Cooperative Air-Ground Wireless Secure and Covert Communications

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Why Security is Important in Wireless Networks?

The rise of 5G/6G technology has made wireless communication a vital part of our lives.

However, this connectivity comes with risks like eavesdropping and data theft.

Securing wireless communication is essential to protect privacy and trust in the digital world.

How to Protect Confidential Data?

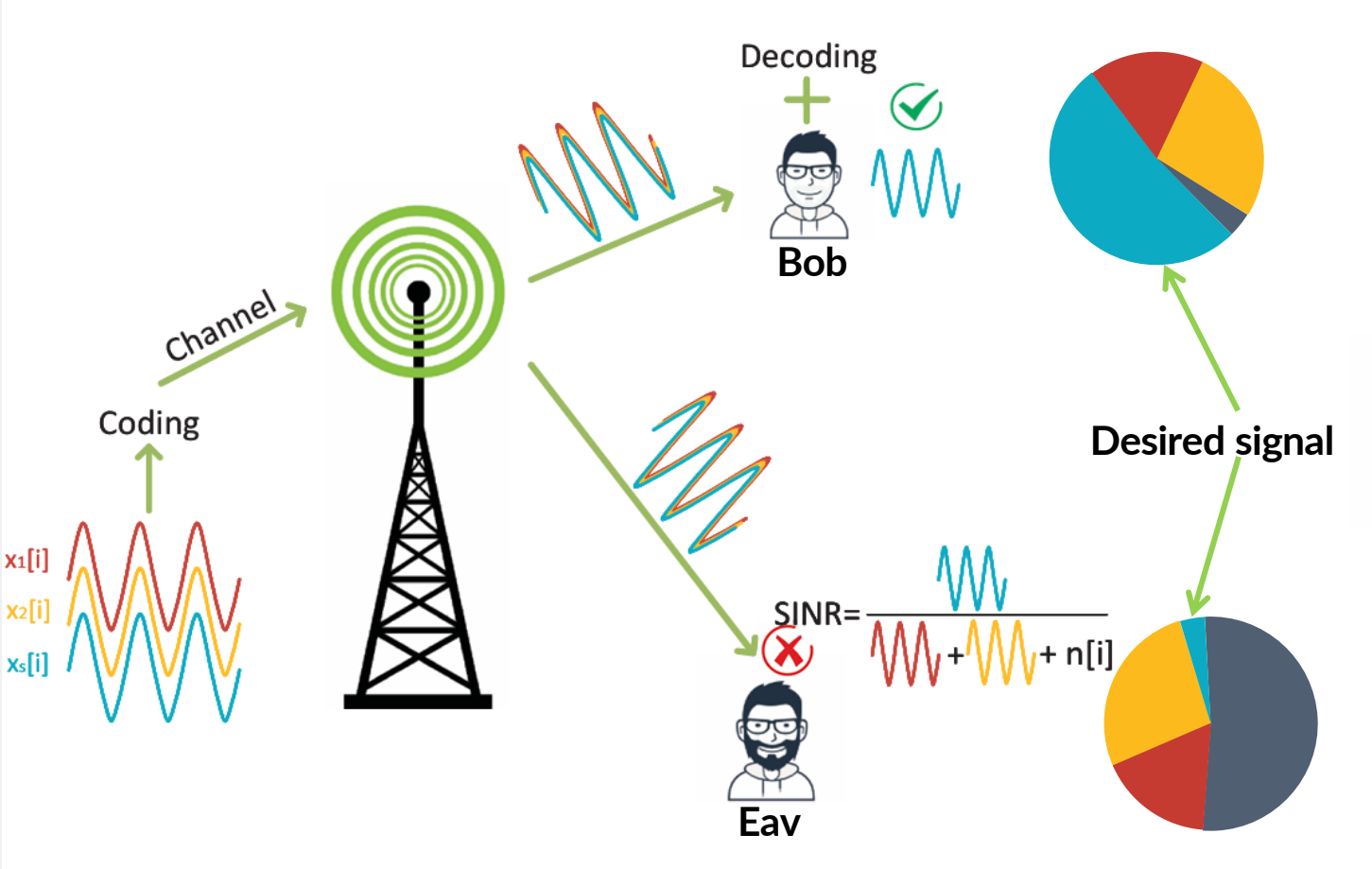
- Encryption
- Physical Layer Security
- Covert Communication

What are PLS and Covert Communication?

Physical Layer Security (PLS):
Secures communication using natural properties of wireless signals.

Covert Communication:
Hides the communication itself, making it undetectable.

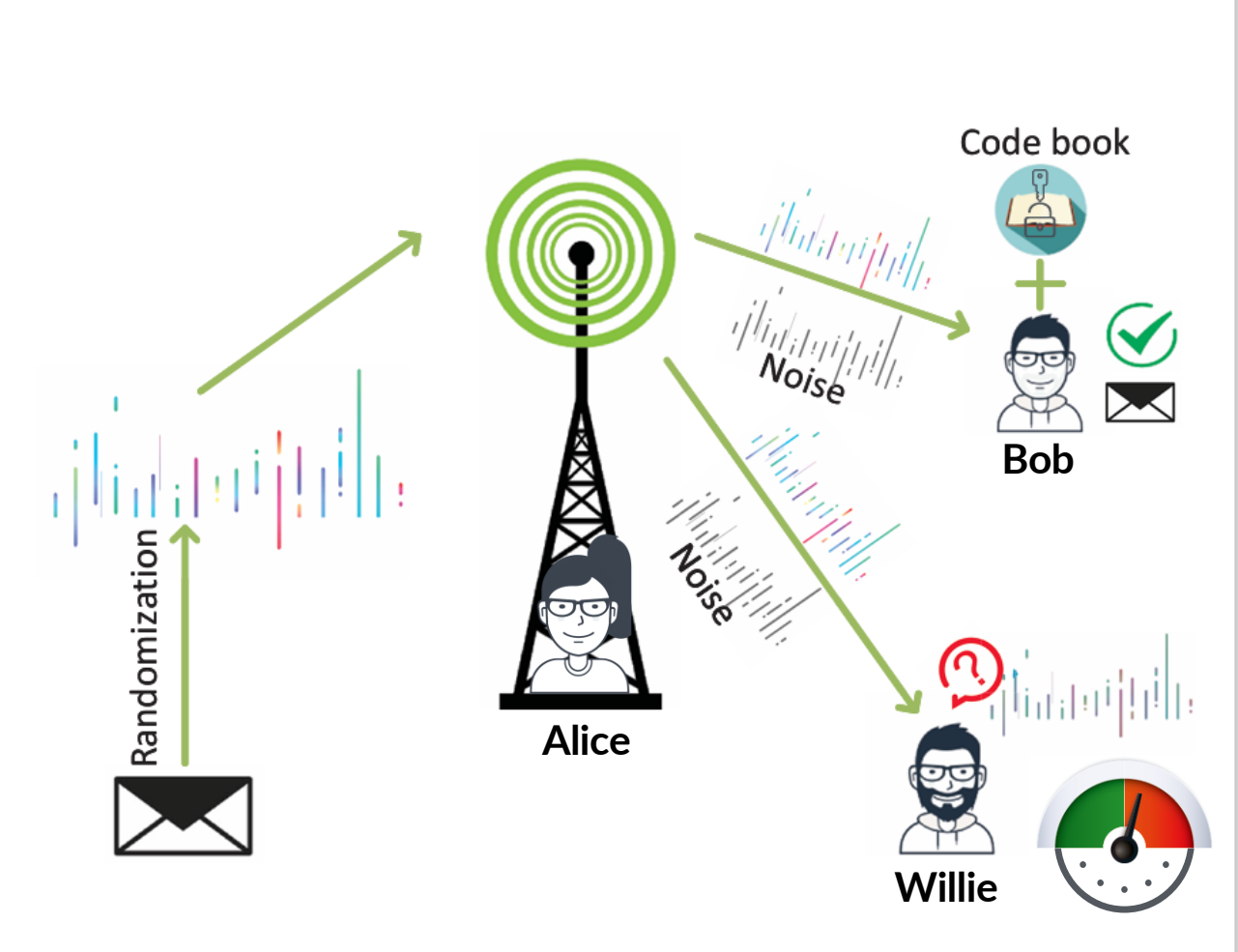
What is Physical Layer Security (PLS)?



How to achieve it?

- Power allocation
- Beamforming
  - Max-SINR
  - Artificial noise (AN)
  - Zero-forcing
- Artificial noise (AN)
- Intelligent Reflecting Surface (IRS)
- Channel-based technique

What is Covert Communication?



Cover it

Covert

-How to achieve it?

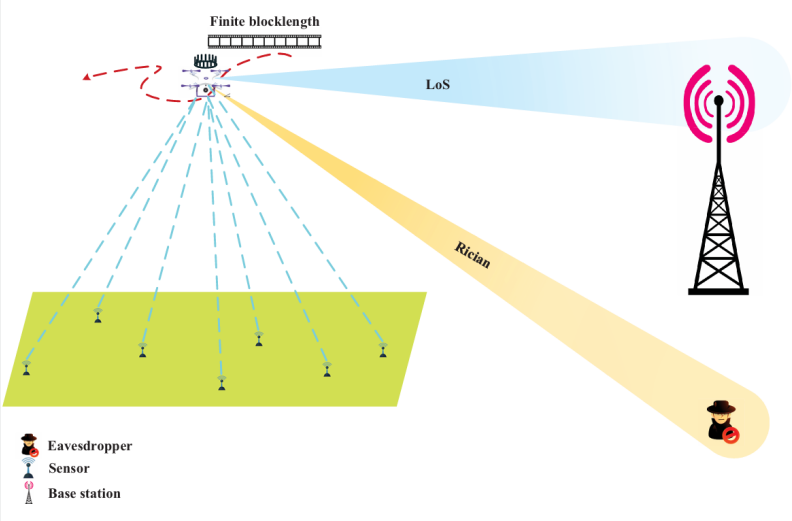
-Randomization

- Transmit power
  - Alice
  - Jammer
  - Relay
- Gaussian signaling
- Location
- Channel fading

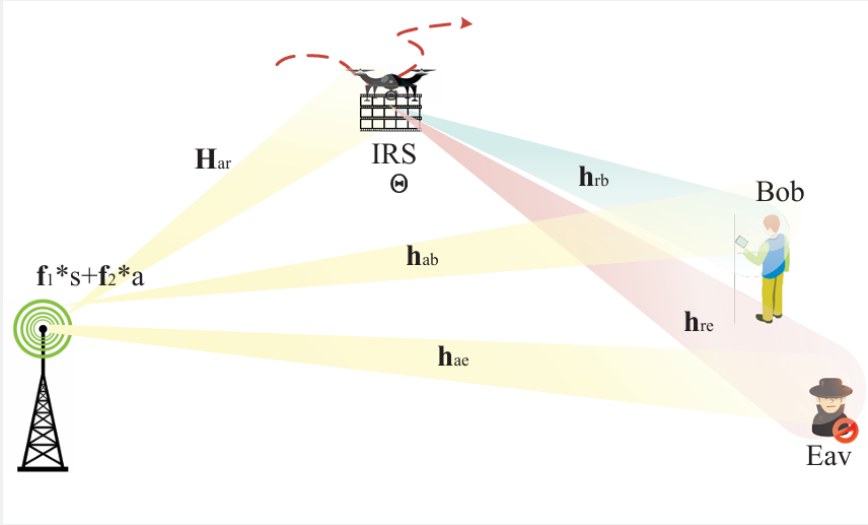
Why Choose PLS and Covert Communication?

- Encryption relies on keys, which can be stolen.
- PLS and covert communications do not depend on keys, making them more secure.
- PLS and covert communications are lightweight and highly adjustive.

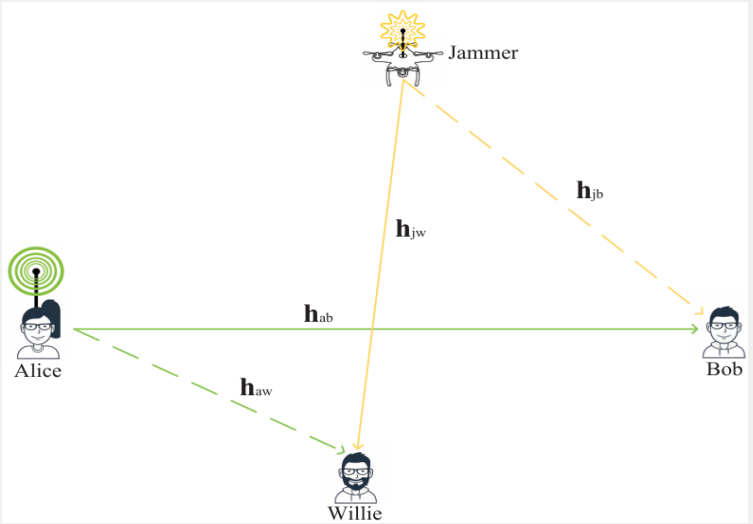
What Does My Research Do?



- Guarantee security.
- Maximize energy-efficiency in UAV data collection network.
- Design trajectory, user scheduling; UAV's transmit power and blocklength.

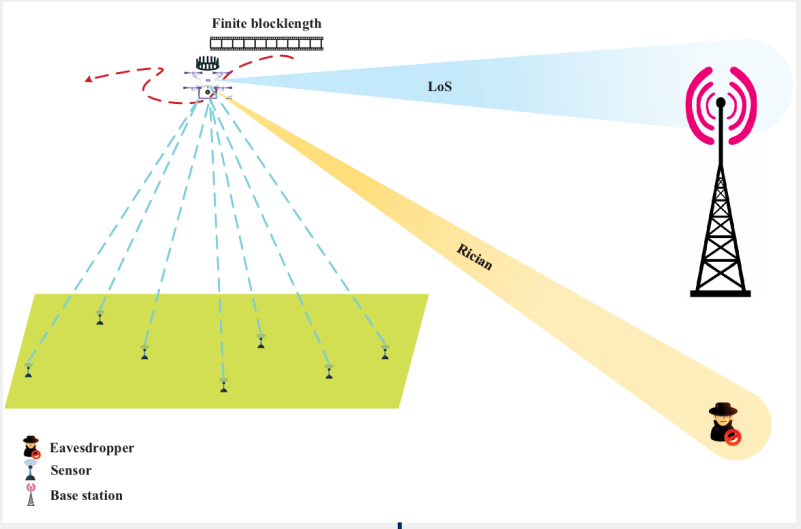


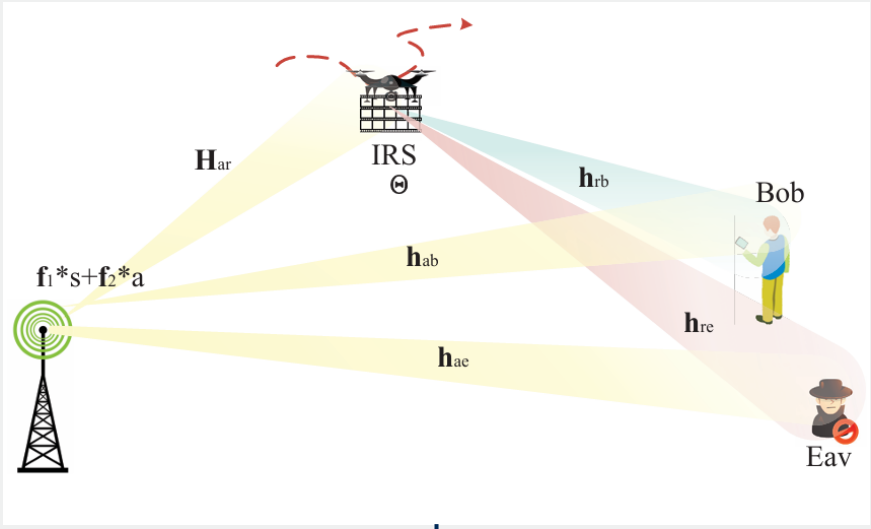
- Guarantee security.
- Improve transmission rate via IRS.
- Design signal/jamming precoding vector, location and phase shifting matrix of IRS.

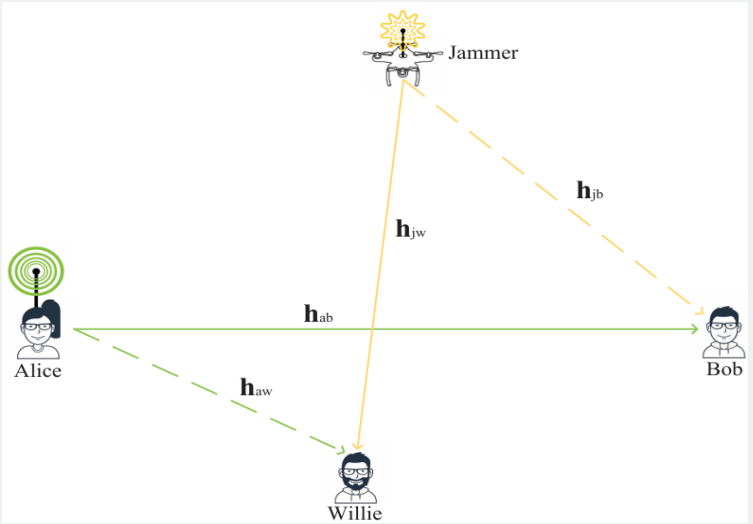


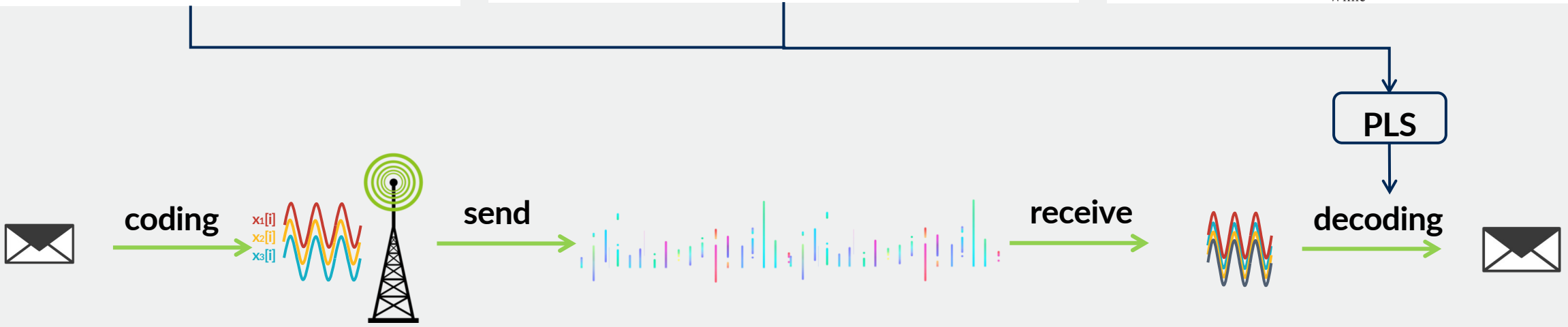
- Guarantee security.
- Increase secure transmitted data amount via PLS method.
- Design transmit power and zero-forcing Gaussian signaling jamming power.

What Does My Research Do?









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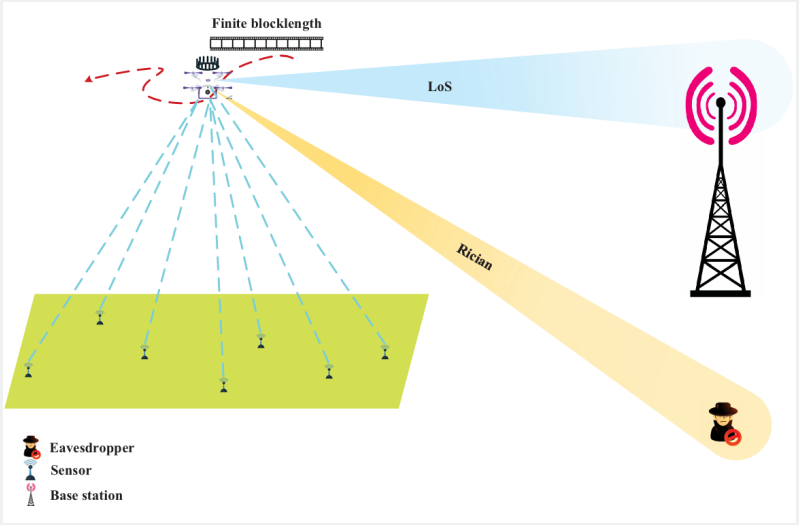
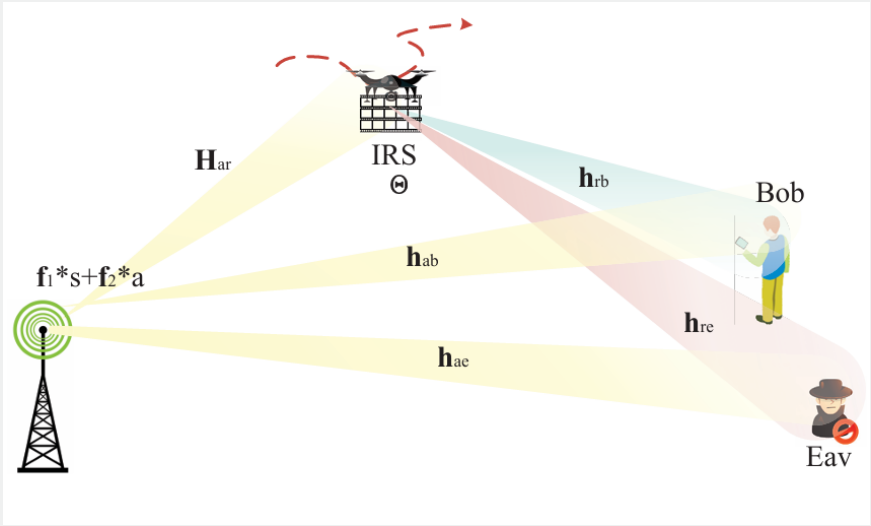
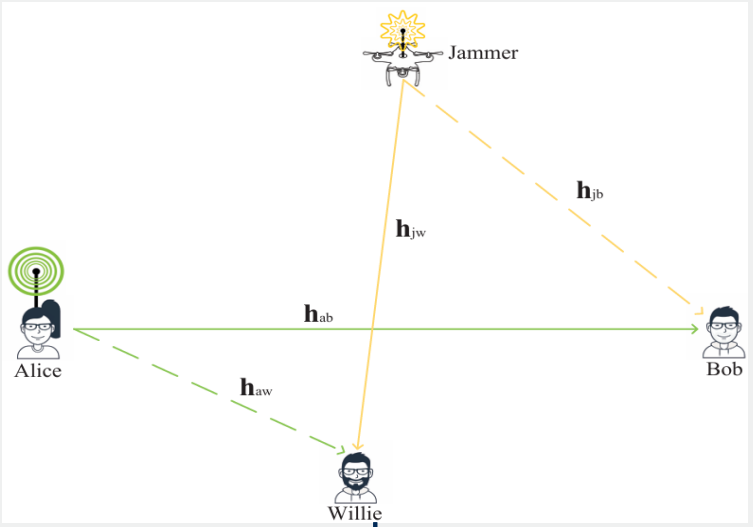
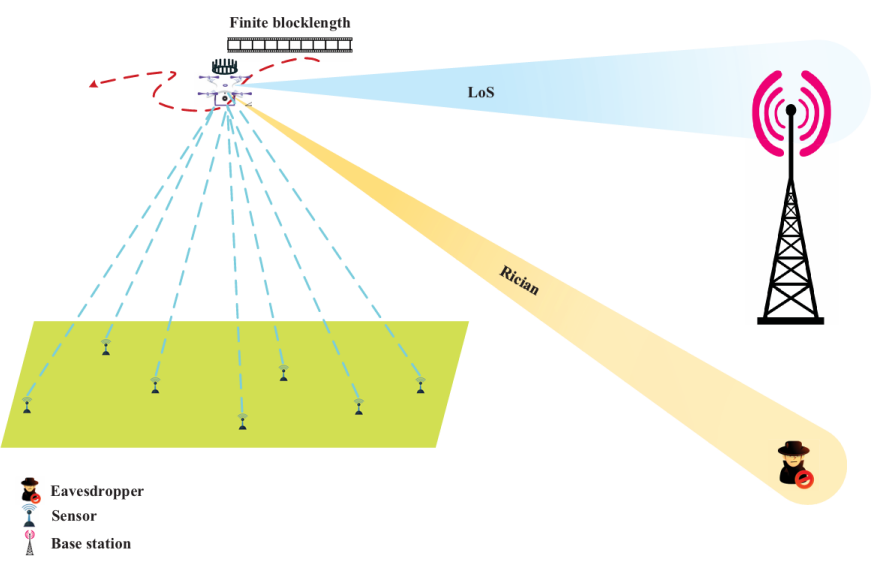


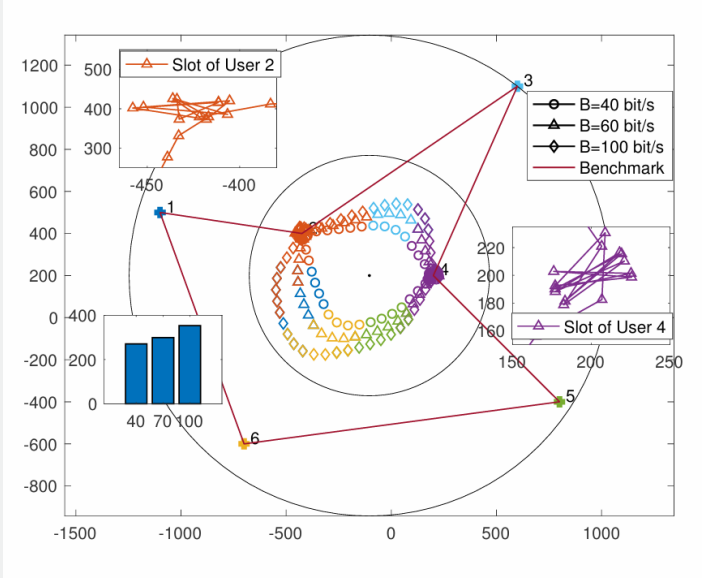




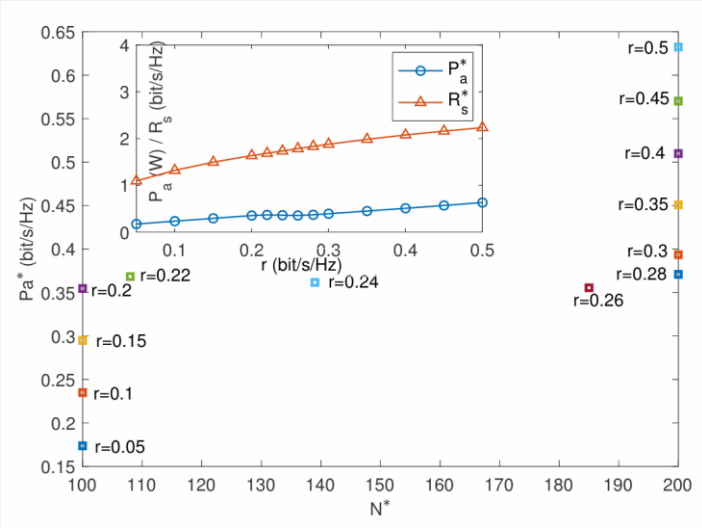
Research Advances and Results



- Secure UAV data collection and transmission
  - Maximize energy-efficiency: w, t, T
  - Maximize secrecy rate: P_a, Nu

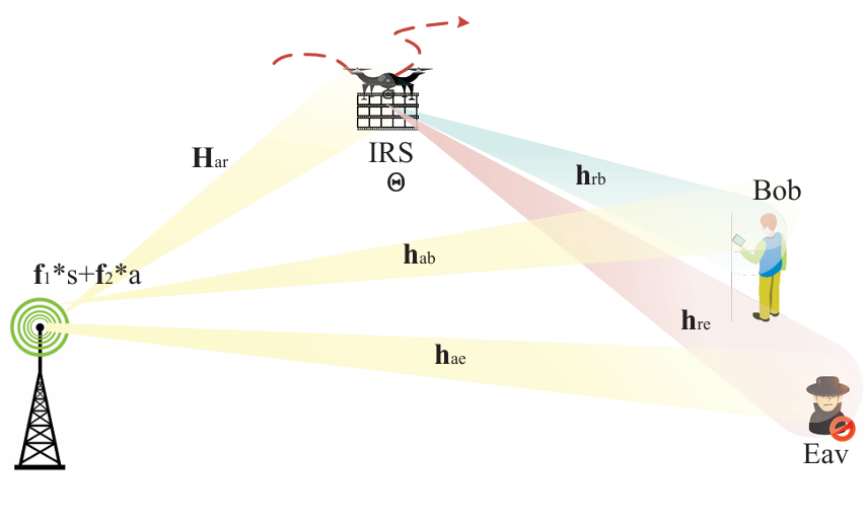


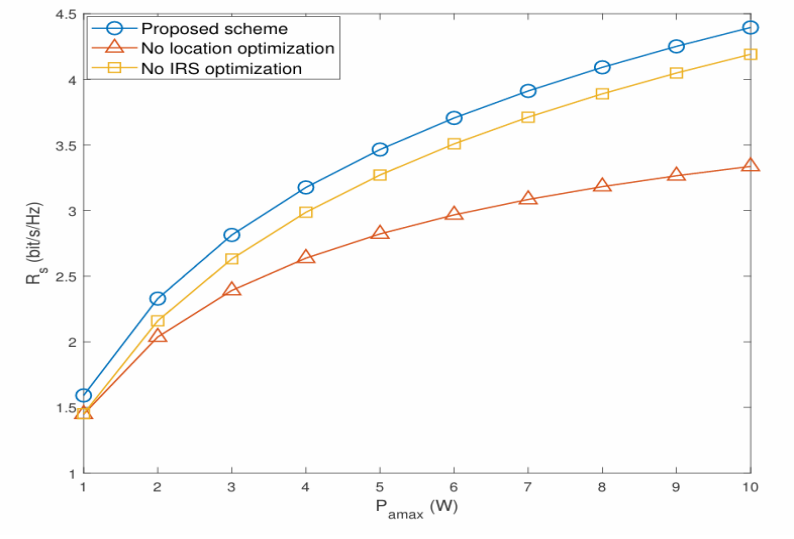
- UAV tends to fly shorter
- UAV flies closer to users when data amount increases



- Higher transmit power and secrecy rate when lower security requirement
- Optimal blocklength changes

Research Advances and Results

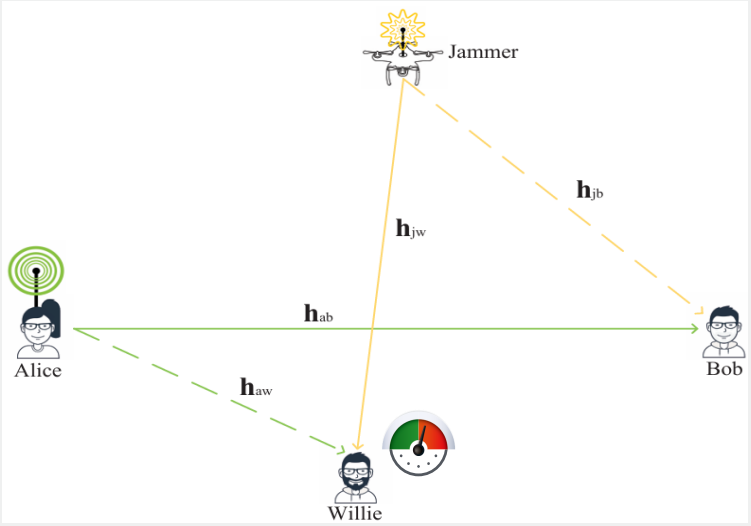


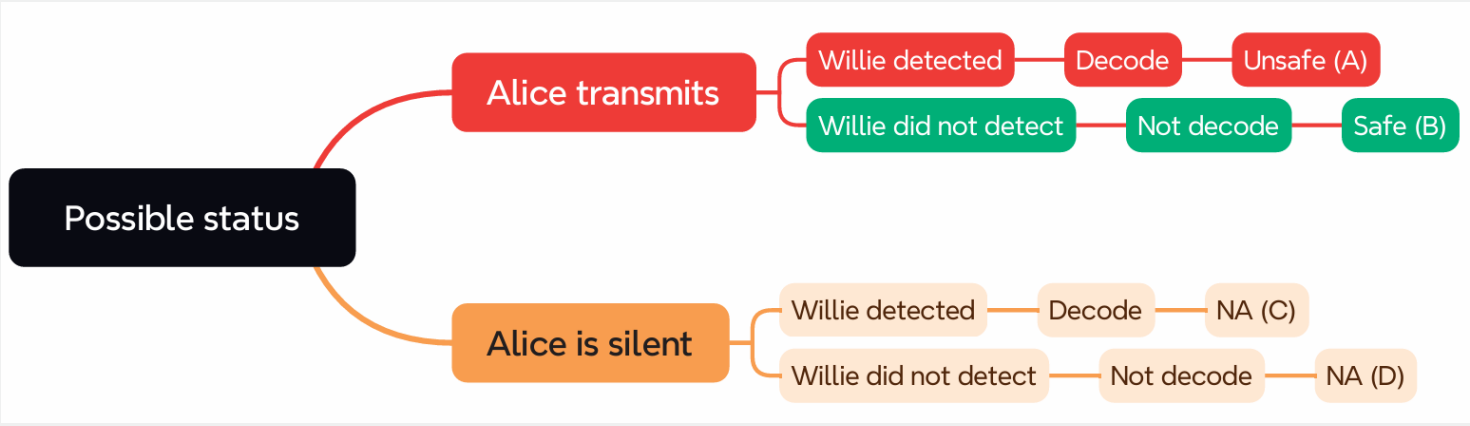


- **IRS-on-UAV Secure Transmission**
  - **Maximize secrecy rate: f1, f2, Θ, Lr**

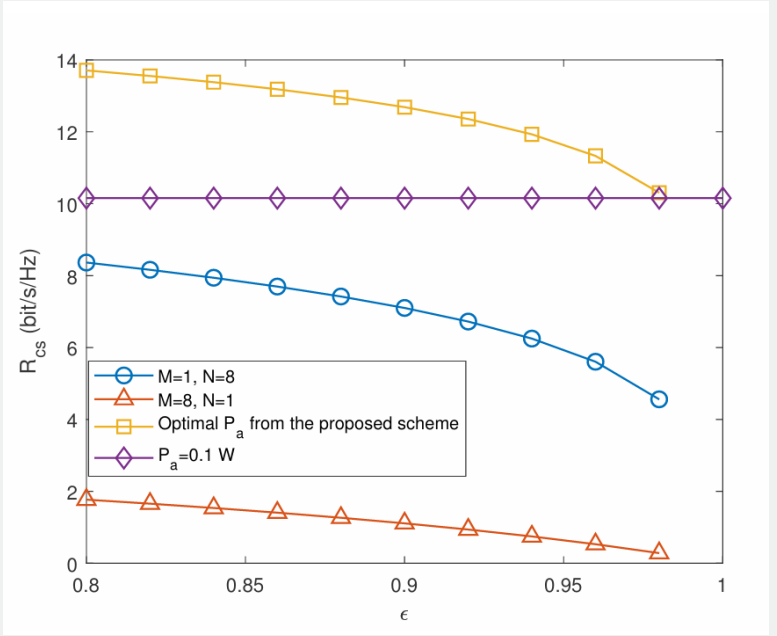
- **Higher secrecy rate as higher allowed transmit power**
- **Better performance compared with benchmarks**

Research Advances and Results





- Improve covert secrecy rate via PLS method
  - Worst case: maximum p_e
  - Maximize covert secrecy rate (case A and B): Pa, Pj



- Higher secure transmission rate than benchmarks
- Proposed scheme still performs better under stricter security requirement

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Conclusion: Impacts and Future Directions

- Ensuring secure communication for critical applications like smart cities and IoT.
- Reducing vulnerability to eavesdropping in wireless networks.
- Paving the way for the combination of covert communication and PLS.

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Is AI Always A Better Solution?

AI Method: ML, DL, RL, DRL, and FL

- Adaptive
- Solves complex, high-dimensional, non-convex problems
- Dynamic and uncertain wireless networks

Traditional Optimization

- Rigorous and interpretable
- Efficient for structured
- Low computational Complexity

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Thank you!

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