

# BBoxDB

A Key-Bounding-Box-Value Store

## BBoxDB Streams: Distributed Processing of Real-World Streams of Position Data

Jan Kristof Nidzwetzki / Ralf Hartmut Güting

Fernuniversität in Hagen, Germany

Database Systems for New Applications

{jan.nidzwetzki@studium., rhg@}fernuni-hagen.de

# Outline

## 1 Introduction

- BBoxDB Streams – Basics
- BBoxDB – Basics
- BBoxDB Streams – Architecture

## 2 Demonstration

- Used Data Streams
- Live Demonstration

# BBoxDB Streams

## BBoxDB Streams...

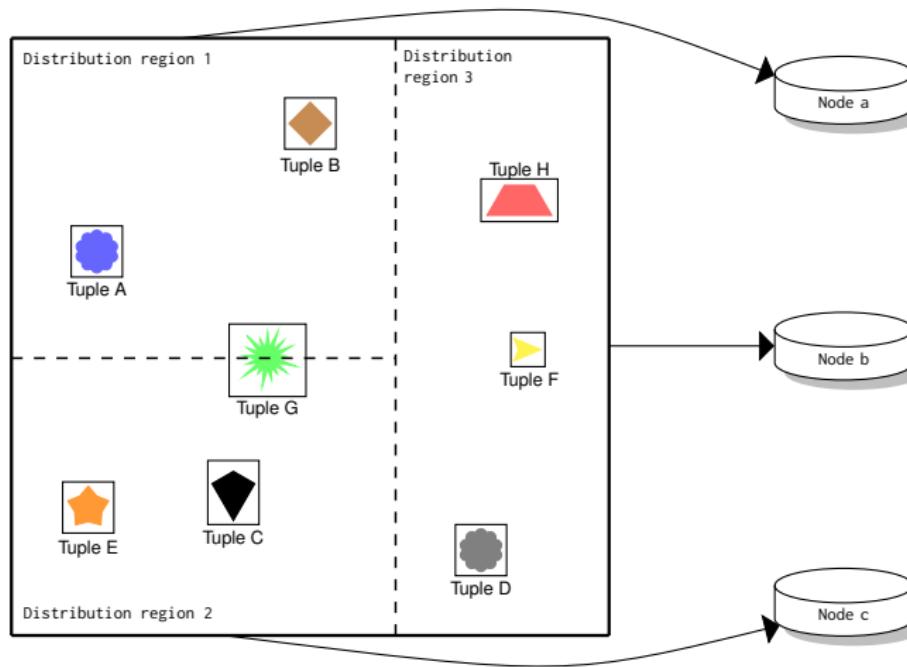
- is a distributed stream processing system that supports  $n$ -dimensional *point* and *non-point data*.
- uses the key-bounding-box-value store BBoxDB as data storage.
- supports continuous range queries.
- **allows efficient continuous spatial joins between static  $n$ -dimensional big data and stream elements.**

# BBoxDB – A distributed key-bounding-box-value store

## BBoxDB...

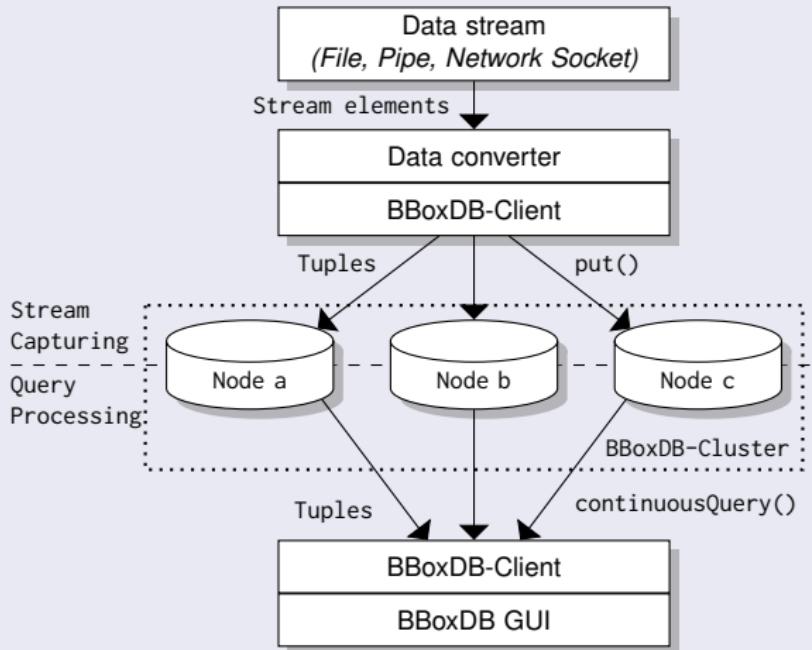
- is a distributed *key-bounding-box-value store*.
- stores each value together with a *bounding box*. The bounding box determines the location of the value in the  $n$ -dimensional space.
- partitions the space dynamically and redistributes the data.
- stores data co-partitioned for efficient spatial joins.
- is freely available and licensed under the *Apache 2.0* license.

# Partitioning the space



# Architecture

## Processing data with BBoxDB Streams





**Figure:** A USB-receiver which is capable of processing ADS-B (*Automatic Dependent Surveillance-Broadcast*) radio transmissions.

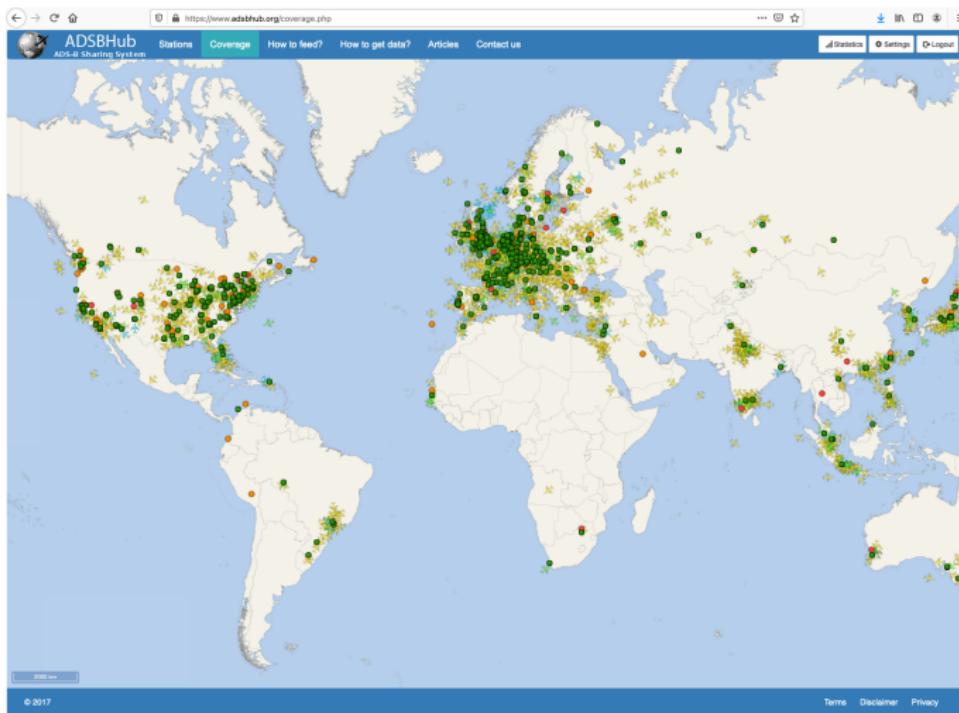


Figure: Aircraft position data fetched from the website <https://adsbhub.org/>

The screenshot shows the homepage of the NSW Open Data website (<https://opendata.transport.nsw.gov.au>). At the top, there are navigation links for 'LOG IN' and 'REGISTER', a search bar, and a 'Used Data Streams' section with links for 'Live Demonstration' and 'Summary'. A banner at the top reads: 'Historical car park data for selected Park&Ride and Metro station car parks is now available. Get it here.' Below the banner, a large image shows people walking through a modern subway station. To the right of the image, the text 'Open data available' is displayed, followed by a detailed description of the data: 'Today we supply real-time data to apps with over 7 million unique customer downloads in total. The Open Data program will make these datasets, along with other transport data, more broadly available. This data will be capable of supporting apps and a whole lot more.' A 'LEARN MORE' button is located below this text. Below the main image, there are four sections with icons and titles: 'Data Catalogue' (catalog icon), 'General Info' (info icon), 'Developers' (code icon), and 'Useful Links' (link icon). Each section has a brief description and a 'MORE' button.

Figure: Public transport data in *GTFS real-time* format are fetched from the website <https://opendata.transport.nsw.gov.au/>

# Live Demonstration

# Summary

## BBoxDB Streams...

- is a stream processing extension of BBoxDB.
- can handle  $n$ -dimensional data streams (e.g., *position data*).
- is able to perform continuous queries such as range queries and spatial joins.
- **the spatial joins are performed between the dynamic stream elements and static  $n$ -dimensional big data.**
- is written in Java and licensed under the *Apache 2.0 license*.

# Questions?

## Further information

- Web: <https://bboxdb.org>
- GitHub: <https://github.com/jnidzwetzki/bboxdb>
- Twitter: @bboxdb
- Google Groups: <https://groups.google.com/forum/bboxdb>

## Backup Slides

# ADS-B data

## ADS-B data in SBS format

```
MSG,1,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,,  
MSG,3,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,30525,,29.562973,33.627777,,,  
MSG,4,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,477.000000,0.000000,,,-448,,,,
```

```
MSG,1,0,0,100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR914,,,,,,,  
MSG,3,0,0,100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,25200,,29.792269,32.485603,,,  
MSG,4,0,0,100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,434.000000,99.000000,,1792,,,
```

```
MSG,1,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,,  
MSG,3,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,424,,52.379501,13.527200,,,  
MSG,4,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,6.000000,150.000000,,,-510,,,,
```

# ADS-B data

## ADS-B data in SBS format

```
MSG,1,0,0 100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,,  
MSG,3,0,0 100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,30525,,29.562973,33.627777,,,,  
MSG,4,0,0 100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,477.000000,0.000000,,,-448,,,,
```

```
MSG,1,0,0 100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,2.485603,,,,,,  
MSG,3,0,0 100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,00000,,1792,,,  
MSG,4,0,0 100DD,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,
```

Aircraft ID

```
MSG,1,0,0 10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,  
MSG,3,0,0 10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,424,,52.379501,13.527200,,,,  
MSG,4,0,0 10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,6.000000,150.000000,,,-510,,,,
```

# ADS-B data

## ADS-B data in SBS format

```
MSG,1,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,  
MSG,3,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,30525,,29.562973,33.627777,,,  
MSG,4,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,477.000000,0.000000,,,-448,,,,
```

MSG,1,0,0,100DD,0,000,2020/02/01,07:07:39.000,MSR914,,,,,,  
MSG,3,0,0,100DD,0,000,2020/02/01,07:07:39.000,,25200,,29.792269,32.485603,,,  
MSG,4,0,0,100DD,0,000,2020/02/01,07:07:39.000,,434.000000,99.000000,,1792,,,

**Call-Sign**

```
MSG,1,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,  
MSG,3,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,424,,52.379501,13.527200,,,  
MSG,4,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,6.000000,150.000000,,,-510,,,,
```

# ADS-B data

## ADS-B data in SBS format

```
MSG,1,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,,  
MSG,3,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,30525,,29.562973,33.627777,,,,  
MSG,4,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,477.000000,0.000000,,,-448,,,,
```

MSG,1,0,0,100DD,0  
MSG,3,0,0,100DD,0  
MSG,4,0,0,100DD,0

```
000,2020/02/01,07:07:39.000,MSR914,,,,,,,  
000,2020/02/01,07:07:39.000,25200,,29.792269,32.485603,,,,  
000,2020/02/01,07:07:39.000,,434.000000,99.000000,,1792,,,,
```

```
MSG,1,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,,  
MSG,3,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,424,,52.379501,13.527200,,,,  
MSG,4,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,6.000000,150.000000,,,-510,,,,
```

# ADS-B data

## ADS-B data in SBS format

MSG,1,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,,  
MSG,3,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,30525,,29.562973,33.627777,,,,  
MSG,4,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,477.000000,0.000000,,,-448,,,,

MSG,1,0,0,100DD,0,000,2020/02/01,07:07:39.000,MSR914,,,,,,,  
MSG,3,0,0,100DD,0,000,2020/02/01,07:07:39.000,,25200,,29.792269,32.485603,,,,  
MSG,4,0,0,100DD,0,000,2020/02/01,07:07:39.000,434.000000,99.000000,,1792,,,,

**Speed  
(Knots)**

MSG,1,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,,  
MSG,3,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,424,,52.379501,13.527200,,,,  
MSG,4,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,16.000000,150.000000,,,-510,,,,

# ADS-B data

## ADS-B data in SBS format

```
MSG,1,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,MSR681,,,,,,,  
MSG,3,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,30525→ 29.562973,33.627777,,,  
MSG,4,0,0,100A4,0,2021/02/01,07:07:39.000,2020/02/01,07:07:39.000,,477.000000,0.000000,,,-448,,,,
```

MSG,1,0,0,100DD,0  
MSG,3,0,0,100DD,  
MSG,4,0,0,100DD,0

**Position  
(WGS84)**

```
000,2020/02/01,07:07:39.000,MSR914,,,,,,,  
000,2020/02/01,07:07:39.000,,25200→ 29.792269,32.485603,,,  
000,2020/02/01,07:07:39.000,,434.000000,99.000000,,1792,,,
```

```
MSG,1,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,NMA6389,,,,,,,  
MSG,3,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,424,52.379501,13.527200,,,  
MSG,4,0,0,10140,0,2021/02/01,07:07:39.000,2020/02/01,07:07:38.000,,6.000000,150.000000,,,-510,,,,
```

# GTFS real-time data

## GTFS real-time data of a bus in GeoJSON format

```
{  
  "geometry" :{  
    "coordinates": [151.17762756347, -33.92598342895],  
    "type" :"Point"  
  },  
  "type" :"Feature",  
  "properties" :{  
    "Speed" :"19.2",  
    "TripStartDate" :"20200121",  
    "TripScheduleRelationship" :"SCHEDULED",  
    "OccupancyStatus" :"MANY_SEATS_AVAILABLE",  
    "TripStartTime" :"02:00:00",  
    "RouteID" :"2437_N20",  
    "Timestamp" :"1579530867",  
    "TripID" :"883447",  
    "Bearing" :"77.0",  
  }  
}
```

# Demonstration

Our demonstration...

- performs continuous queries on real-world data streams.
- visualizes the results interactively on a map.
- performs spatial joins between *OpenStreetMap* data and a data stream.

Performed continuous queries

- *Which aircraft is currently in the area of Berlin?*
- *Which bus drives currently through a forest?*