Secure Energy Efficiency Fairness Maximization in Backscatter Throughput Constrained UAV-assisted Data Collection

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Introduction

- ✓ **Reliable** data collection over extended rural areas for surveillance
- ✓ Backscattering provides a **sustainable and low-cost** solution
- ✓ Data non-encryption, accuracy & responsiveness pose **challenges**
- ✓ Unmanned Aerial Vehicle (UAV) assistance can address concerns
- ✓ Information **leaks** or eavesdropping by untrusted tags is an issue
- ✓ Solution: **Physical layer security** enabled data collection by UAV

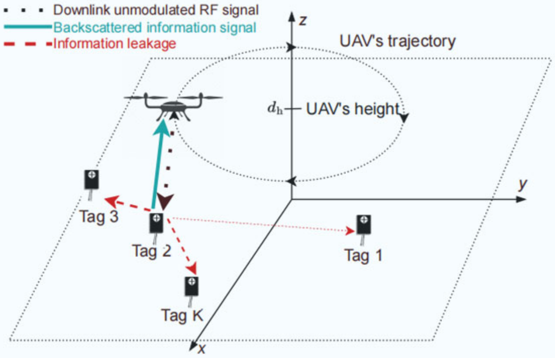
Key Objectives

- ✓ Maximize **fairness-aware secure rate efficiency** across tags by optimising UAV's trajectory to manage leakage & consumption.
- ✓ Transform the problem into convex form by relaxing constraints to obtain a locally optimal trajectory with **low complexity**.
- ✓ Evaluate proposed scheme's performance by comparing it with benchmarks and quantifying complexity through **simulations**.

Innovation & Significance

- ✓ Addressing the undesired **overhearing** by backscattering tags
- ✓ Existing UAV-assisted backscatter physical layer security systems **do not** effectively manage the consumption of energy.
- ✓ **Green and secure** a UAV-assisted backscattering data collection
- ✓ A **novel** optimisation algorithm that takes into account both the security of backscattering and the energy consumption of UAVs.

Network Topology and Access Protocol



Single antenna UAV-assisted static network of K single antenna backscattering tags spread across a two-dimensional flat ground.

Optimisation Formulation

$$(\mathrm{P}) \quad : \quad \max_{\{\mathbf{u}[n],\forall n\in\mathcal{N},k\in\mathcal{K},R_{\text{fair}}\}} \frac{R_{\text{fair}}}{E_{\text{total}}}, \qquad \text{subject to}$$

$$\mathrm{C1}: \ R_k \geq R_{\text{fair}}, \forall k \in \mathcal{K},$$

$$\mathrm{C2}: \ \|\mathbf{u}[n+1]-\mathbf{u}[n]\| \leq V_{\max}t, \forall n \in \mathcal{N} \setminus N,$$

$$\mathrm{C3}: \ \mathbf{u}[1]=\mathbf{u}[N], \qquad \mathrm{C4}: \ \sum\nolimits_{n=1}^{N} E_k[n] \geq E_{\text{th}}, \forall k \in \mathcal{K},$$

- ✓ Maximise the *ratio of minimum secrecy rate among tags and UAV consumption* by controlling its trajectory
- ✓ C1: Ensures that each tag gets a desired or **fair** secrecy rate.
- ✓ C2: Maximum **speed** constraint of the UAV
- ✓ C3: **Same** start and end point of the UAV
- ✓ C4: **Minimum** energy required constraint by the tag
- ✓ Applied Convex approximation & Fractional programming

Simulations

Insights

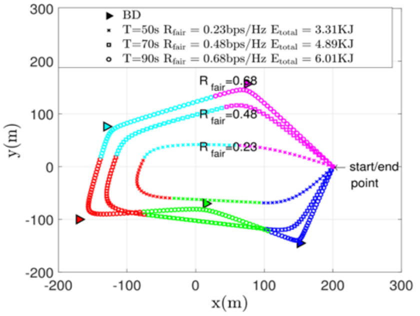
- ✓ The trajectory loop **grows** larger with flight duration
- ✓ Increasing the flight duration leads to **better** secrecy rates realised across tags.

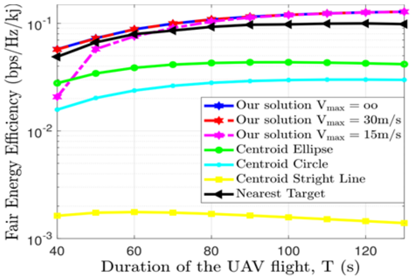
Comparison

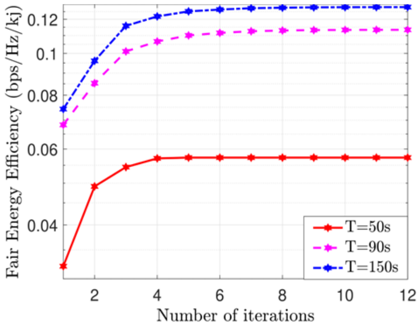
- ✓ Our solution **outperforms** the benchmarks
- ✓ We benefit from **dynamically** optimizing UAV trajectory to improve energy efficiency.

Validation

- ✓ Our algorithm **converges very fast** to the solution







Conclusion

- Proposed fairness-aware data collection design conside-ring backscattering safety & UAV energy efficiency.
- **Low-complexity** design outperforms benchmarks
- To be extended to *multiantenna & multiple UAV settings*

Acknowledgments

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