Challenges in NextGen Air Traffic Management

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Introduction

In order to meet future demands in increasingly congested airspaces, aviation authorities are currently upgrading air-traffic management systems. The **Automatic Dependent Surveillance-Broadcast (ADS-B)** protocol is at the core of Next Generation Air Transportation. It allows aircraft to broadcast their position periodically over a radio frequency to ground stations or other aircraft. Originally open by design, ADS-B lacks any security or authentication mechanism. Without authentication and integrity checks, every passive and active attack on the wireless communication is possible. This includes but is not limited to the injection or flooding of a ground station with ghost aircraft, virtual trajectory modification, aircraft disappearance, and aircraft spoofing.

Objectives

Our research presented in this poster seeks to address the security challenges in the Automatic Dependent Broadcast Protocol. We want to understand both the channel behavior to advance protocol development and research statistical detection methods to create transparent security improvements. This includes:

1. Designing a trajectory verification method based on RSS sampling.
2. Fingerprinting transponder signals with self-defined features in the time domain.
3. Searching for advanced fingerprinting features in the frequency domain employing fast Fourier transform and principal component analysis.

Fingerprinting 1 - VeriFly

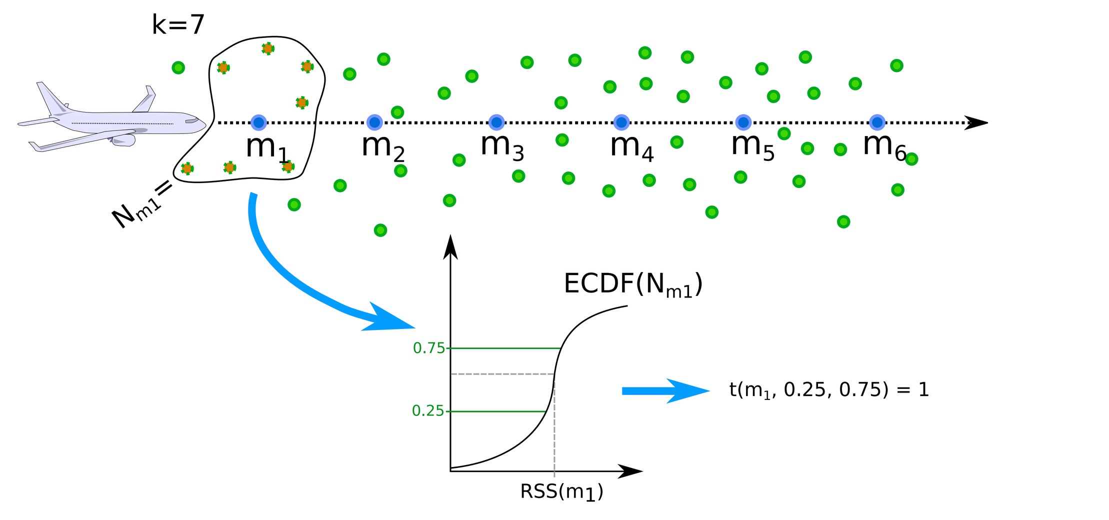


Figure 1: Schematic mode of operation of VeriFly: (1) The reception range is sampled with trusted (green) aircraft (2) The sampled data is transformed in an RSS map and stored in a database (3) Untrusted aircraft are verified using (4) the previously stored RSS map.

We propose VeriFly, an RSS-profiling based approach, which uses three-dimensional RSS maps to verify an aircraft's reported trajectory. We assume only one single verifier, thus VeriFly can be deployed at each ground station independently. As we use RSS for our approach, we assume that all aircraft transmit their position reports using the same transmission power. VeriFly operates in two phases. In the calibration phase, the reception range is sampled by legitimate senders in order to establish a three-dimensional RSS map. In the second phase, the verification phase, untrusted trajectories are verified using the previously established RSS map. Figure 2 shows the VeriFly scheme against a knowledgeable attacker.

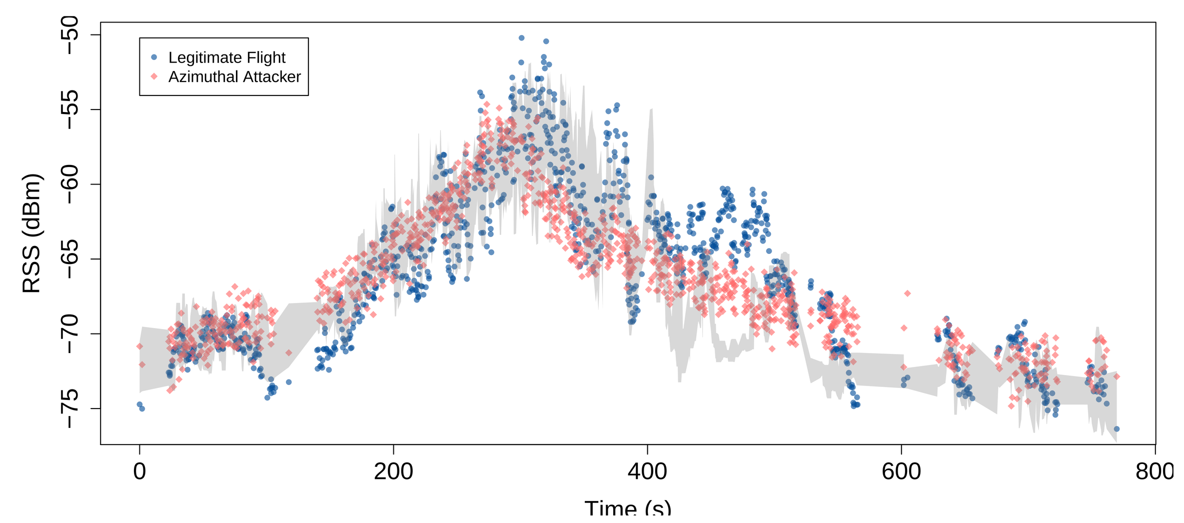


Figure 2: Real-world VeriFly profiling.

Fingerprinting 2 - Time Domain

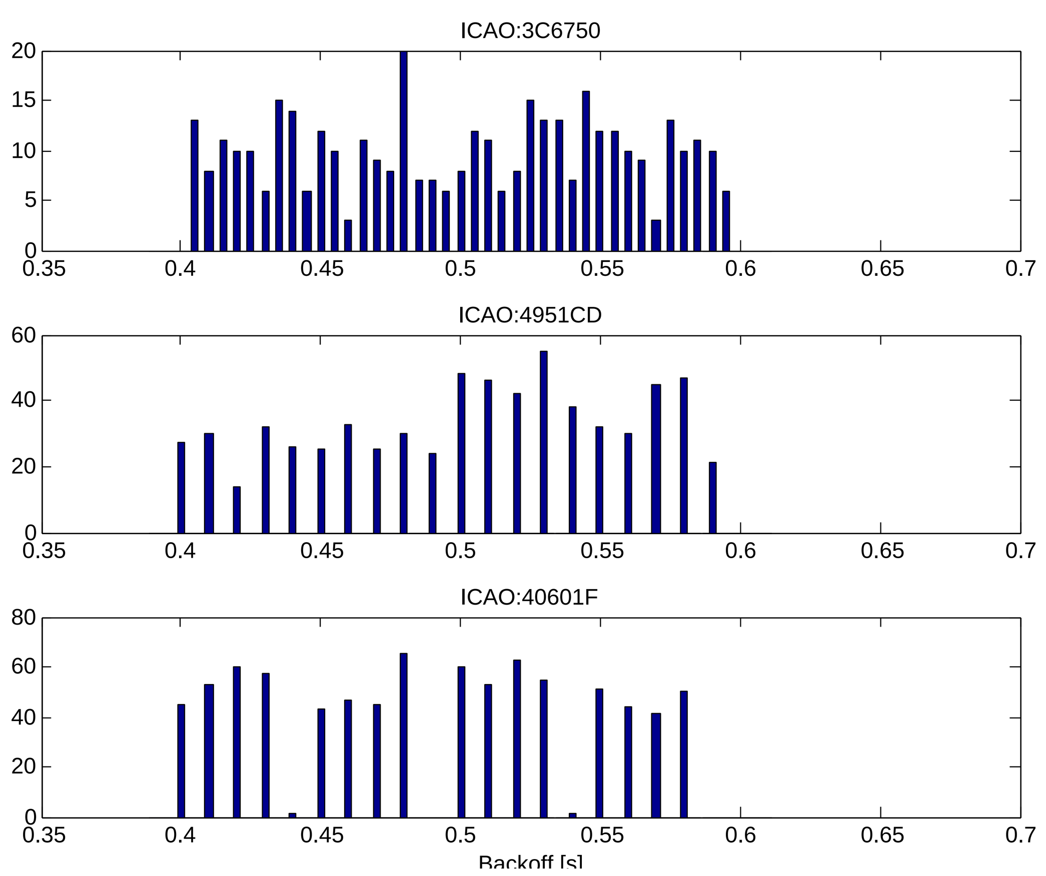
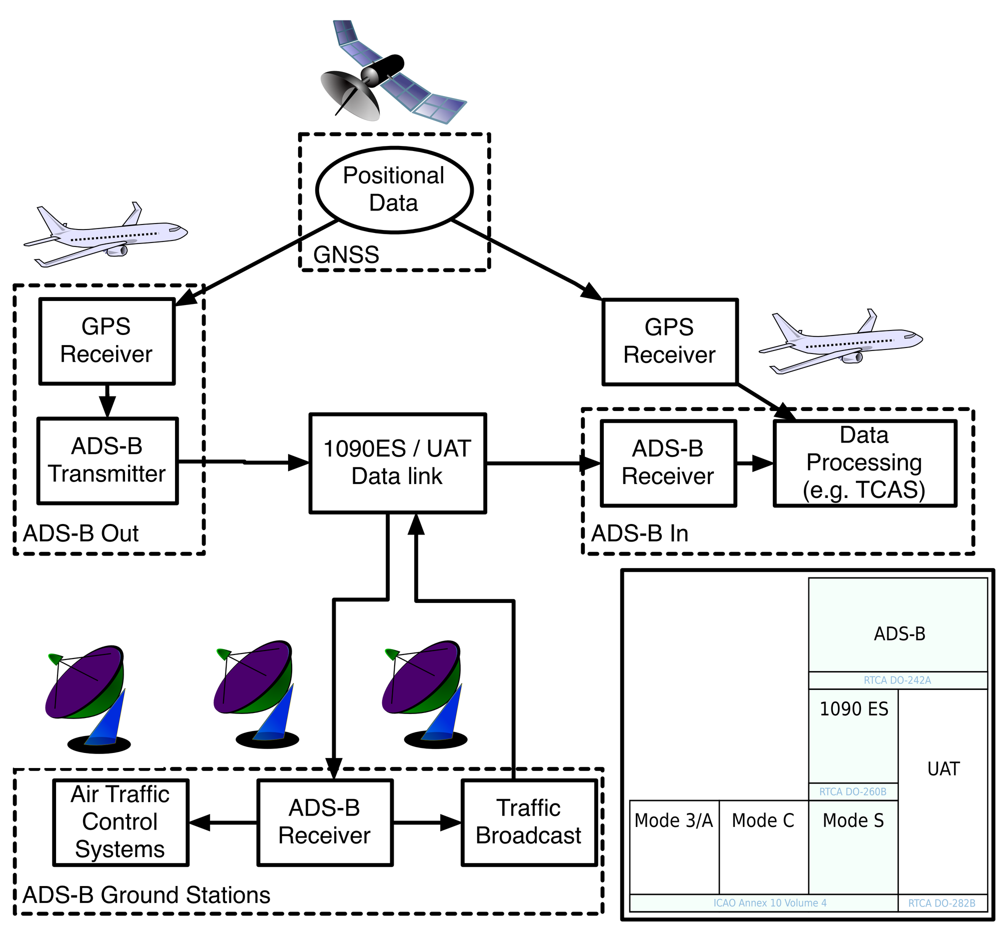


Figure 4: Example of varying random backoff behavior in positional messages of ADS-B equipped aircraft

Besides RSS sampling, we are looking at various approaches to fingerprint the transponders of ADS-B equipped aircraft. One example for a distinguishing feature would be the behavior of the random generator that generates the backoff between the periodically broadcasted ADS-B messages. The different transponders installed in commercial aircraft show very distinct behavior when we have a close look at the precise time periods between two subsequent messages (position, velocity, or call sign). One example of this backoff property between positional messages is shown in Figure 4. There are various classes, each exhibited by between 5% and 30% of the monitored aircraft.

ADS-B System Overview



OpenSky Sensor Network

For our real-world experimental studies., we created OpenSky, a sensor network based on low-cost hardware. OpenSky works with off-the-shelf sensors run by volunteers distributed over Central Europe. Currently comprising 11 sensors, it covers an area of 720,000 km^2. We capture more than 30% of Europe's commercial air traffic. Our data shows that despite the fact that ADS-B is still in testing stage, a majority of commercial flights (about 70%) over Central Europe has already adopted the new standard.

Online Since	31/01/2013
Received messages	> 4,500,000,000
Flights per day	ca. 7,500
Different aircraft	ca. 13,000

Table 1: OpenSky statistics as of February 2014.

References

[1] M. Strohmeier, M. Schäfer, V. Lenders, and I. Martinovic. Realities and Challenges of NextGen Air Traffic Management: The Case of ADS-B. *IEEE Communications Magazine*, 52(5), 2014.

[2] M. Schäfer, M. Strohmeier, V. Lenders, I. Martinovic, and M. Wilhelm. Bringing Up OpenSky: A Large-scale ADS-B Sensor Network for Research. In *ACM/IEEE IPSN*, April 2014.

Further Research

In further research, we look to independently verify ADS-B data received by ground stations. We employ the fast Fourier transform in conjunction with principal component analysis to improve our fingerprinting schemes. We will both further our statistical countermeasures and examine cryptographic protocols to authenticate ADS-B messages, taking into account channel characteristics.

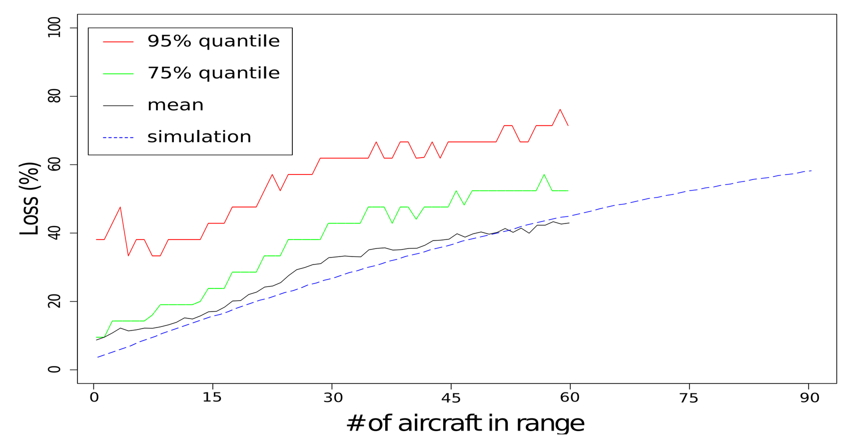


Figure 3: Real-world channel loss behaviour.

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