Demo: Adversarial Aerial MetaSurfaces

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ABSTRACT

Investigating the security vulnerabilities of wireless backhaul links to aerial metasurfaces, we define and demonstrate for the first time "**R**emotely Positioned **M**etaSurface-**D**rone" (**RMD**) attack in our paper [1]. In the attack, the adversary Eve remotely approaches hard-to-reach wireless backhaul links, e.g., between towers, and secretly manipulates highly directive backhaul transmissions on-the-fly, enabling remote eavesdropping. Here, we show the key aspects of [1], including the design and fabrication of the light-weight power-free transmissive on-drone diffractive metasurface. We also demonstrate the implementation of the attack on sub-THz wireless networks, presenting a video of RMD attack experiments. Our results reveal that the attacker can effectively intercept back-haul transmissions while leaving a minimal energy footprint on legitimate communication.

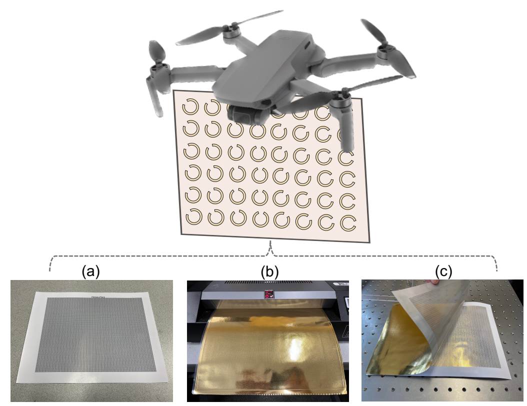

Figure 1: Adversarial aerial metasurface fabrication

1 ATTACK OVERVIEW

Wireless backhaul links are a critical part of wireless communication and commonly exploit mmWave and sub-THz frequency bands (30-300 GHz) for high-data-rate and low-latency transmissions. Wireless backhaul antennas are usually positioned in elevated hard-to-reach regions and employ highly directive links, thus presumably immune from over-the-air attacks. In [1], we show for the first time that a strong adversary can secretly manipulate the backhaul transmission wavefront on-the-fly and enable remote eavesdropping.

Exploring the foundation of the attack, we describe Eve's on-drone metasurface design strategy and show how she induces a secret 3D diffraction radiation beam on the intercepted backhaul transmission, re-purposing it for eavesdropping. We also discuss Eve's flight navigation strategy that allows her to adapt the RMD flight pattern to dynamically shape the radiation pattern in the attack and consistently improve her signal reception at a remote location [1].

2 OUR DEMO

RMD Design and Prototype. In this demo, we present the design and fabrication of the lightweight power-free transmissive on-drone diffractive metasurface. Particularly, we demonstrate the RMD with C-shaped split ring resonator meta-atoms [2] and show how the attacker controls the overall EM response of the metasurface based on the geometrical properties of each meta-atom, i.e., radius r, slit opening α, and orientation β. We also demonstrate Eve's strategy of rapidly fabricating [3] such metasurface employing only standard office supplies such as a piece of paper, a metallic foil, and a laminator as shown in Figure 1. As such, we show that the effective metasurface can weigh less than 10 grams (without frame) and does not require any external power supply, attacker performing aerial wavefront manipulation with minimal extra payload.

Attack Implementation. Moreover, we demonstrate the implementation and preliminary experimental evaluation of the RMD attack in the sub-THz network, presenting the video of the experiments (as it is costly to transport the sub-THz testbed). Specifically, we first show the experimental setup built upon the TeraNova testbed [4] targeting 130 GHz center frequency with 5 GHz of bandwidth and the RMD based on an off-the-shelf DJI drone and fabricated metasurface of size A4 paper. Conducting a series of small-scale experiments, we demonstrate the effectiveness of the RMD attack and show that it leaves a minimal attack footprint, which also may be hard to differentiate from the effects of weather [4].

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