Atmospheric phenomena radio localization system

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Problem definition

Recent radio systems have significant capabilities to detect the presence of meteor trails. There is noticeable progress in the localization of these pathways. Unfortunately, the current localization methods have important requirements, which limits its practical use. One example is a necessity of correct model initialization, but the initial lack of position estimate result in a bad estimation performance. Therefore we present a new receiver and signal processing system which could obtain a better data to initialize the trajectory estimation model. As extra the proposed method can be used to detect more atmospheric phenomena than meteor trails.

To obtain the initial position estimate. The information about the direction of the signal source is needed. Such data can be obtained by radio direction finding methods. The most perspective method is antenna array direction finding because it allows simultaneous processing of the signal from multiple or complex signal sources.

Station Hardware

Antenna array direction finding systems are complicated systems without universal the shelf solutions; therefore, the reception system needs to be developed.

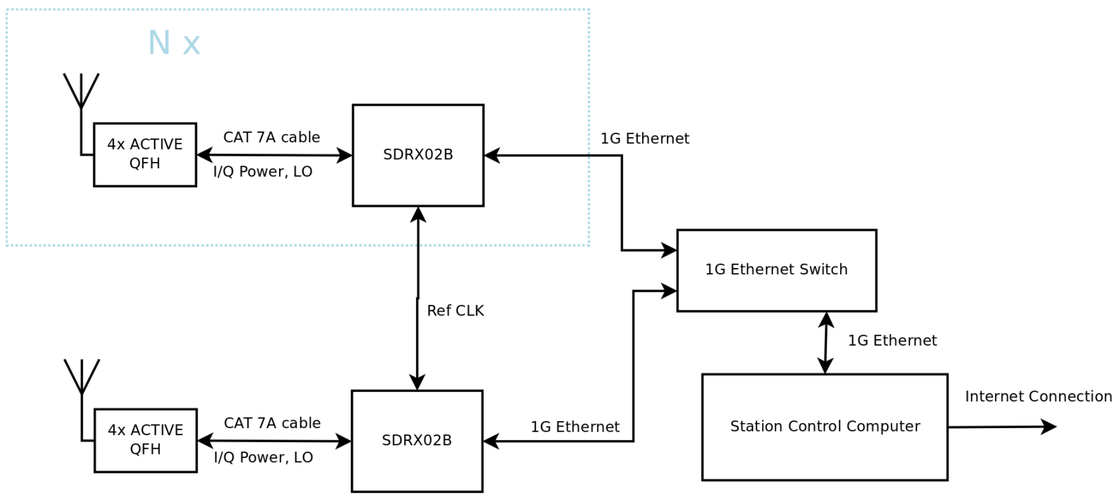

Figure 1 – Proposed radio reception station setup with multiple antennae arrays.

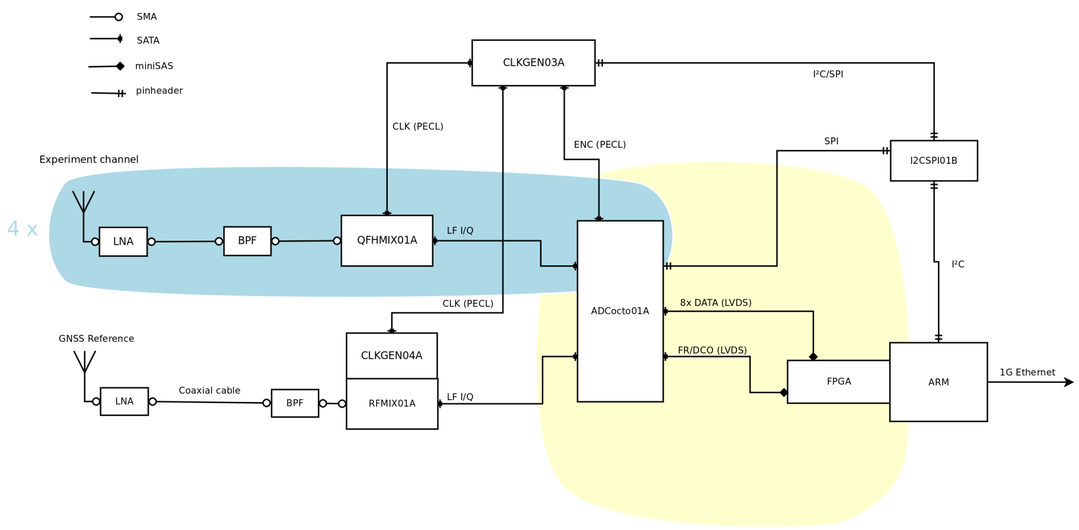

Figure 2 – Single receiver block. The full expansion of SDRX02B part from Figure 1.

Therefore the new receiver hardware architecture is introduced to cover as many as possible scientific use cases of antenna array receiver.
Figure 1. shows overall schematics of receiver station connected to the network. The single station consists multiple blocks containing four antenna elements. The antenna block is visualized in Figure 3.

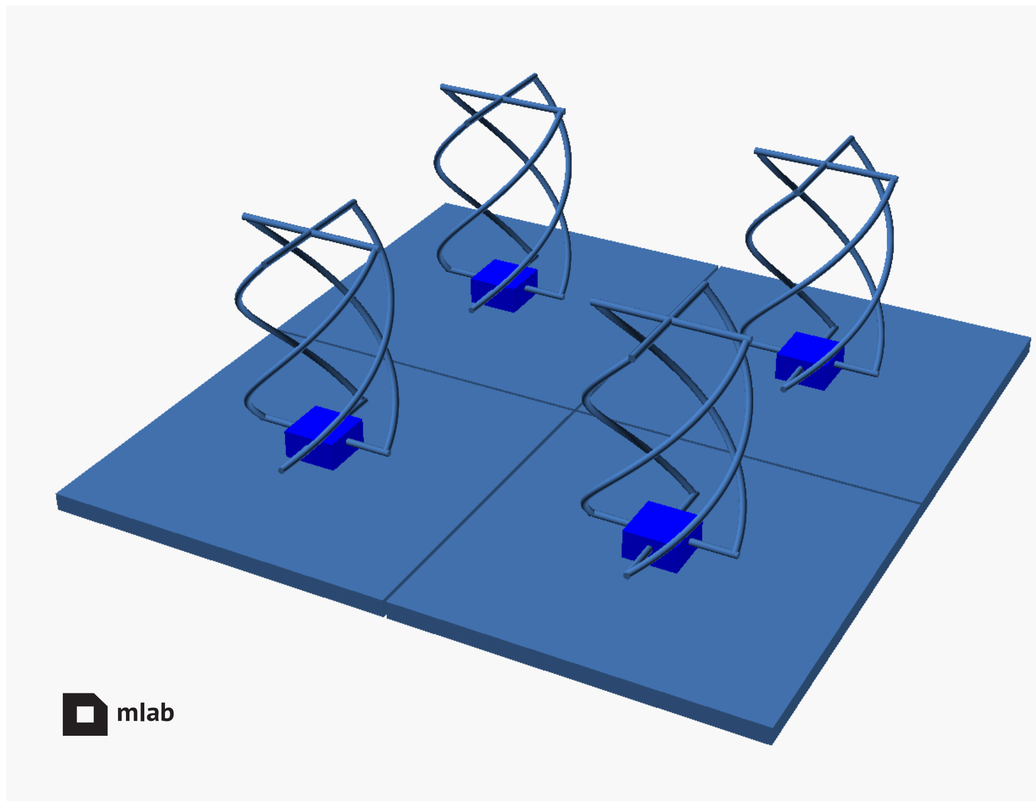

Figure 3 – Antenna array block. It consists four active Quadrifillar Helix antennas with LNA, band-pass filters, and mixers.

Station Software

Each station has multiple computation units. The antenna blocks are equipped by Xilinx Zinq FPGA containing ARM which allows running a Linux and Gnuradio. It allows basic processing antenna block signal and extracting GNSS reference data. The complete signal flow is displayed in Figure 4.

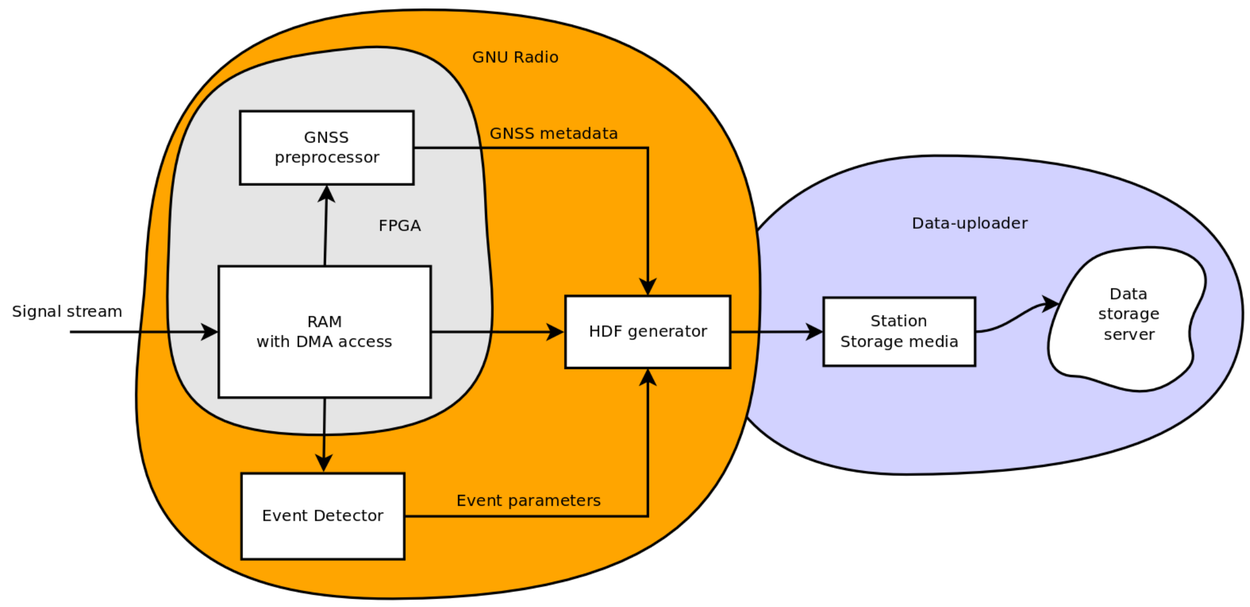

Figure 4 – The station signal processing diagram.

Network Deployment

It is supposed to exchange suitable existing Bolidozor network stations with new hardware allowing directional finding. The upgrade is not possible for all stations because the antenna array needs the specific environment to work correctly. It must have a flat and conductive surface with minimal obstacles to avoid distortion of antenna radiation patterns.
Therefore the most suitable are observatories with large flat roofs.

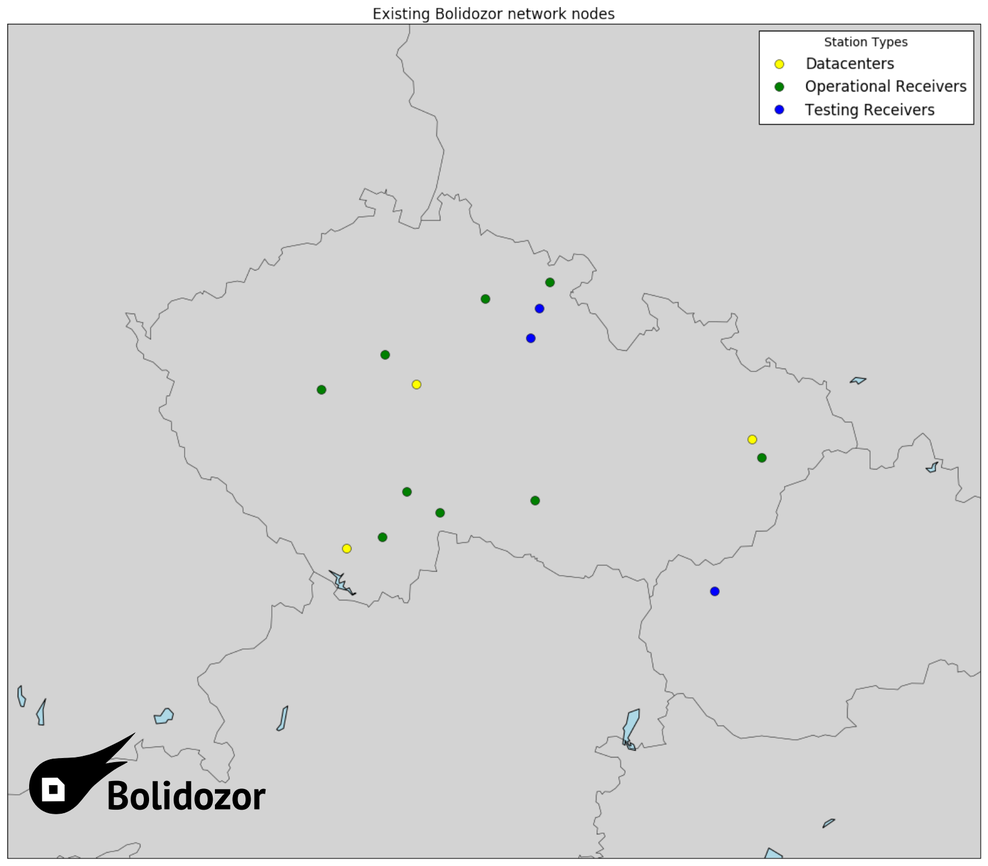

Figure 5 – The map of Bolidozor network nodes.

Network Architecture

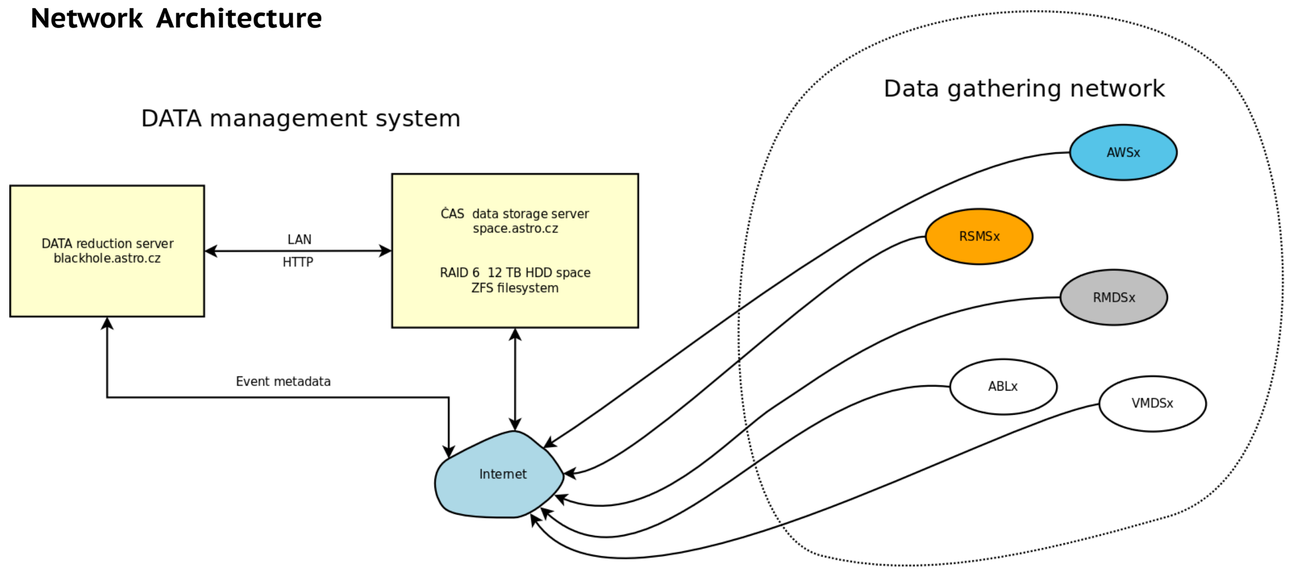

Figure 6 –The system architecture of data processing

Expected Data

The proposed system has parameters enough to detect and collect data about multiple scientific research targets. It can be used for radio detection and localization of meteor trails, lightning mapping, or for reception of satellite telemetry. It is possible because the receiving radio band is limited mostly by antenna design. Therefore reception band could be changed by using a differently sized antenna element or the station could be equipped with multiple antenna blocks each suitable for the different scientific project.
The proposed architecture allows the creation of software-defined radio reception campaigns triggered over distributed and redundant receiver network.

This publication was supported by OP RDE, MEYS, under the project CRREAT, CZ.02.1.01/0.0/0.0/15_003/0000481.