, which uses existing nodes only, and altruistic DISH, which requires additional nodes called altruists. Generally comparison is done with five protocols with respect to these strategies and identifies altruistic DISH to be the right choice in general: it 1) conserves 40-80 percent of energy, 2) maintains the throughput advantage, and 3) more than doubles the cost efficiency compared to protocols without this strategy. On the other hand, our study also shows that in-situ energy conscious DISH is suitable only in certain limited scenarios. a new notion of cooperation was proposed to solve multi-channel coordination problems. When a transmit-receive pair wishes to initiate communication, neighboring nodes share their knowledge of channel usage. This helps to substantially reduce collisions and increases throughput significantly. However, it comes at the cost of increased energy consumption since idle nodes have to stay awake to overhear and acquire channel usage information. In fact this can be as high as 264% of a power-saving protocol without cooperation. The core idea is to introduce specialized nodes called altruists in the network whose only role is to acquire and share channel usage information. All other nodes, termed peers, go in to the sleep mode when idle. This strategy seems naïve because it needs additional nodes to be deployed.**

Keywords: Cooperation, Energy Efficiency, MAC Protocol, Multi-Channel, in-situ energy conscious DISH, wireless ad hoc networks

I. INTRODUCTION

The main challenge to multi-channel MAC protocol design for ad hoc networks is a multi-channel coordination problem. It consists of a channel conflict problem, caused by a node (unintentionally) selecting a busy channel for data transmission, and a deaf terminal problem, caused by a node initiating communication with another node which is however on a different channel. The first sub problem results in packet collision and the second leads to unnecessary retransmissions. The mainstream of proposed solutions uses either multiple transceivers or time synchronization to address the problem, but it clearly increases cost, overhead and complexity. Recently, Luo et al. introduced a new notion of cooperation and thereby propose a cooperative multi-channel MAC protocol called CAM-MAC. Unlike in traditional MAC protocols nodes making decisions independently, in CAM-MAC idle neighbors actively aid transmit-receive pairs in selecting correct channels and avoiding deaf terminals. The protocol uses a single transceiver and is fully asynchronous, and demonstrates significant throughput advantages. In particular, it substantially outperforms three recent and representative multi-channel MAC protocols, MMAC, SSCH, and AMCP. However, we point out that the performance gain comes at the cost of significant energy consumption. In order to cooperate, nodes have to stay awake during idle periods in order to gather and share channel usage information, which prevents them from sleeping to save energy. We evaluated this via simulations in a single-hop network, comparing it with a power-saving protocol without cooperation. We found that, when there are 40 nodes forming 20 disjoint source destination pairs and each source generates traffic at 160kbps, the cooperative protocol consumes energy as high as 264% of the power-saving uncooperative protocol. This motivates the need of designing energy efficient strategies for cooperative protocols, however it is even more difficult than for traditional protocols, because (i) the prerequisite of cooperation is information gathering which can be done only when nodes are awake, and (ii) extra energy has to be spent on transmitting/receiving cooperative messages. In this paper, we propose a strategy called altruistic cooperation which is a simple solution to this challenging problem. The key idea is to introduce additional nodes called altruists, whose only role is to cooperate but not carry traffic. These altruists always stay awake so that existing nodes can sleep when idle. This strategy seems naive since it uses additional resources to improve performance. In fact it is unclear whether (i) the total energy can be conserved, (ii) throughput will be compromised, and (iii) the increased network cost will pay off.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 2, February 2013

II. MEDIA ACCESS CONTROL

Media access control is an essential part of the wireless communication stack and it has obtained intensive research attention. More recently, to achieve higher communication throughput, multi-channel MAC has been studied. This paper focuses on how to incorporate both the advantages of multiple channels and TDMA into the MAC design with low overhead, when each node in the network is only equipped with a single half-duplex radio transceiver. Such hardware can not transmit and receive at the same time, but it can switch its frequency dynamically.

Many of the previous multi-channel MAC designs require multiple radio transceivers. Multiple radios not only result in higher product prices, but also consume more power from energy-constrained devices. Plus, most current IEEE 802.11 devices are equipped with a single half-duplex radio transceiver. Therefore, it is important to devise an energy efficient multi-channel MAC protocol based on a single half-duplex transceiver. In this single transceiver context, conventional multichannel MAC designs adopt explicit frequency negotiation, through certain kinds of control messages.

III. ENERGY-EFFICIENT STRATEGIES

The main challenge to achieving energy efficiency for DISH is that a prerequisite of information sharing is information gathering, a process that requires nodes to stay awake for overhearing, which presents a challenge for nodes to switch off radio when idle. The strategies we elaborate below meet this challenge.

In-Situ Energy Conscious DISH

In this strategy, all the existing nodes rotate the responsibility of information sharing (i.e., cooperation) such that nodes without the responsibility can sleep when idle. There are two methods to implement this strategy:

. Probabilistic method: Each node decides whether to cooperate or not according to a (static or dynamic) probability. This is similar to probabilistic flooding, and probabilistic routing in ad hoc networks, and cluster-head rotating algorithms (e.g., LEACH and HEED) in sensor networks.

. Voting method: nodes periodically vote or elect a subset of nodes to cooperate. This is similar to GAF, Span, PANEL, and VCA. An apparent advantage of the in-situ strategy is that it does not require additional nodes. On the other hand, a runtime probabilistic or voting mechanism must be introduced and must be 1) distributed, 2) fair (in terms of energy consumption), and 3) adaptive (to network dynamics such as traffic and energy drainage). These would introduce considerable complexity and overhead. In addition, it has to consider other factors as listed below. However, broadcasting in a multichannel environment is shown by So et al to be very unreliable and difficult because each broadcast can reach only a subset of neighboring nodes. Alternatively, broadcasts might be reduced or avoided by determining cooperative nodes based on geographic information. However, this requires expensive GPS support or a distributed localization algorithm which introduces additional overhead and complexity to those incurred by rotation itself. Second, rotating the responsibility of cooperation also involves other resource-consuming factors including two-hop neighbor discovery and the assessment of dynamic information (such as energy and traffic. Third, how to integrate a probabilistic or voting mechanism into a legacy DISH protocol is a nontrivial problem and a viable solution is yet to be found. In summary, the complexity, overhead, and unreliability of in-situ energy conscious DISH would consume considerable resource and eventually negate its possible performance gain.

Altruistic DISH

In this strategy, additional nodes called altruists are deployed to take over the responsibility of information sharing (i.e., cooperation) from the existing nodes, which we call peers to distinguish from altruists, so that peers can sleep when idle. Altruists are the same as peers in terms of hardware, but are different in terms of software: they solely cooperate (do not carry data traffic) and always stay awake. An apparent drawback of this strategy is that it requires additional nodes. However, this is offset by substantive advantages. First, it is very simple to implement the strategy: one only needs to introduce a Boolean flag to disable data related functions on altruists and cooperation related functions on peers. We have done this in both our simulation code and hardware implementation code. Equally importantly, there is no additional runtime mechanism and hence runtime overhead. Second, unlike the in-situ strategy, this strategy does not have the multichannel broadcasting problem. Altruists always stay on the same channel (control channel) and send/receive packets only on the control channel. Third, this strategy is robust to network dynamics (such as traffic and residual energy).

Every altruist is cooperative and will react to every MCC problem that it identifies; they do not need to adjust any parameter on the fly. In fact, even the deployment of altruists, which is an offline process, can be done with a constant number for any given peer density since peers only carry data traffic and need not to cooperate, they are like nodes in traditional (non-DISH) networks and thus can adopt a legacy sleep-wake scheduling algorithm, where a lot of choices are available. Finally, unlike the in-situ strategy and the original DISH where cooperation is provided in an opportunistic manner—meaning that cooperative nodes are not always available, altruistic DISH provides cooperation in a guaranteed manner.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 2, February 2013

IV. INTRODUCTION TO DISH

Various design approaches have been proposed in thelast decade or so, but most of them require either multiple radios or time synchronization. Recently, Luo et al proposed a distinct approach called Distributed Information SHaring (DISH), which uses a single radio but operates asynchronously. The authors designed a DISH-based protocol called CAM-MAC, in which neighboring nodes share control information with each sender-receiver pair to facilitate it to choose collision-free channels or to avoid busy receivers. DISH is essentially a form of node cooperation, but the key difference is that, in traditional cooperation, intermediate nodes help relay data for source and destination nodes, but DISH, on the other hand, only requires control information to be sent. Therefore, the former can be called data-plane cooperation and the latter can be called control-plane cooperation.

V. NETWORK DEPLOYMENT

Consider a random network with peers distributed on a plane according to a 2D Poisson point process, the question is to determine the density of altruists to be deployed, ρ_{alt}, in order to guarantee a certain cooperation coverage, p_{cov} (say 90%).

Denote by p^{cov}_{ij} the probability that an arbitrary UP (i, j) is covered (i.e., is a CUP). By Definition 1, p^{cov}_{ij} is equivalent to the probability that there is at least one altruist in the common radio range of i and j, which is given by

$$p^{cov}_{ij} = 1 - e^{-\rho alt Aij}, \qquad (1)$$

where A_{ij} is the intersected area of i and j's radio ranges.

The problem is equivalent to guaranteeing $p^{cov}_{ij} >$ pcov for all UPs (i, j), hence we have

$$\min(i,j)\ p^{cov}_{ij} > p_{cov}. \qquad (2)$$

By determining the minimum we can finally obtain

$$\rho_{alt} > -\frac{\ln(1-p_{cov})}{(\frac{2\pi}{3}-\frac{\sqrt{3}}{2})r^2} \qquad (3)$$

Inequality (3) gives the lower bound to the altruist density that guarantees a cooperation coverage of pcov. We provide typical values in Table 1, where the unit of density is r−2.

Table 1: Altruist Density versus Cooperation Coverage

p_{cov}	50%	60%	70%	80%	90%	95%	99%
$\rho_{alt} >$	0.56	0.75	0.98	1.31	1.87	2.44	3.75

A judicious choice of altruist density is a key to the performance of altruistic cooperation. We conduct simulations in multi-hop networks and vary altruist density from $0.56/r^2$ to $3.75/r^2$, which corresponds to a cooperation coverage from 50% to 99% as indicated in Table 2. Two peer densities are considered: $10/r^2$ and $20/r^2$, which amount to 360 and 720 peers in a network, respectively. The traffic generation rate at each peer is 25kbps.

The results are shown in Fig. 1. We observe the following: in Fig. 1(a), both curves level off at the altruist density of around $1.36/r^2$, while in Fig. 1(b), both curves have a minimum also at around $1.36/r^2$. This suggests that an optimal throughput-energy trade-off can be achieved within the range of $1.3–2/r^2$.

VI. COST EFFICIENCY

Cost efficiency is important from a system design perspective.To evaluate it, we propose a metric called *bit-price ratio*(BPR), which captures the trade-off among three critical factors:network throughput, lifetime, and cost. This metric is defined as

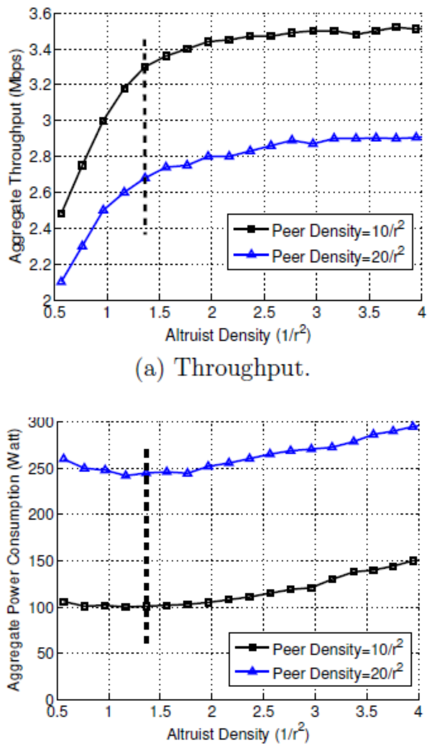
$$BPR \triangleq \frac{S}{(N_p + N_p).\max(P_p^{max}.P_a^{max})}$$

where S is aggregate network throughput, N_p and N_a are the total number of peers and altruists, respectively,P_ρ^{max} and P_α^{max} are the maximum power consumption among all peers and all altruists, respectively.

BPR can be understood as Throughput×Lifetime/Cost, which gives the amount of data that can be delivered by a network throughout its operational time, normalized by available system resources. The lifetime is defined as the period from the start of network operation until the first node runs out of battery. For networks without altruists, simply set Na = 0 and $P^{max}{}_a = 0$.

BPR allows for a fair comparison of cost efficiency across different protocols. We compute BPR for different protocols via simulations in multi-hop networks, where for altruistic cooperation,

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 2, February 2013



(a) Throughput.

(b) Energy consumption.

Figure 1: Multi-hop performance versus altruist density.

Table 2: BPR Comparison

Peer Density $(1/r^2)$	5	10	20	30
BPR_{Auto}	22.3	9.32	3.8	2.26
$BPR_{AutoPSM}$	33	10.9	4.1	2.7
$BPR_{InSituCoop}$	22.5	14.8	6	3.77
$BPR_{AltCoop}$	42.4	31.2	10.9	5

we deploy altruists with a density of $1.31/r^2$ based on the suggestion from network deployment ($1.3–2/r^2$), which corresponds to a cooperation coverage of 80%. Traffic generation rate is 25kbps.

VII. PERFORMANCE EVALUATION

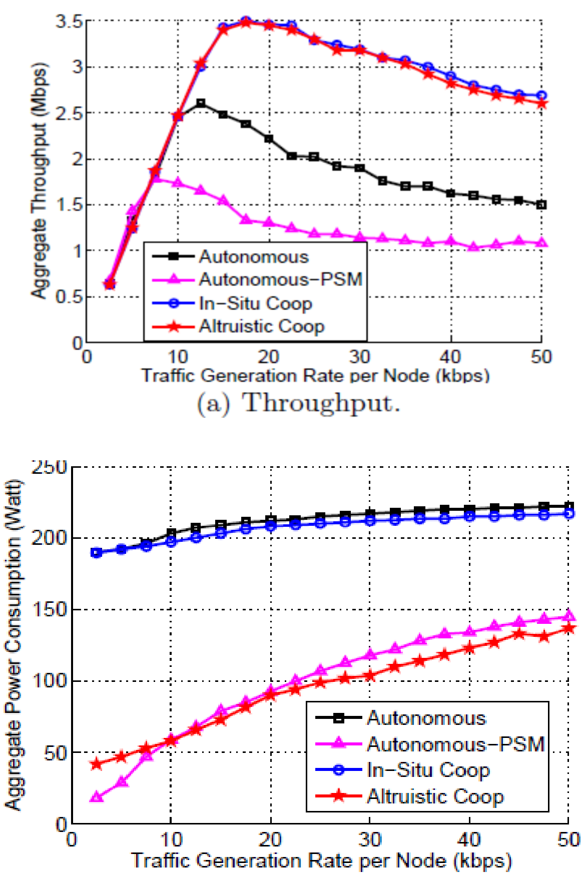
We evaluate performance of all the four schemes they are (a) carry traffic, (b) gather information, and (c) share information. Here information means channel usage information. Based on this, we classify nodes into two categories: (i) peers are existing nodes whose role is to carry traffic, and can optionally take the other two roles, and (ii) altruists are additional nodes whose only role is information gathering and sharing. Table 3 shows that different role assignments combined with the choice of using the power saving mode lead to different schemes. in multi-Hop networks.

Table 3: Roles Assignment

Schemes	Traffic	Gather	Share	PSM
Auto-PSM	peer	×	×	✓
Autonomous	peer	peer	×	×
In-situ Coop	peer	peer	peer	×
Altruistic Coop	peer	altruist	altruist	peer

Peer density is $10/r^2$, and for altruistic cooperation, altruist density is set to be $1.31/r^2$, as used in Section 4. From the throughput shown in Fig. 2(a), we observe clear gaps among the schemes.

The gap between autonomous and autonomous-PSM is because of the role of information gathering, and the gap between the cooperative schemes and the autonomous scheme is because of the role of information sharing which is introduced by cooperation. More importantly, we see that altruistic cooperation does not sacrifice throughput in comparison to in-situ cooperation.



(a) Throughput.

(b) Energy consumption.

Figure 2: Multi-hop network performance.

At the traffic generation rate of 20kbps, altruistic cooperation uses power of only 39% of both in-situ cooperation and the autonomous scheme. Furthermore, altruistic cooperation even slightly outperforms autonomous-PSM under higher traffic load. This is because, although altruists incur added energy drain, they help avoid a large number of retransmissions caused by multi-channel coordination problems.

VIII. CONCLUSION

Distributed information sharing can significantly boost the system throughput for multichannel MAC protocols, but it also heighten the energy consumption due to its information sharing component (which subsumes information gathering). In this paper, we propose two energy-efficient strategies and conduct a comparative study on five protocols that differ in the usage of DISH and the strategies.

This paper explains the effective energy conservation by the proposed two effective energy strategies: in-situ energy conscious DISH, which uses existing nodes only, and altruistic DISH, which requires additional nodes called altruists. But with the energy conservation the cost is increasing by 2 times and there is a scope to reduce the cost.

Acknowledgment

We would like to express our heartfelt thanks to **Almighty**. We (P.SivaChnadrika, A.Shiva Kumar, K.Srinivasulu) take immense pleasure to express our deep sense of gratitude to our beloved **Mr. B.Sunil Kumar**, Assistant Professor, Department of IT, G.Pullaiah College of Engineering and Technology for his guidance and suggestions, keen interest and thoroughly encouragement extended throughout period in the preparation of this journal paper. We (A.Shiva Kumar, K.Srinivasulu) would like to express our heartfelt thank to **P.SivaChandrika** (B.Tech), G.Pullaiah College of Engineering and Technology, Kurnool for her dedications towards work in the completion of this journal preparation. I (P.SivaChandrika) would like to express my heartfelt thanks to my beloved **Parents** for their cooperation and help in the successful completion of this journal.

REFERENCES

[1] T. Luo, M. Motani, and V. Srinivasan, "*Altruistic Cooperation for Energy-Efficient Multi-Channel MAC Protocols*," Proc. ACM MobiCom, 2007.

[2] T. Luo, M. Motani, and V. Srinivasan, "*Cooperative Asynchronous Multichannel MAC: Design, Analysis, and Implementation*," IEEE Trans. Mobile Computing, vol. 8, no. 3, pp. 338-352, Mar. 2009.

[3] S.-L. Wu, C.-Y. Lin, Y.-C. Tseng, and J.-P. Sheu, "*A New Multi-Channel MAC Protocol with On-Demand Channel Assignment for Multi-Hop Mobile Ad Hoc Networks*," Proc. Int'l Symp. Parallel Architectures, Algorithms and Networks (I-SPAN), 2000.

[4] A. Nasipuri, J. Zhuang, and S.R. Das, "*A Multichannel CSMA MAC Protocol for Multihop Wireless Networks*," Proc. IEEE Wireless Comm. and Networking Conf. (WCNC '99), 1999.

[5] A. Nasipuri and J. Mondhe, "*Multichannel CSMA with Signal Power-Based Channel Selection for Multihop Wireless Networks*," Proc. IEEE Vehicular Technology Conf. (VTC '00), 2000.

[6] N. Jain, S.R. Das, and A. Nasipuri, "*A Multichannel CSMA MAC Protocol with Receiver-Based Channel Selection for MultihopWireless Networks*," Proc. 10th Int'l Conf. Computer Comm. And Networks (ICCCN '01), 2001.

[7] A. Adya, P. Bahl, J. Padhye, and A. Wolman, "*A Multi-Radio Unification Protocol for IEEE 802.11 Wireless Networks*," Proc. First Int'l Conf. Broadband Networks (Broadnets '04), 2004.

[8] R. Maheshwari, H. Gupta, and S.R. Das, "*Multichannel MAC Protocols for Wireless Networks*," Proc. IEEE Third Ann. Comm. Soc. Sensor and Ad Hoc Comm. and Networks (SECON '06), 2006.

[9] J. Chen, S. Sheu, and C. Yang, "*A New Multichannel Access Protocol for IEEE 802.11 Ad Hoc Wireless LANs*," Proc. IEEE 14th Personal, Indoor and Mobile Radio Comm. (PIMRC '03), 2003.

[10] J. So and N. Vaidya, "*Multi-Channel MAC for Ad Hoc Networks: Handling Multi-Channel Hidden Terminals Using a Single Transceiver*," Proc. ACM MobiHoc, 2004.

[11] P. Bahl, R. Chandra, and J. Dunagan, "*SSCH: Slotted Seeded Channel Hopping for Capacity Improvement in IEEE 802.11 Ad-Hoc Wireless Networks*," Proc. ACM MobiCom, 2004.

[12] H.-S. W. So, G. Nguyen, and J. Walrand, "*Practical Synchronization Techniques for Multi-Channel MAC*," Proc. ACM MobiCom, 2006.

Biography

B.Sunil Kumar received the B.Tech degree in computer science engineering from the RGM College of Engineering and Technology, Kunool, and the M.Tech degree in computer science from the JNTU College of Engineering, Hyderabad. He is currently working as an Assistant Professor in Department of Information Technology in G.Pullaiah College of Engineering and Technology, Kurnool. He has published the papers in 3 International journals and 1 National Conference. He is a Life Member of ISTE.

Patil SivaChandrika is doing her B.Tech final year in Bachelor of Technology in Information Technology in G.Pullaiah College of Engineering and Technology, Kurnool and a Member of CSI.

ISSN (Print) : 2319-5940
ISSN (Online) : 2278-1021
International Journal of Advanced Research in Computer and Communication Engineering
Vol. 2, Issue 2, February 2013

A.Shiva Kumar is doing his B.Tech final year in Bachelor of Technology in Information Technology in G.Pullaiah College of Engineering and Technology, Kurnool and a Member of CSI.

K.Srinivasulu is doing his B.Tech final year in Bachelor of Technology in Information Technology in G.Pullaiah College of Engineering and Technology, Kurnool and a Member of CSI.