Anonymous Remote Identification of Unmanned Aerial Vehicles

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Agenda

UAV Security and Privacy

Background on UAVs, Security and Privacy Issues

Anonymous Remote IDentification

Our proposed framework: ARID

FAA Remote Identification Rule

Remote Identification *aka* RemoteID

Security Analysis & Performance Evaluation

Security features offered by ARID and its performance assessment.

Scenario and Adversarial Model

What we assumed for our scenario and for the adversary capabilities

Conclusion and Future Work

What we offered and what are the future ARID extensions

Background - UAVs and Drones

1

The new Market

UAVs are becoming enabling technology for several applications including monitoring, surveillance and shipping.

Market size is currently valued at $5.80 billion

Compound annual growth rate (CAGR) of 56.5% up to the 2025

2

The Features

Exploit the Wi-Fi bands (2.4GHz - 5GHz) or 4G-LTE/5G

Navigation relies on GNSS technologies (GPS, Galileo, …)

Limited battery lifetime

Capability to perform missions autonomously

3

I(oT) can fly …

Flying constrained devices (UAVs as the new “Flying IoT”)

Worldwide Drone Incidents

- Police and air traffic control intervene after drone spotted at Newcastle – Stadiums - Newcastle, United Kingdom - October 8, 2021

- Criminals Use Drones to Drop 5 Liters of Flammable Liquid - Law Enforcement/First Responders - October 1, 2021

- Drone crashes into Leaning Tower of Pisa - Private/Non-Corporate - Pisa, Italy - September 28, 2021

- Drone spies on private home - Private/Non-Corporate - Albringhausen, Germany - July 11, 2021 …

SOURCE: HTTPS://WWW.DEDRONE.COM/

FAA Remote Identification Rule

US-based **Federal Avionics Administration**(FAA) recently published a new dedicated regulation, namely *RemoteID*

- To enable enhanced accountability of Unmanned Aerial Vehicles(UAVs) operations
- It forces all UAVs operators to broadcast messages reporting their identity, location (GPS position), and information about ground station
- *RemoteID* does not specify how to generate such identifiers, nor provide guidelines to operators for their design
- *RemoteID* regulations became effective on the 21st of April 2021, and UAV operators need to comply with this rule from September 2022

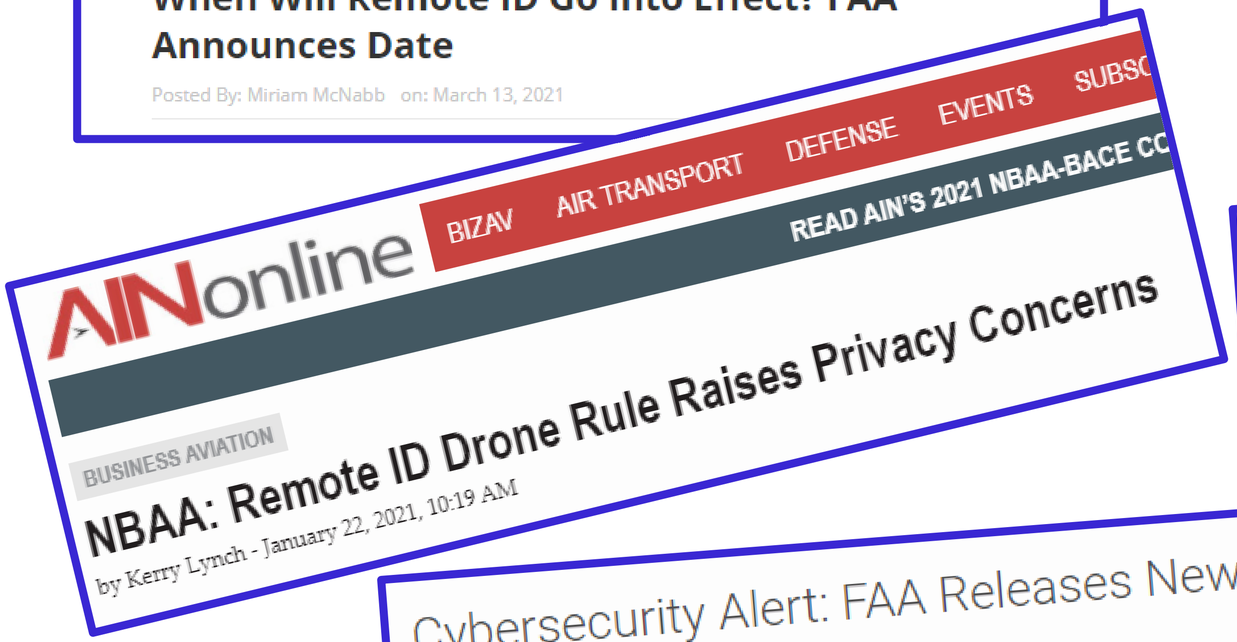
Federal Aviation Administration

REMOTE ID RULE

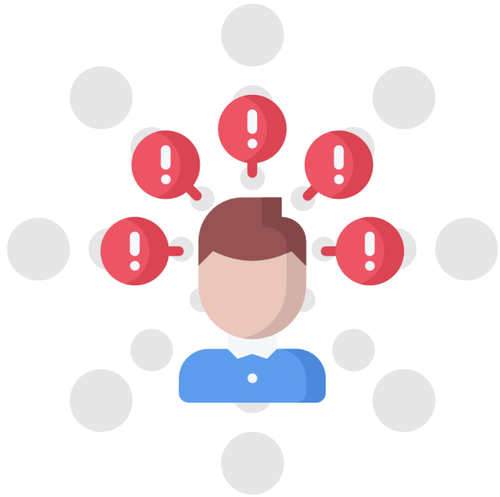
According to the Remote ID specification, UAV must periodically broadcast messages containing at least the following information

Unique ID	**Drone Latitude, Longitude, Altitude, Speed**	**GCS Latitude, Longitude, Altitude**	**Timestamp**	**Emergency Status**

Motivations



Privacy Issue for Drone Operators



Drone Operators do not want to put privacy at risk

- Passive Tracking
- Privacy leakages for people (manufacturer, etc.)
- Operators want evidences for misbehaving drones

System and Security Requirements

Drones

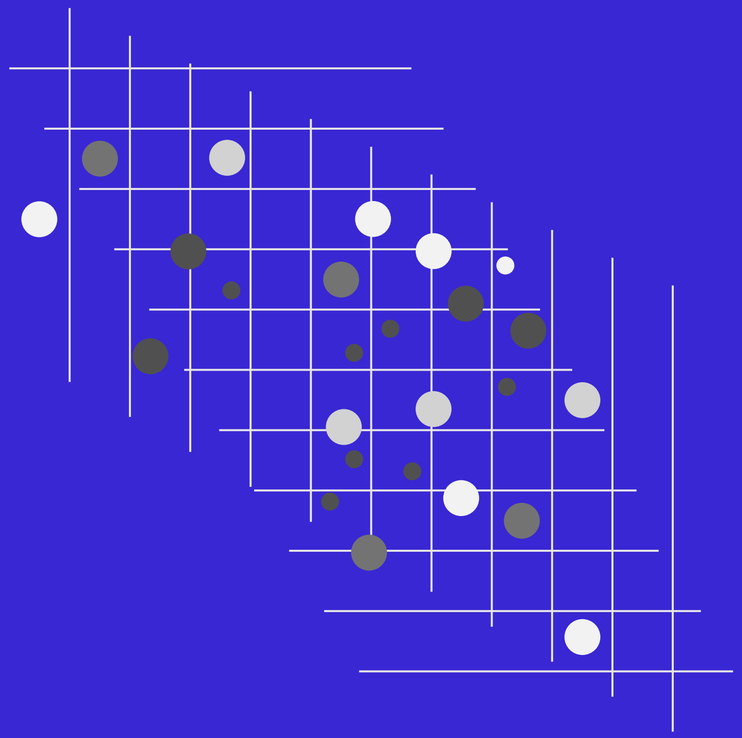
- No Long-Term Identity Broadcast
- Only Authority (based on a formal report) should identify long-term identity from messages
- Protection against External Cheating (False Reports)

Operators (e.g., Airport)

- Report misbehaving drones invading private areas

Authority (e.g., FAA)

- Verify private areas invasion claims by operators
- Identify misbehaving drones
- Be sure that operator is not cheating on drone position
- Zero interaction with drones' operators



Scenario and Adversary Model

Critical Infrastructure
generic receiver listening to the packets to detect any UAV invasion

Trusted Third Party
it releases the cryptographic materials, limited storage overhead---no storing of any sensitive data (*only TTP private key*)

UAVs
broadcast connection-less interactions between any group of UAV (nullified MAC addr)

Adversary
passive and active capabilities---drone tracking, eavesdropping long-term identity, UAV spoofing

ARID - PHASES

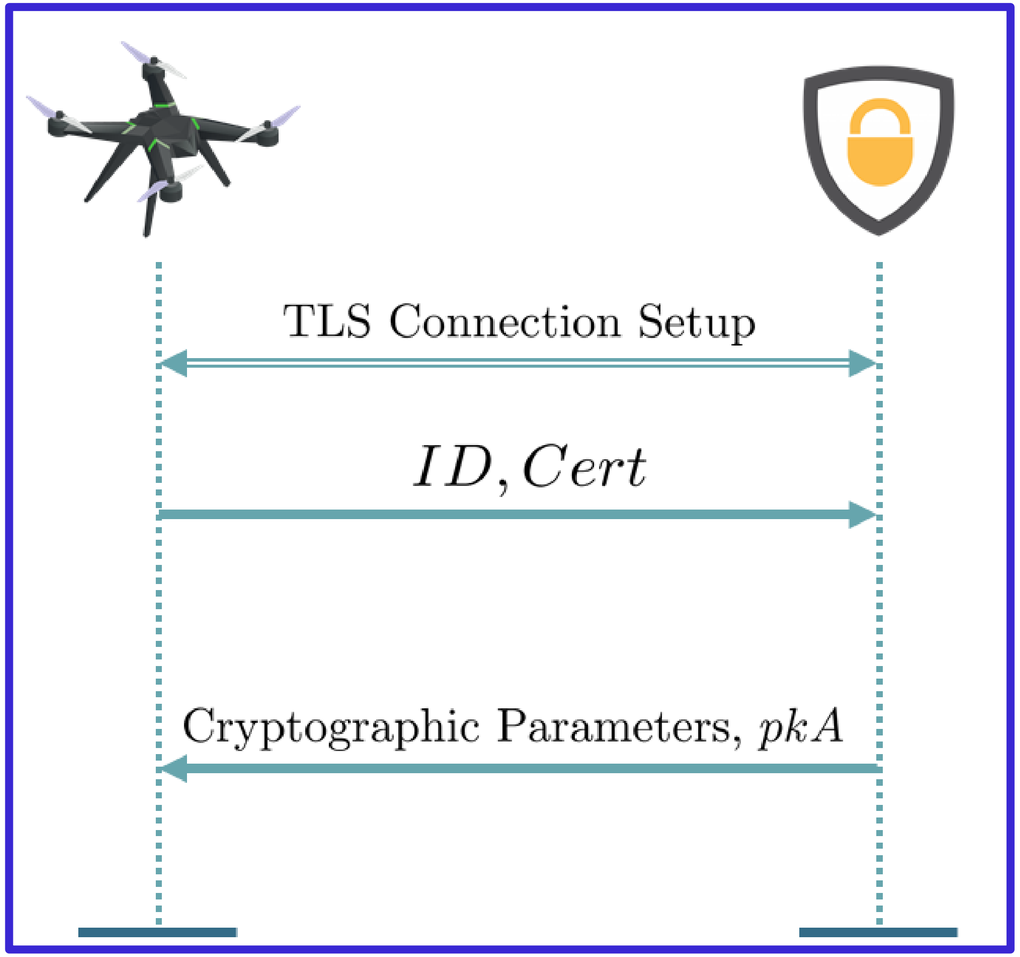
1) Registration Phase

2) On-Line Phase

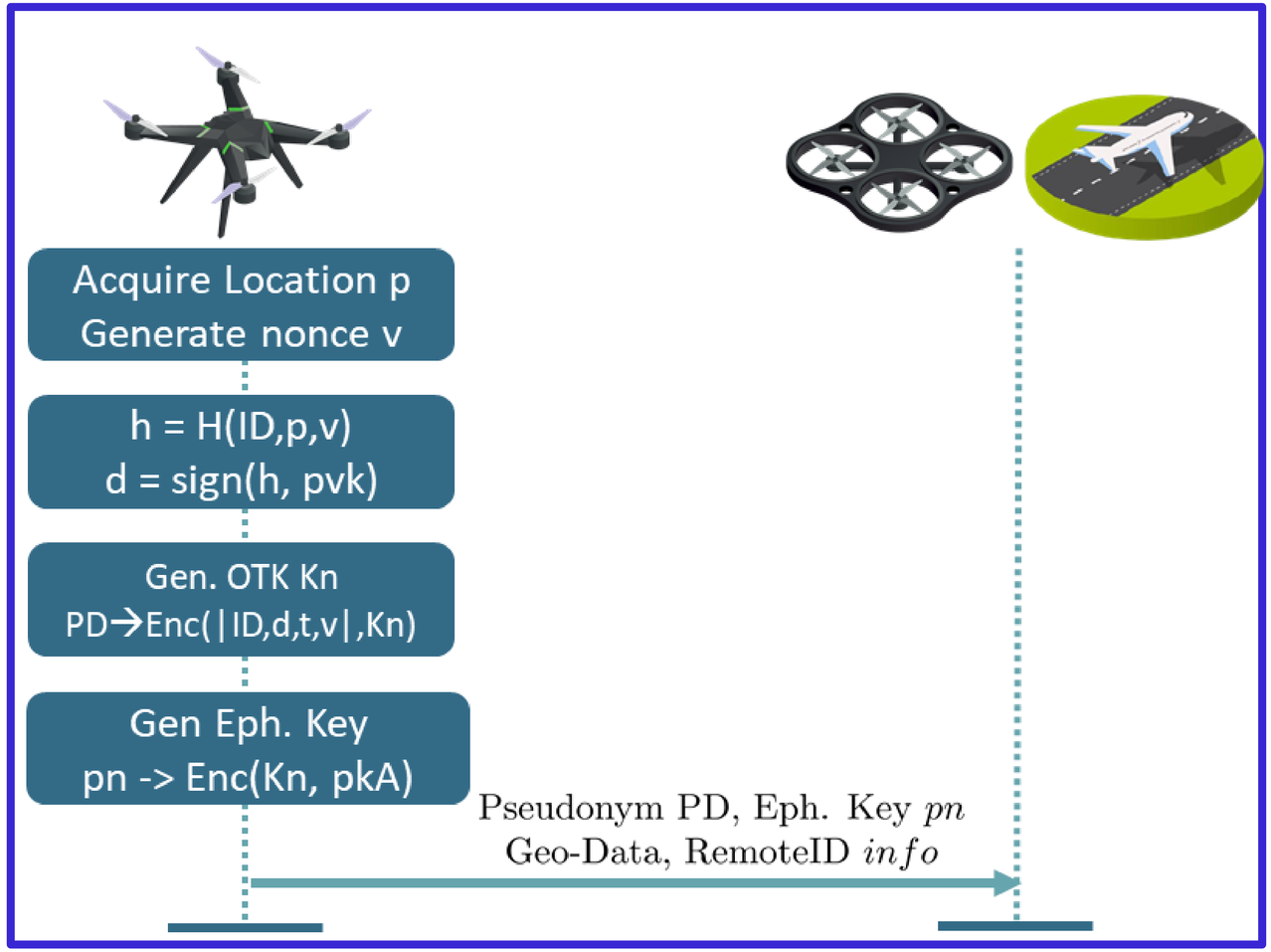
3) Reporting Phase

ARID: Anonymous Remote IDentification

1 *Registration Phase*

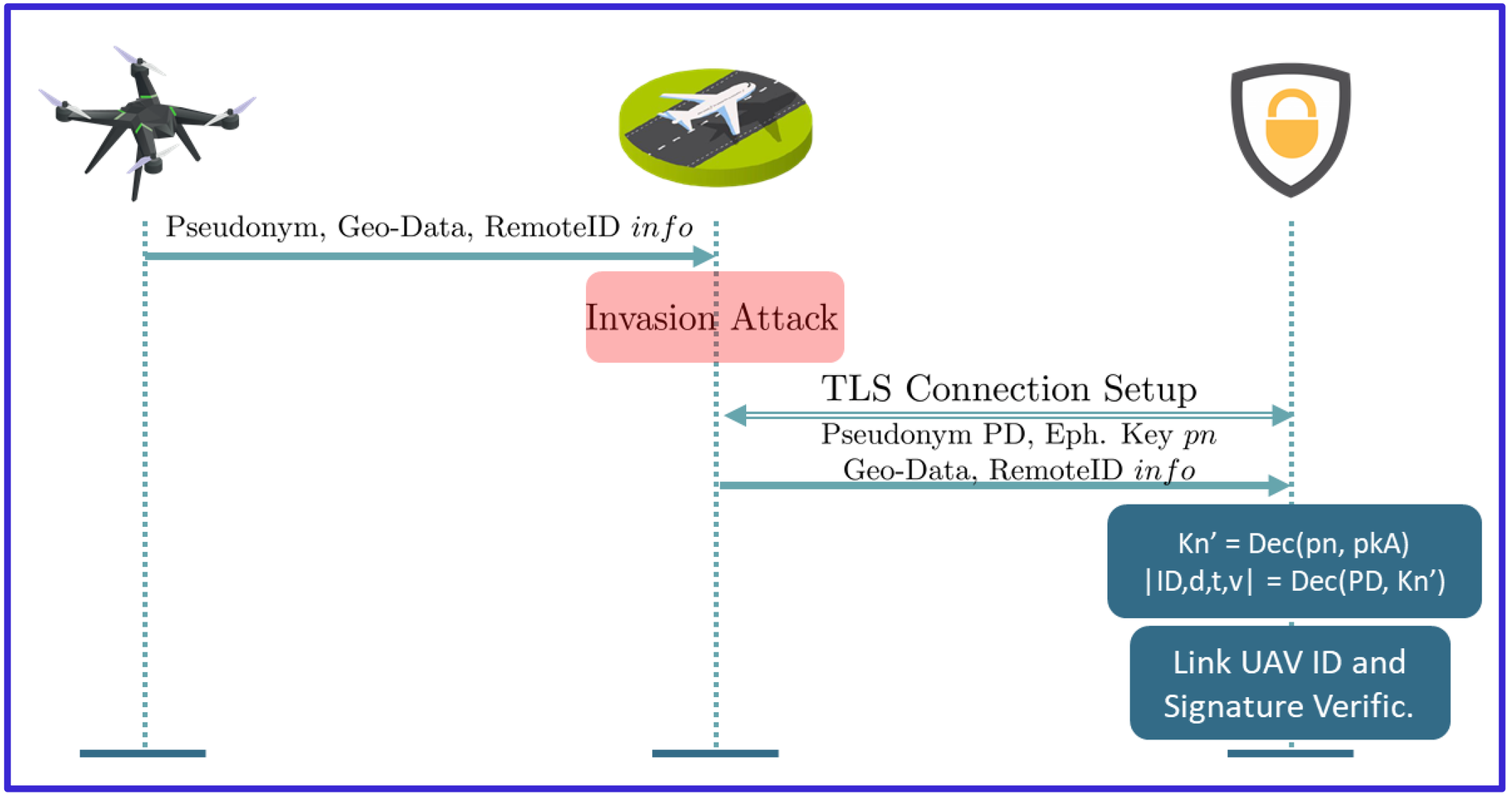


2 *Online Phase*



ARID: Anonymous Remote IDentification

3 *Reporting Phase*

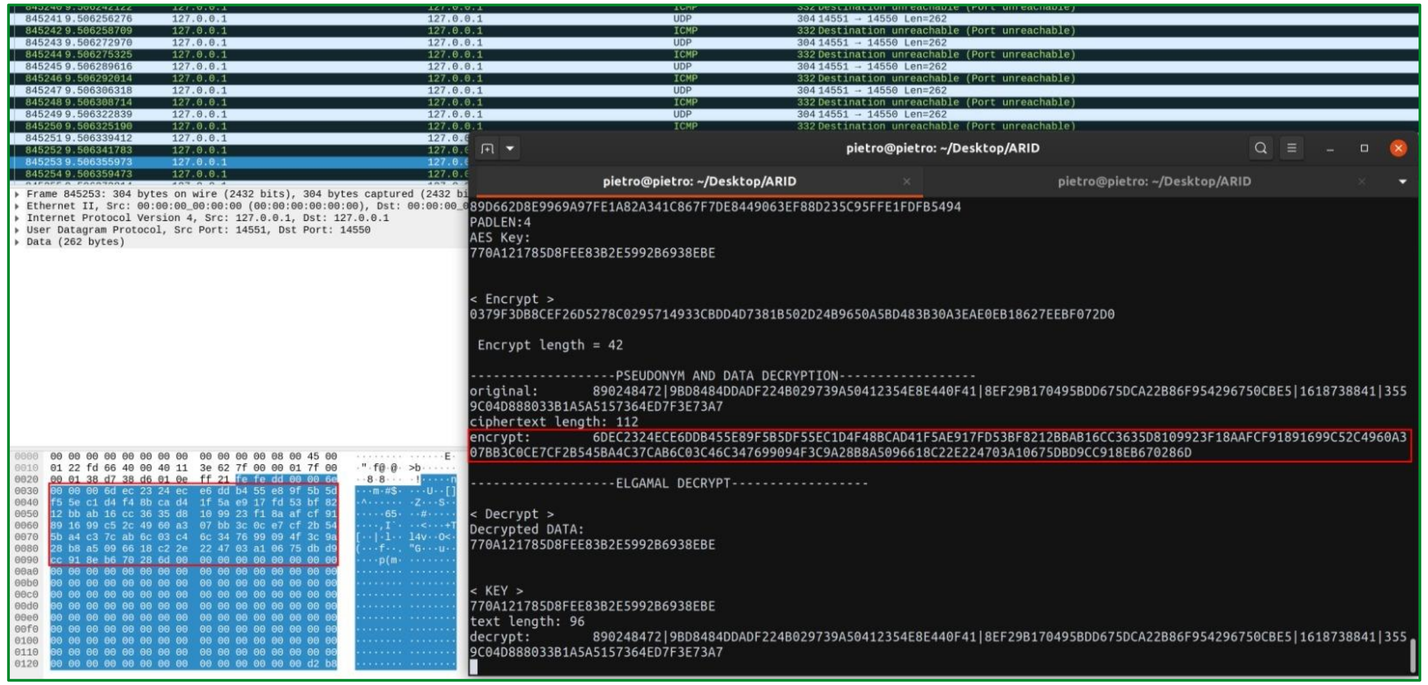


Security Services

Security features offered by **ARID**

- UAV Anonymity
- UAV Message Authenticity
- Protection against Replay Attacks
- Partial Protection against UAV tracking

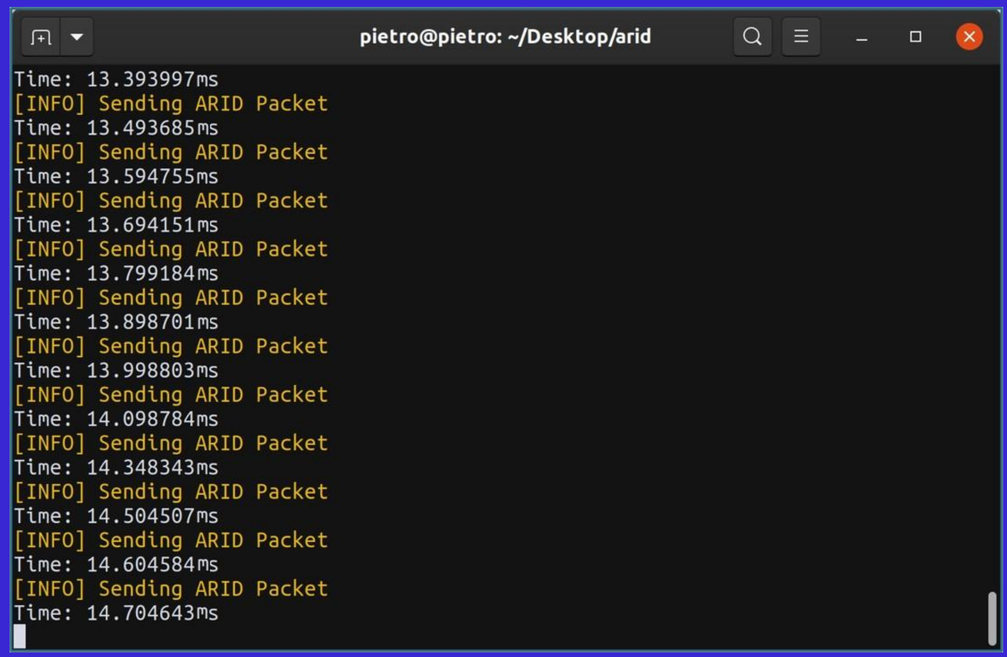
ARID at work




```
RESULT event(termAuth(id_1)) ==> event(acceptUAV(id_1)) is
true.
RESULT not attacker(IDA[]) is true.
RESULT Non-interference IDA is true.
```

3DR Solo Details + ProVerif

- 3DR-Solo, CPU i.MX6 Solo - 1.00GHz ARM Cortex A9
- 7,948MB ROM, 512MB RAM
- Cryptographic Acceleration and Assurance Module
- 3DR Poky OS 1.5.1, OpenSSL 1.0.0, MAVLink 1.0



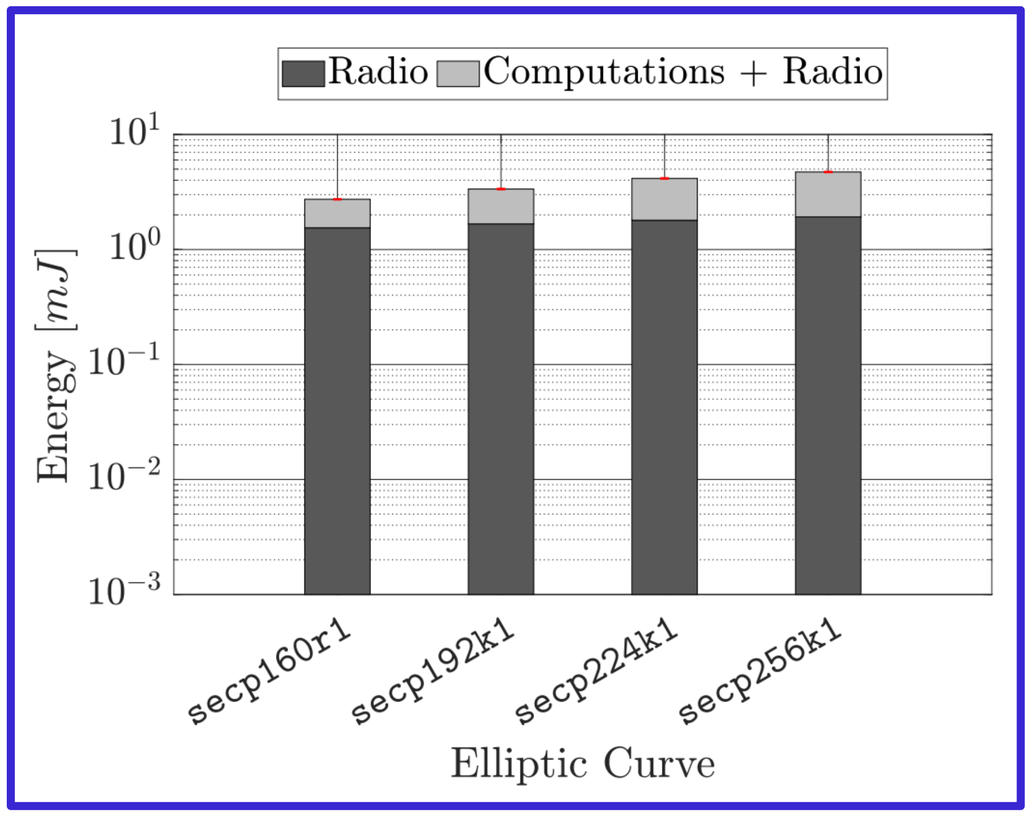
MAVLINK
MICRO AIR VEHICLE COMMUNICATION PROTOCOL

OpenSSL
Cryptography and SSL/TLS Toolkit

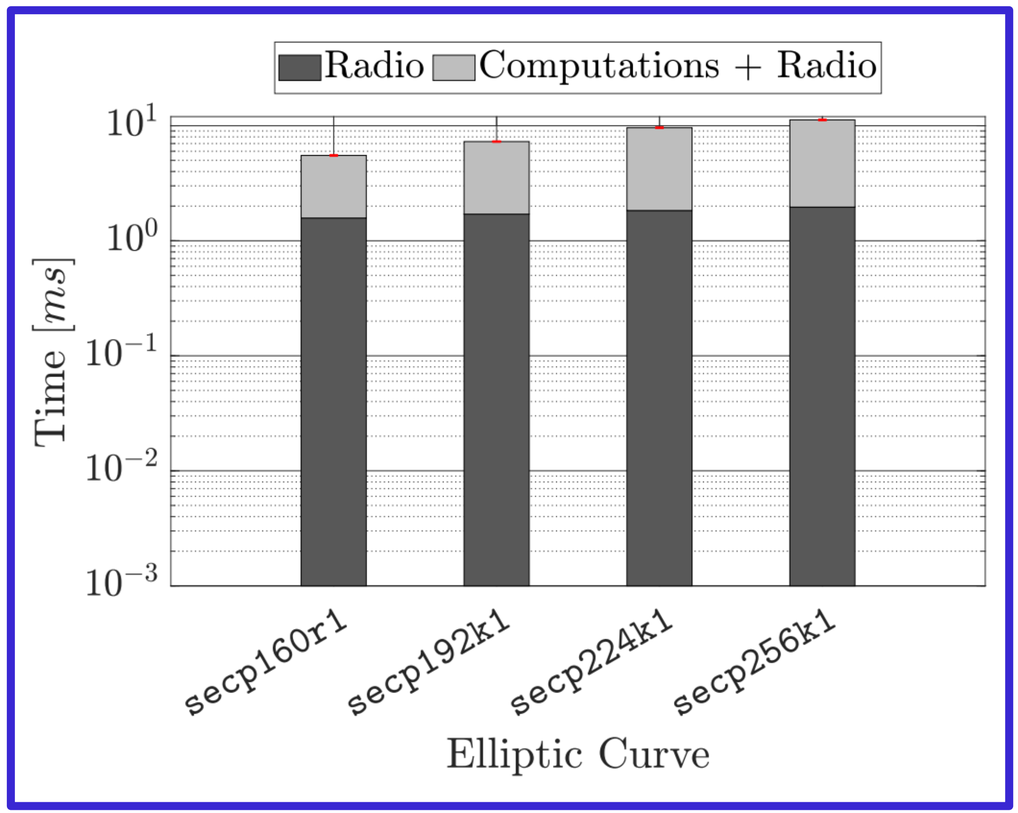
Performance Assessment

Impact of ARID on the battery lifetime. The most energy-consuming configuration of ARID (*secp256k1*) reduces the lifetime of the 3DR-Solo **by only 1.05%** compared to the default (non-anonymous) *RemoteID* configuration, **further demonstrating its limited overhead**.

Energy Consumption



Radio and Computation Time



Conclusion and Future Work

- Fully compliant with the latest *RemoteID* regulations by the FAA
- Complete anonymity and unlinkability of UAV broadcast messages + tunable level of security
- 11.23ms to create and transmit anonymous *RemoteID* messages & 4.72mJ of energy ($\mathbf{1.67 \cdot 10^{-6}}$% of the overall battery)
- Security properties have been discussed/formally proved via ProVerif
- **Proof of Concept released as Open Source @ *https://github.com/pietrotedeschi/arid***

GitHub

THANK YOU !

Any Questions?

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