**[0. Wireless Powered Communication Networks Overview]**

<https://arxiv.org/pdf/1508.06366.pdf>

**<0-0. Terms>**

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| EN (energy node) | **Transmit wireless energy** to WDs in the **downlink** |
| WD (wireless device) | **Use harvested energy to transmit data** to information access points in the **uplink** |
| AP (access point) |  |
| HAP (hybrid access point) | **Pair of EN and AP** |

**<0-1. Figures>**

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| Energy node | Wireless device | Access point | HAP |
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**<0-2. AP and HAP mechanism>**

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| AP mechanism **(Separated)** | HAP mechanism **(CO-located)** |
| **ENERGY FLOW** / **INFORMATION FLOW** | **ENERGY FLOW** / **INFORMATION FLOW** |

**<0-3. Problems>**

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| Doubly Near Far | HAP에 가까운 노드는 전력을 **많이 공급받으면서** 정보를 다시 HAP으로 전송하는 데 **에너지가 적게 든다**.  그러나, HAP에서 먼 노드는 전력을 **적게 공급받으면서** 정보를 다시 HAP으로 전송하는 데 **에너지가 많이 든다.**  즉, **사용자 간 불공평**이 생긴다. |
| Throughput Maximization | Ref: Throughput Maximization in Wireless Powered Communication Networks (<https://arxiv.org/pdf/1304.7886v4.pdf>) |

**<0-4. Performance comparisons of different operation models in WPCN>**

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| Network Setups |  |
| Graph | **Full duplex:** 2개의 device가 동시에 독립된 회선을 사용하여 데이터 송수신  **Half duplex:** 한쪽이 송신하는 동안 다른 쪽에서 수신하는 방식으로, 전송 방향 교체    실험 결과, d=**1m~4m**에서는 **Full duplex, co-located, 80dB SIC**, d=**5m~9m**에서는 **Full duplex, separated, 80dB IC**의 throughput이 가장 크다. |

**[1. Throughput Maximization in Wireless Powered Communication Networks]**

<https://arxiv.org/pdf/1304.7886v4.pdf>

**<1-0. Terms>**

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| DL (downlink) | Where **wireless energy** is broadcasted by HAP |
| UL (uplink) | Where WD send independent **information** to HAP |
| WET | Wireless **energy** transfer |
| WIT | Wireless **information** transmission |
| TDMA (Time-division multiple access) | Channel access method for shared-medium networks   * Allows **several users** to **share same frequency channel** by **dividing signal into different time slots** |
| Convex optimization | Mathematical optimization for finding **smallest value of convex() function** (eg: Least-square method) |
| Baseband signal | **Original** transmission signal (not be modulated) |
| Feasible | There is **no error** for using the value |

**<1-1. Formulas>**

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|  | **Channel power gain**  where  are **complex random variables** |
|  | **:** **time portion** in each block allocated to HAP and **user** , for UL WET and DL WIT **()**  **:** each **block transmission time (use normalized unit block time T=1)** |
|  | **:** **Transmitted baseband signal of HAP** in one block of interest  **:** **received** **noise** at  **:** **received** **signal** at , |
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**<1-1. Formulas (Cont.)>**

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| **Previous page** | |
|  | **:** **energy harvesting efficiency** at each receiver   * Assume:   **:** (large such that energy harvested due to receiver noise is negligible)  **:** **amount of energy harvested by each user** in the DL, |
|  | **:** **fixed portion of harvested energy** given to user   * Used for its **information transmission** in the UL   **:** **average transmit power** at , given by |
|  | **:** **complex baseband signal transmitted by**  **:** **received noise at HAP** during **slot**  **:** **received signal at HAP** during **slot** , |
|  | **:** **signal-to-noise (SNR)** ratio  **:**  **:** **Achievable UL throughput of**  (in bits/second/Hz, bps/Hz) |

**<1-2. Throughput vs. time allocated to DL WET in a single-user WPCN>**

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| * Throughput은 **일 때는 증가하다가 일 때는 감소**한다. * 결론적으로 **Throughtput을 최대화하는 의 값이 존재**한다. |

**<1-3. Sum-Throughput Maximization Problem 1>**

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| Problem 1  (P1) |  |
| Lemma 3.1 |  |
| Lemma 3.2 | ***f(x)=xlnx-x+1*** |
| Proposition 3.1 | **Optimal time allocation sol. for P1** denoted by is given by |
| Corollary 3.1 | In the **optimal time** allocation solution of P1, **is a monotonically decreasing function of A>0** |

**<1-4. Sum-Throughput Maximization Problem 2>**

**“tackle DOUBLY NEAR-FAR problem by applying COMMON-THROUGHPUT MAXIMIZATION approach”**

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| Problem 2  (P2) | **: common throughput**  **D: feasible set of**  specified by |
| Feasibility problem | Finds.t.   * 이것은 **convex**하므로 이것의 Lagrangian은 다음과 같다고 할 수 있다. |
| Remark 4.1 | P2 is designed to guarantee **throughput of user with worst channel condition**  (eg. Largest distance from HAP) |
| Lemma 4.1 | For a **given** , Feasibility problem above is **infeasible** **if and only if** there exists such that |

**<1-5. Weighted Sum-Throughput Maximization Problem>**

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| Problem W  (PW) | * Like P1, **PW is convex** and thus can be **solved by convex optimization** |
| Proposition 4.1 | Given , **optimal time allocation sol. for PW** ()is  where is solution of following equations: |
| 와 **Proposition 4.1**을 해결하여 도출된 를 이용하면 를 구할 수 있고, 따라서 를 구할 수 있다.   * 이면 **infeasible,** 이므로  **감소시켜 feasibility problem을 다시 해결해야 한다.** * 이면 아래 알고리즘을 이용하여 **를 업데이트**할 수 있다. |

**<1-6. Algorithm to solve P2>**

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|  | 요약)   1. infeasible하면 R의 **값의 범위를 [Rmin, R]로 바꾸고** 다시 1번으로 2. feasible하면 stopping criteria가 될 때까지 **를 업데이트**한 후 **R의 값의 범위를 [R, Rmax]로 바꾼다**. 3. 1, 2를 Rmax-Rmin의 값이 error tolerance에 도달할 때까지 반복 |

**<1-7. Common-throughput (bps/Hz) vs. time allocation>**

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|  | P2를 해결하기 위한 optimal time allocation: |