Joint Transceiver Design in Full-Duplex MISO Wireless Powered Communication Networks with User Cooperation

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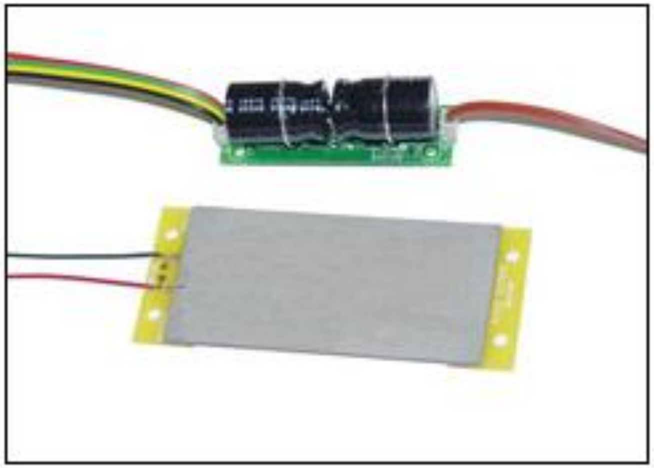
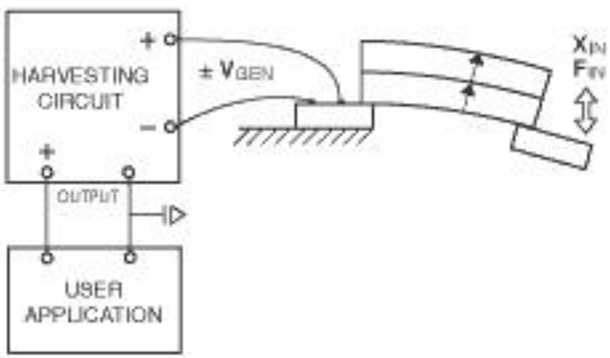
Introduction





Radio-frequency (RF) energy harvesting (EH)

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Simultaneous wireless information and power transfer (SWIPT)

wireless powered communication network (WPCN)

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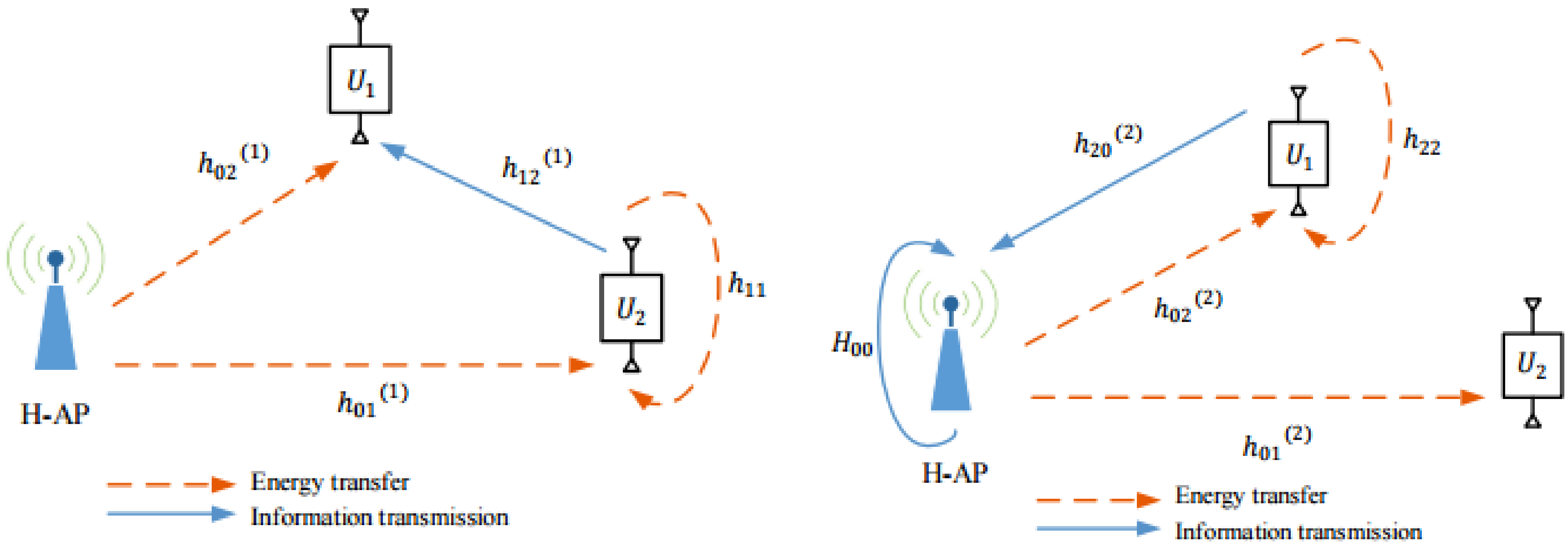
A. SYSTEM MODEL



Since the throughput increases monotonically with SNR, the maximization problem is formulated as

$$\begin{aligned} \mathrm{P1}: \ & \max_{\tilde{\mathbf{w}}_0^t, \mathbf{w}_0^{re}} \tilde{S}\left(\tilde{\mathbf{w}}_0^t, \mathbf{w}_0^{re}\right) \\ \text{s.t.} C_1 & : \mathbf{w}_0^{re} \mathbf{H}_{00} \mathbf{w}_0^t = 0 \\ C_2 & : \|\mathbf{w}_0^{re}\| = \|\mathbf{w}_0^t\| = 1 \end{aligned}$$

B. JOINT BEAMFORMING DESIGNS AT TRANSCEIVER

◆1、add the ZF constraint to cancel the RSI

$$\mathbf{y}_0{}^{(2)} = \mathbf{w}_0^{re}\mathbf{h}_{20}^{(2)}\left(\mathbf{h}_{12}^{(1)}\sqrt{\beta P_1 P_2}\mathbf{x}_1 + \sqrt{\beta P_2}\mathbf{n}_2\right) + \mathbf{w}_0^{re}\mathbf{H}_{00}\mathbf{w}_0^{t(2)}\mathbf{x}_0 + \mathbf{w}_0^{re}\mathbf{n}_0$$

↓

$$\mathbf{w}_0^{re}\mathbf{H}_{00}\mathbf{w}_0^{t} = 0$$

↓

$$\mathbf{y}_0{}^{(2)} = \mathbf{w}_0^{re}\mathbf{h}_{20}{}^{(2)}\left(\mathbf{h}_{12}{}^{(1)}\sqrt{\beta P_1 P_2}\mathbf{x}_1 + \sqrt{\beta P_2}\mathbf{n}_2\right) + \mathbf{w}_0^{re}\mathbf{n}_0$$

B. JOINT BEAMFORMING DESIGNS AT TRANSCEIVER

◆2、decompose the energy beamforming vector and the information beamforming vector

$$\mathbf{w}_0^t = \mathbf{N}_0^t \mathbf{v}_0^t$$

$$\mathbf{w}_0^{re} = \mathbf{v}_0^{re} \mathbf{N}_0^{re}$$

↓

Accordingly, (P1) can be reformulated as

$$\mathrm{P2}: \max_{\tilde{\mathbf{w}}_0^t, \mathbf{v}_d^{re}} \tilde{S}\left(\tilde{\mathbf{w}}_0^t, \mathbf{v}_d^{re}\right)$$

$$s.t. \left\|\mathbf{v}_0^{re}\right\| = \left\|\tilde{\mathbf{w}}_0^t\right\| = 1$$

B. JOINT BEAMFORMING DESIGNS AT TRANSCEIVER

◆3、introduce an auxiliary parameter x

$$\tilde{\mathbf{w}}_0^t = x \frac{\prod_{\tilde{\mathbf{h}}_{01}^H} \tilde{\mathbf{h}}_{01}^H}{\prod_{\tilde{\mathbf{h}}_{01}^H} \tilde{\mathbf{h}}_{02}^H} + \sqrt{1-x^2} \frac{\prod_{\tilde{\mathbf{h}}_{01}^H}^{\perp} \tilde{\mathbf{h}}_{02}^H}{\prod_{\tilde{\mathbf{h}}_{01}^H} \tilde{\mathbf{h}}_{02}^H}$$

(P2) can be equivalently transformed into :

$$\max_{0<x\leq 1} f(x)$$

where $f(x)$ is defined as

$$\mathrm{P3}: f(x) = \max_{\mathbf{v}_0^{re}} \tilde{S}\left(\tilde{w}_0^t(x), v_0^{re}\right)$$
$$s.t. \left\|\mathbf{v}_0^{re}\right\| = 1$$

B. JOINT BEAMFORMING DESIGNS AT TRANSCEIVER

◆4、 a series of efficient variable substitution operations and exploiting iterative algorithm

$$\begin{aligned} &\mathrm{P5}: \max f(x) \\ &s.t. C1: 0 < x \leq 1 \\ &C2: \left\|\tilde{\mathbf{w}}_0^t(x)\right\| = 1 \end{aligned}$$

$$f(x) = \frac{h(x)}{g(x)} = \frac{Ax^2\left(bx + c\sqrt{1-x^2}\right)}{B\left(bx + c\sqrt{1-x^2}\right) + Cx^2 + d} \tag{27}$$

where $A = a^2\eta P_0\left|\mathbf{h}_{12}^{(1)}\right|^2\left|\mathbf{h}_{20}^{(2)}\right|^2$, $B = \delta_2^2\left(1-|\mathbf{h}_{11}|^2\right)\left|\mathbf{h}_{20}^{(2)}\right|^2$, $C = a^2\delta_0^2\left|\mathbf{h}_{12}^{(1)}\right|^2$

To summarize, the algorithm to solve (P5) is given in Algorithm 1 to find the global optimum.

Initialize $l = 0, u = 1$ and define $t = \left(\sqrt{5} - 1\right)/2$.
Repeat
Set $x_1 = l + (1 - t)(u - l)$ and $x_2 = l + t(u - l)$;
Given (25), compute $f(x_1)$ and $f(x_2)$ respectively;
If $f(x_1) \geq f(x_2)$, then $u = x_2$; else $l = x_1$.
Until $u - l \leq \varepsilon$, where ε is the convergency accuracy.
Return the the optimal beamforming vector $\mathbf{w}_0^t$ and $\mathbf{w}_0^{re}$.

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Simulation Results and Analyses

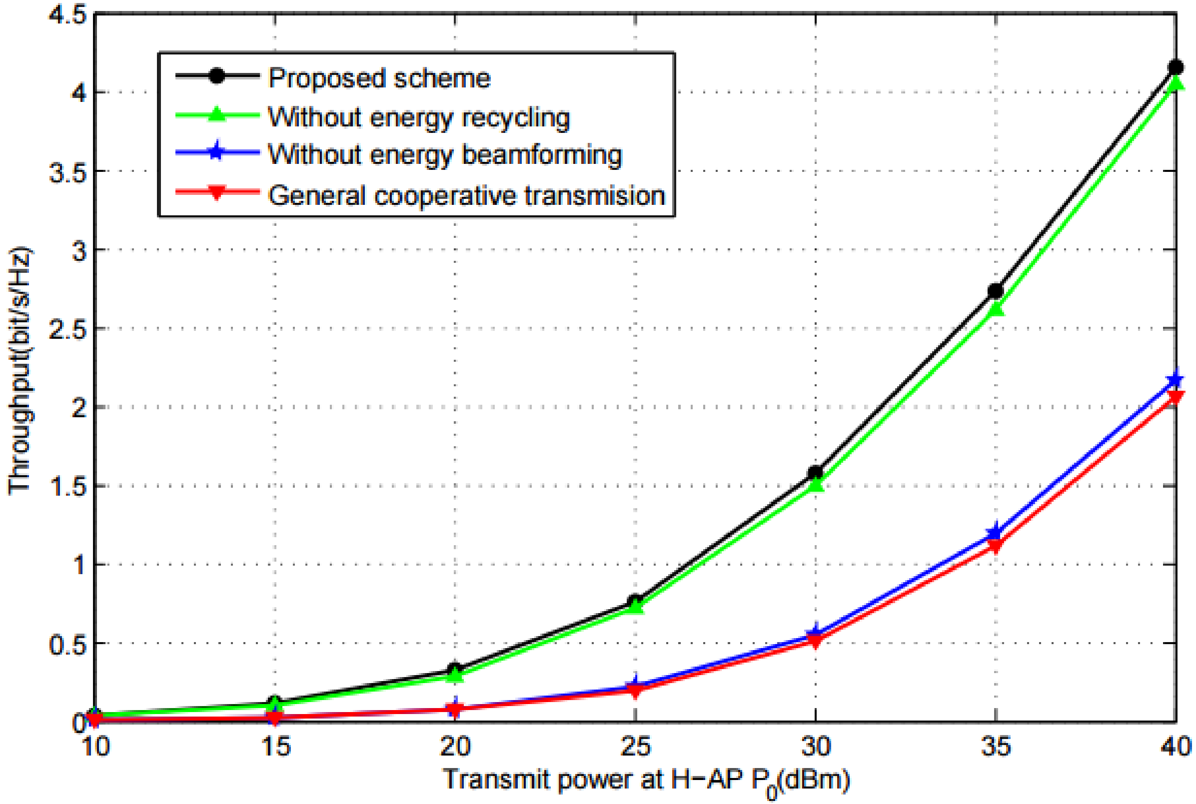

Fig. 2. Maximum throughput versus transmit power at H-AP P_0 with $N = 5, \alpha = 4$

Compared with the following cases:

1)The beamforming of energy and information is jointly optimized. However, the users is unable harvest the power from its own transmitted signal.

2)Maximal -ratio-combining (MRC) method is considered at the receiver of H-AP, which brings beneficial gain for SNR. No energy beamforming is carried out at the H-AP, which indicates that the transmitting power is allocated uniformly among all antennas.

3) the general AF cooperative transmission. The users only can harvest energy from the H-AP and no beamforming design is implemented.

Simulation Results and Analyses

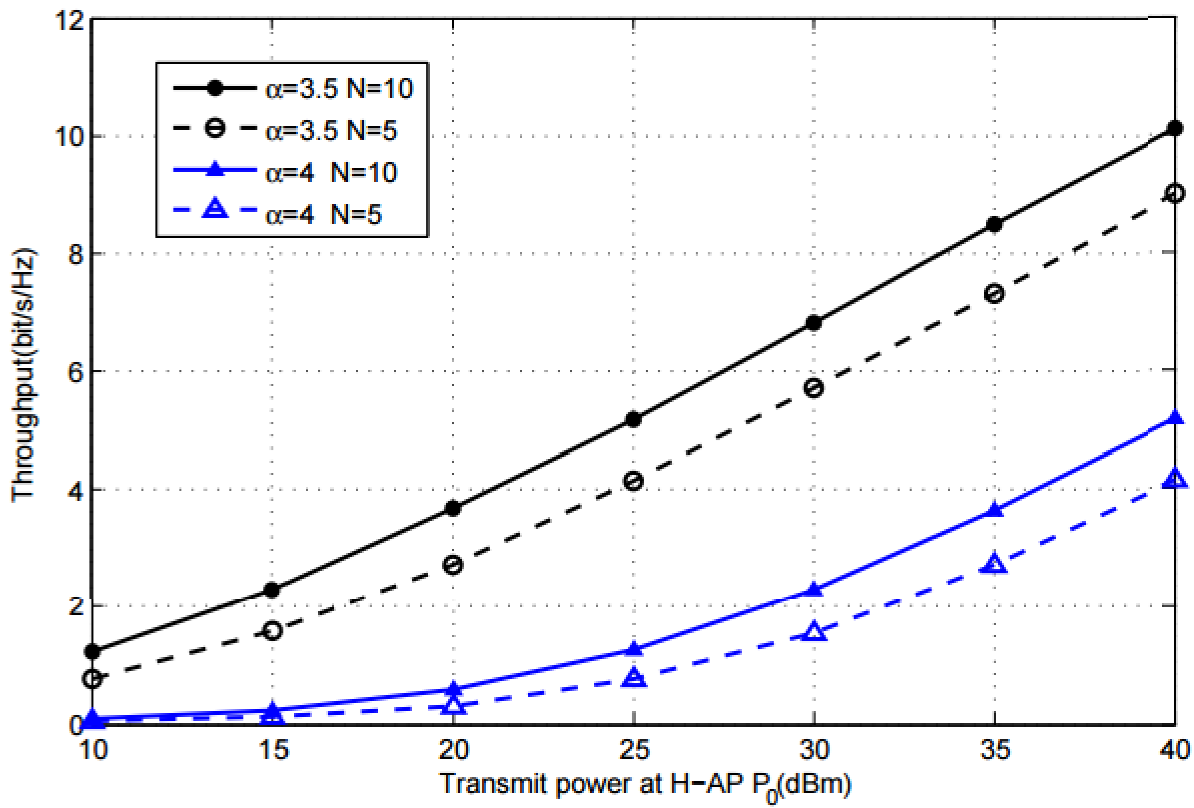

Fig. 3. Maximum throughput versus P_0 with different N and α

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Conclusions

◆This paper has proposed a co-channel scheme and a low complexity algorithm to jointly design energy and information beamforming of the transceiver for FD-WPCN with two users, which achieves uninterrupted information transmission and also self-energy recycling.

◆ Formulated quasi-concave optimization problem to maximize the system throughput. In addition, the global optimum can be achieved via a series of efficient variable substitution operations and exploiting iterative algorithm. Finally, numerical results have showed the superiority of our proposed algorithm to the reference schemes.

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Acknowledgment

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Thank you for your attention