Maximization of Throughput in Wireless Powered Communication Networks

Sushama S. Mule
PG Student M B E Society's College of Engineering,
Ambajogai Maharashtra, India

ABSTRACT
This work concentrates the recently developing remote wireless powered communication network in which one hybrid access point (H-AP) with constant power supply coordinates the wireless energy/information transmissions to/from a set of distributed users that do not have other energy sources. A "harvest-then- transmit" procedure is planned where all client first harvest(save) the wireless energy transmit by the H-AP in the downlink(DL) and then send their autonomous information to the HAP in the uplink (UL) by time-division-multiple-access (TDMA).First, we study the sum-throughput maximization of all users by jointly optimizing the time allocation for the DL wireless power transfer versus the users' UL information transmissions given a total time limit based on the users' DL and UL channels as well as their average harvested energy values. By applying convex optimization techniques, we obtain the closed form expressions for the optimal time allocations to maximize the sum-throughput. Our clarification reveals an attractive "doubly-near-far" phenomenon due to both the DL and UL distance dependent signal attenuation, where a far user from the HAP, which receives less wireless energy than a nearer user in the DL, has to transmit with more power in the UL for reliable information transmission. As a result, the maximum sum throughput is revealed to be achieved by allocating significantly more time to the near users than the far users, thus resulting in unfair rate allocation among different users. To overcome this problem, we furthermore propose a new performance metric so called common-throughput with the additional constraint that all users should be allocated with an equal rate regardless of their distances to the H-AP. In this work, We solve the common-throughput maximization problem. Simulation results demonstrate the effectiveness of the common-throughput approach for solving the new doubly near-far problem in communication network.

General Terms
Energy harvesting, Throughput maximization of wireless network.

Keywords
Wireless power, Doubly near-far problem, TDMA, Convex optimization.

1. INTRODUCTION
Specially, radio signals radiated by encompassing transmitters turn into a possible new source for wireless energy harvesting. It has been reported that 3.5mW and 1uW of wireless power can be harvested from radio-frequency (RF) signals at distances of 0.6 and 11 meters, respectively, using Powercast RF energy Harvester operating at 915MHz [1].Furthermore, recent advance in designing highly efficient rectifying antennas will enable more efficient wireless energy harvesting from RF signals in the near future [2]. It is worth noting that there has been recently a growing interest in studying wireless powered communication networks (WPCNs), where energy harvested from ambient RF signals is used to power wireless terminals in the network, e.g., [3]-[5]. In [3], a wireless powered sensor network was investigated, where a mobile charging vehicle moving in the network is employed as the energy transmitter to wirelessly power the sensor nodes. In [4], the wireless powered cellular network was studied in which dedicated power-beacons are deployed in the cellular network to charge mobile terminals. Moreover, the wireless power-driven cognitive radio network has been measured in [5], where active primary users are utilized as energy transmitters for charging their nearby secondary users that are not allowed to transmit over the same channel due to strong interference. furthermore, as radio signals transmit energy as well as information at the equal instant, a joint examination of simultaneous wireless information and power transfer (SWIPT) has recently tense a important attention (see e.g. [6]-[11] and the references therein).Large number of works wireless routing matrices is done in traditional wireless sensor network. In wireless communication network it is significant to cautiously locate the high value path in multi-hop wireless networks, a large number of routing protocols have been proposed for multi hop wireless networks. However, a fundamental problem with existing wireless routing protocols is that minimizing the overall number of transmissions to deliver a single packet from a source node to a destination node does not necessarily maximize the end-to-end throughput. We examine two type of routing protocols, with single-path routing and any path routing. The task of a single-path routing protocol is to select a cost minimizing path, along which the packets are delivered from the source node to the destination node. In spatial reusability of wireless signals weaken in propagation, two links are free of interference if they are far away enough, and thus can transmit at the same time on the same channel. To the best of our knowledge, most of the existing routing protocols do not take spatial reusability of the wireless communication. We consider spatial reusability of wireless sensor network routing using spatial reusability of by single path routing and any path routing media into account. Routing protocols are generally implemented based on transmission cost minimizing routing metrics, they cannot guarantee maximum end-to-end throughput when spatial reusability require to be measured. They need centralized control to realize MAC-layer planning, and to discard transmission contention. The algorithms proposed in this work do not require any scheduling, and the SASR algorithms can be implemented in a distributed manner. Our approach can be extended to adapt to multiple transmission rates, as long as the conflict graph of links can be calculated. Proposed system motivate to simply select the (any) path that minimizes the overall transmission counts or transmission time for delivering a packet.

2. LITERATURE SURVEY

Zungeru et al, presented a radio frequency energy harvesting and management for WSN (wireless sensor network) [1]. Radio Frequency Energy harvesting, using Powercast harvesters to support the limited available energy of wireless sensor networks, and its management using Ant Colony Optimization metaheuristic was adopted, which improves the lifetime of sensor networks.

Micropower energy harvesting [2]. It is use for power management circuit. These circuits worn for rectification and DC–DC conversion are becoming able to efficiently convert the power from these energy harvesters. These circuits solve the problem of node autonomy in sensor networks and also target size and cost reduction of batteries.

On renewable sensor networks with wireless energy transfer proposed in [3].In which wireless energy transfer based on magnetic resonant coupling is a promising technology to reload energy to sensor nodes in a wireless sensor network (WSN). Through jointly optimizing traveling path, flow routing and charging time at each cell. By employing discretization and a novel reformulation-linearization technique.

K. Huang et al, in Enabling wireless power transfer in cellular networks in [4] architecture, modeling and deployment. That present a new network architecture that overlays an uplink cellular network with randomly deployed Power Beacons (PB) for powering mobiles, called a hybrid network. Microwave power transfer (MPT) delivers energy wirelessly from stations called PBs to mobile devices by microwave radiation. This provides mobiles practically infinite battery lives and eliminates the need of power cords and chargers.

K. B. Huang et al, opportunistic wireless energy harvesting in cognitive radio networks. That increase energy and spectrum efficiency demand.[5] To maximize energy efficiency, we proposed a new method with co-existence of primary and secondary transmitters in which low carrier form a secondary network.

R. Zhang and C. K. Ho, both are represented in Mimo broadcasting for simultaneous wireless information and power transfer[8].In this study we investigated the performance limits of promising "wireless-powered" communication networks by means of opportunistic energy harvesting from ambient broadcasting signals or devoted wireless power transfer. Under a simplified three-node setup, our study discovered some fundamental tradeoffs in designing wireless MIMO systems for maximizing the throughput of simultaneous information and energy transmission

J. Broch, D. A. Maltz, D. B. Johnson et.al [12] From the sub graphs , first we allocate all the channel . Then we allocate channel using the Channel Allocation algorithm .The main objective is to balance the number of edges across channels and to reduce the node degrees in each channel. The second involvement is the improvement of network partitioning (i.e. channel allocation) algorithms that produce sub networks with large power regions, while enabling distributed throughput maximization in each of the sub networks. To the best of our knowledge, this is the first attempt to study the algorithmic implications of Local Pooling. In An ad hoc network wireless sensor nodes dynamically forming a network without the use of any existing network infrastructure administration. Which limit communication range of wireless network devices, several networks "hops" may be needed for one node to swap data with another across the network. So existing work proposed, a variety of new routing protocols targeted specifically at this environment have been developed, but little concert information on each protocol and no practical performance comparison between them is existing.

Yong Zeng, Bruno Clerckx, and Rui Zhang et al [19] Communications and Signals Design for Wireless Power Transmission. The study of this paper conclude that an various wireless power transfer (WPT) technology. Such as inductive coupling, magnetic resonant coupling, electromagnetic (EM) radiation, and laser power beaming. At the present time, by the extensive use of portable electronic devices during the past decade, mostly determined by the fast rising market on smart phones, tablets, wearable electronic devices, etc., there is also an ever-increasing interest for powering devices wirelessly. Earlier device are charged by batteries which has limited power storage capacity and that required to be often recharged or replaced. Compared to the conventional battery, wireless charging is a promising choice that is in general more user friendly by eliminating the irritate of connecting cables, more cost-effective by enabling on-demand energy supplies and uninterrupted operations, more environmental preserving by avoiding massive battery disposal, and sometimes essential for applications in which manual battery replacement/recharging is dangerous (e.g., in toxic environment) or even impossible (e.g., for biomedical implants). The input enabler for wireless charging is the advancement of committed wireless power transfer (WPT) technology.

Then, paper focuses on the new communication and signal processing techniques that can be applied to attempt these challenges. Topics discussed include energy harvester modeling, energy beamforming for WPT, channel gaining, power region characterization in multi-user WPT, waveform design with linear and non-linear energy receiver model, safety and health issues of WPT, massive MIMO (multiple-input multiple-output) and millimeter wave (mmWave) enabled WPT, wireless charging control, and wireless power and communication systems co-design. We also point out directions that are promising for future research.

Rui Zhang et al, presented a new type of wireless RF (radio frequency) powered communication network [15] with a harvest then- transmit protocol, where the H-AP first broadcasts wireless energy to distributed users in the downlink and then the users transmit their independent information to the H-AP in the uplink by TDMA.

S. Bi, Y. Zeng, and R. Zhang et al represent the Wireless powered communication networks: an overview [20]. This paper represent the a new networking model named as Wireless powered communication network (WPCN) that eliminates the need of regular manual battery replacement/recharging, and thus extensively improves the performance over conservative battery-powered communication networks in many aspects, such as higher throughput, longer device lifetime, and lower network operating cost. In WPCN, the battery of wireless communication devices can be remotely replenished by means of microwave wireless power transfer (WPT) technology. This paper represents an overview of the key networking structures and performance enhancing techniques to build an efficient WPCN. However, the design and future application of WPCN is essentially challenged by the low WPT efficiency over long distance and the complex nature of joint wireless information and power transfer within the same network.

K. Huang, C. Zhong, and G. Zhu et al present the Some new research trends in wirelessly powered communications [21]. This review Extensive research has been conducted on developing wirelessly powered communications (WPC) theory and techniques, building on the extremely rich wireless communications literature covering diversified topics such as transmissions, resource allocations, medium access control, and network protocols and architectures. Recent attempts to address open issues have resulted in the emergence of various new research trends in the WPC area. Open issues such as mobile complexity, power transfer efficiency, and safety. Furthermore, the essential limits of WPC remain largely unknown. The vision of impeccably integrating information transfer (IT) and microwave based power transfer (PT) in the same system has led to the emergence of a new research part, called WPC.

3. PROPOSED SYSTEM APPROACH

In this work, we consider WPT system called a "wireless powered communication network" (WPCN). A WPCN is a network in which wireless devices are powered only by WPT [15]. The WPCN model considered in this paper is the same as in [15] and is shown in Figure. 1, where one hybrid access point (H-AP) with an effectively unlimited power supply coordinates the wireless energy/information transmissions to/from a set of distributed users. Each user is ready with an energy storage device and thus can harvest and store (save) the wireless energy broadcasted by the H-AP in the downlink. The users transmit their independent information using their individually harvested energy to the H-AP in the uplink. In [15], a block transmission model was considered where it was assumed that users harvest energy during a downlink transmission the first part of the block and then each user uses all of their harvested energy during an uplink transmission later in that block. In other word, users do not save energy for later blocks.

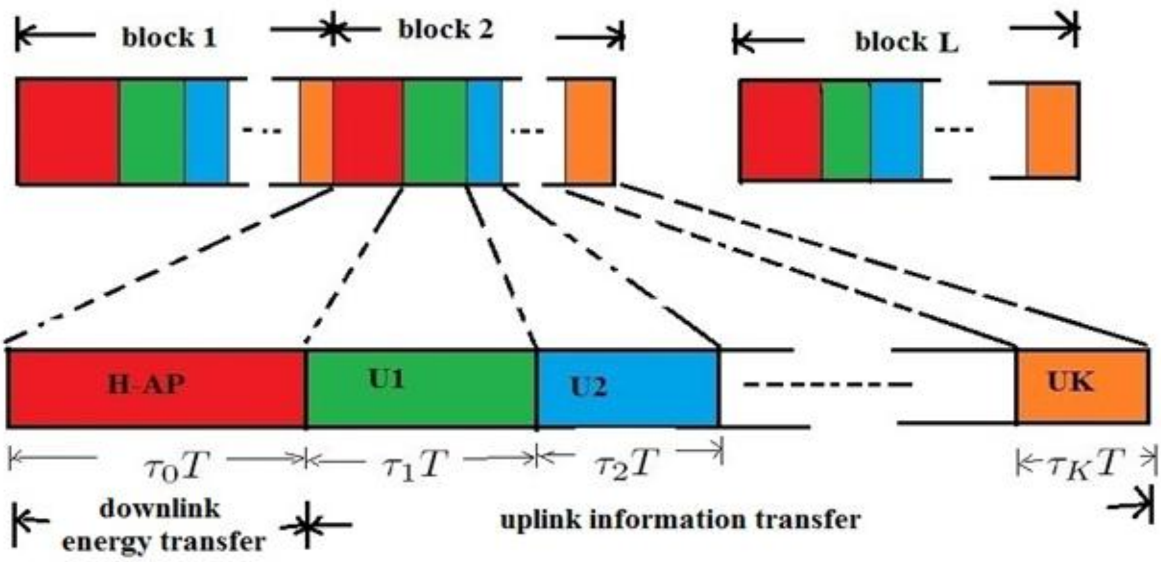

Figure 1: Harvest-then-transmit protocol and block structure.

The analysis assumes an "oracle" provides knowledge of the channel states for all blocks prior to the commencement of the first block. Hence, the results developed in this paper can be considered an upper bound for finite-horizon energy saving schemes with causal channel knowledge. The initial optimization problem is separated into two sub-problems: (i) calculating the optimal time allocation by fixing energy allocation and (ii) calculating the optimal time allocation and energy allocation of downlink WET. The former is a convex optimization technique, which gives us a closed-form relation between the time allocation of downlink WET and uplink WIT and the latter can be formulated as a standard box-constrained nonlinear programming problem, which can be solved efficiently using the trust-region-reflective algorithm [16], [17]. An upper bound with low computational complexity is provided by relaxing the energy harvesting causality, which give us a water-filling typed solution. Simulation results are also provided to demonstrate the "harvest-then- transmit" protocol with energy saving provides improved sum throughput increasing with the number of transmission blocks. The resulting gains are somewhat modest, however, and require significant computation as well as "oracle" channel estimates. Hence these results show that the original "harvest-then- transmit" protocol without energy saving is a practical strategy offering good performance for WPCN.

Advantages of Proposed System

1. Reduced energy consumption in WSN.
2. Secure node to node communication.
3. Reduce packet drop attack with trust based active source routing.

3.1 Experimental Results

As already studied, energy efficient WSN deployment is not an easy task due to large number of parameters, i.e., energy parameters and cluster head selection then their data transmission procedure. Java programming platform is used for coding. Finally, the comparative performance of all algorithms is explained. The parameters considered during simulation have their own significance for the better performance of the network. The important definitions in the WSNs related to this project are: Average rate of successful packet delivery. The throughput is the most important parameter to analyze the performance of the network, to get better through-put the error should be corrected, instead of retransmitting the packet. If the error is corrected there is no need of retransmitting the packet. If the retransmission traffic is reduced the congestion will not occur. If there is no congestion there is no packet loss that is error. If more number of packets in the network the performance of the network degrades which leads to congestion, which leads to packet loss. If there is an error correction technique which corrects the error instead of going for retransmission it improves throughput. In this section, we compare the maximum sum throughput using energy saving with systems in which the users are assumed to use all their energy within current block. We continue to use the simulation parameters in [15]. The bandwidth is assumed to be 1MHz. Both the downlink and uplink channel shows the normalized maximum sum throughput versus the number of transmission blocks for different number of users.

Table 1: Simulation Parameters

Simulation parameter	Value
Area of sensor field	1000*1000 m
Transmission type	TDMA
No. of sensor node	7 Nodes
Routing protocol	AODV
Frequency of packet generation	(1/Time interval)
Transmission rang of H-AP	200m
Movement	Active
Simulation speed	Fast
Packet Length	512 Byte

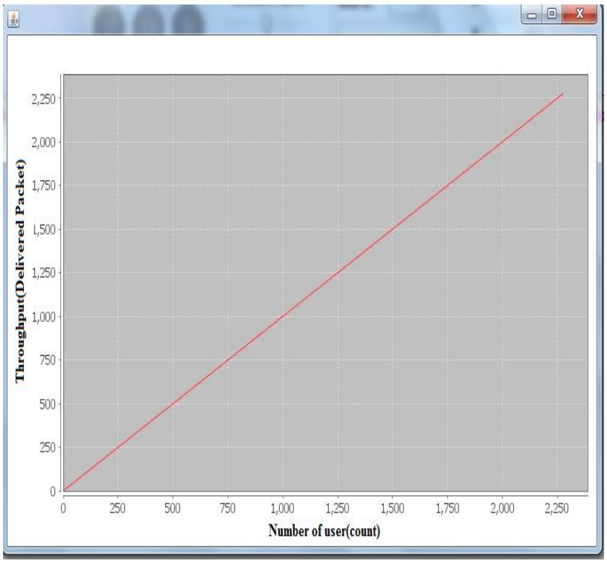

Figure 2: Graph for packet delivery ratio

The graph shown in Figure2 illustrates that, PDR (Packet Delivery Ratio) for TDMA based Transmission Type. In This type of Transmission, packets are sent to the HAP (Hybrid access point)by using Harvest-then transmit protocol with time division manner that help reduce buffering of packet. Here no packet loss. hence, packet delivery ratio will increases. Packet size is of 512 bytes. The X-axis represents reporting Number of users (count) and Y-axis represents Throughput (Delivered Packet).

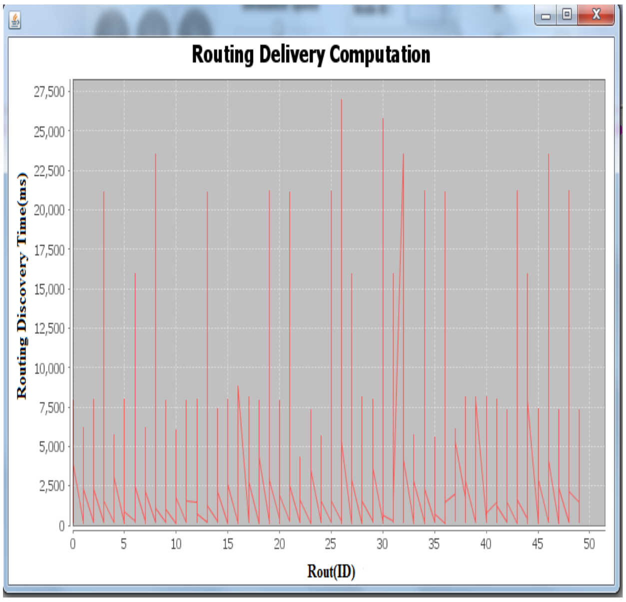

Figure 3: Graph for routing delivery ratio

The graph shown in Figure 3, demonstrates end-to-end routing comparison traced with reporting rate of 10 and packet size of 512 bytes. Here X-axis represents Rout (ID) and Y-axis represents routing discovery time (ms) values in milliseconds. Initially rout can discover for transmission of packet by using harvest -then -transmit protocol with TDMA method. Hence Rout is discover then corresponding packet with it's rout ID that can be transmitted on to discovered rout.

5. CONCLUSION

In this paper, we have studied the throughput maximization problem in WPCN with a finite horizon energy saving scheme. To obtain the optimal solution, the initial optimization problem is separated into two sub-problems and finally is formulated into a standard box-constrained optimization problem, which can be solved efficiently by the trust-region-reflective algorithm. We have observed that the improvement of the sum throughput with long-term energy saving is not considerable if considering the computational complexity. This indicates that the initial scheme without energy saving is a practical and favorable strategy in WPCN Future scope: we can improve transmission of energy and information simultaneously in downlink and uplink respectively.

6. REFERENCES

[1] A. M. Zungeru, L. M. Ang, S. Prabaharan, and K. P. Seng, "Radio frequency energy harvesting and management for wireless sensor networks," Green Mobile Devices Netw.: Energy Opt. Scav. Tech., CRC Press, pp. 341–368, 2012.

[2] R. J. M. Vullers, R. V. Schaijk, I. Doms, C. V. Hoof, and R. Mertens, "Micropower energy harvesting," Elsevier Solid-State Circuits, vol. 53,no. 7, pp. 684–693, July 2009.

[3] Y. Shi, L. Xie, Y. T. Hou, and H. D. Sherali, "On renewable sensor networks with wireless energy transfer," in Proc. 2011 IEEE INFOCOM, pp. 1350–1358.

[4] K. Huang and V. K. N. Lau, "Enabling wireless power transfer in cellular networks: architecture, modeling and deployment," submitted for publication. Available: arxiv:1207.5640.

[5] S. H. Lee, R. Zhang, and K. B. Huang, "Opportunistic wireless energy harvesting in cognitive radio networks," *IEEE Trans. Wireless Commun.*, vol. 12, no. 9, pp. 4788–4799, Sept. 2013.

[6] L. R. Varshney, "Transporting information and energy simultaneously," in *Proc. 2008 IEEE Int. Symp. Inf. Theory*, pp. 1612–1616.

[7] P. Grover and A. Sahai, "Shannon meets Tesla: wireless information and power transfer," in *Proc. 2010 IEEE Int. Symp. Inf. Theory*, pp. 2363–2367.

[8] R. Zhang and C. K. Ho, "MIMO broadcasting for simultaneous wireless information and power transfer," *IEEE Trans. Wireless Commun.*, vol. 12, no. 5, pp. 1989–2001, May 2013

[9] L. Liu, R. Zhang, and K. C. Chua, "Wireless information transfer with opportunistic energy harvesting," *IEEE Trans. Wireless Commun.*, vol. 12, no. 1, pp. 288–300, Jan. 2013.

[10] X. Zhou, R. Zhang, and C. K. Ho, "Wireless information and power transfer: Architecture design and rate-energy tradeoff," to appear in *IEEE Trans. Commun.*. Available: arXiv:1205.0618

[11] A. M. Fouladgar and O. Simeone, "On the transfer of information and energy in multi-user systems," *IEEE Commun. Lett.*, vol. 16, no. 11, pp. 1733–1736, Nov. 2012.

[12] D. B. Johnson and D. A. Maltz, "Dynamic source routing in adhoc wireless networks," Mobile Comput., vol. 353, pp. 153–181, 1996.

[13] R. Vaze and K. Jagannathan, "Finite-horizon optimal transmission policies for energy harvesting sensors," in Acoustics, Speech and Signal Processing (ICASSP), 2014 IEEE International Conference on, May 2014, pp. 3518–3522.

[14] A. Goldsmith, Wireless Communications. Cambridge University Press.

[15] H. Ju and R. Zhang, "Throughput maximization in wireless powered communication networks," Wireless Communications, IEEE Transactions on, vol. 13, no. 1, pp. 418–428, January 2014.

[16] T. F. Coleman and Y. Li, "An interior trust region approach for nonlinear minimization subject to bounds," SIAM Journal on Optimization, vol. 6, no. 2, pp. 418–445, 1996.

[17] "On the convergence of reflective newton methods for large-scale nonlinear minimization subject to bounds," Mathematical Programming, vol. 67, no. 2, pp. 189–224, 1994.

[18] S. Boyd and L. Vandenberghe, Convex Optimization. Cambridge University Press, 2004.

[19] Yong Zeng, Bruno Clerckx, and Rui Zhang, "Communications and Signals Design for Wireless Power Transmission" IEEE Transactions (Invited Paper) 21 November 2016.

[20] S. Bi, Y. Zeng, and R. Zhang, "Wireless powered communication networks: an overview," IEEE Wireless Commun., vol. 23, no. 2, pp.10–18, Apr. 2016.

[21] K. Huang, Zhong, anG. Zhu, "Some new research trends in wirelessly powered communications," IEEE Wireless Communication, vol. 23,no. 2, pp. 19–27, Apr. 2016.