A Framework for the Collection, Analysis, and Verification of Next-Generation Infrasound Data

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Traditional Infrasound

- Traditional infrasound arrays are fantastic, but...
  - Higher density
  - Quicker deployment

Figure: IS39 Array

Next Generation Sensors

- Reduce size, weight, power, costs
- Easy to maintain
- Ubiquitous
- Multiple ways to communicate
- Built using industry standard technologies

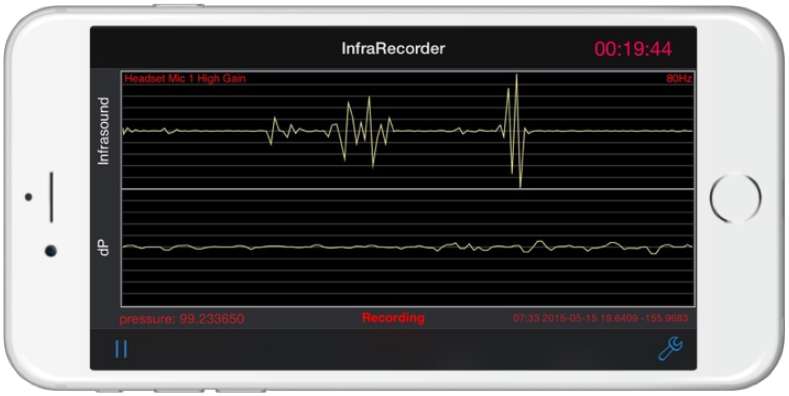


Figure: Infrasound App

Realm of Big Data

A single server isn't enough

- Velocity

Realm of Big Data

A single server isn't enough

- Velocity
- Volume

Realm of Big Data

A single server isn't enough

- Velocity
- Volume
- Variety

Next Generation Framework

- Scalable Data Acquisition
- Monitoring / Data Discovery
- Time Synchronization
- Real-Time Analysis / Classification
- Embrace open source

Data Acquisition

- Data Acquisition
  - Extract meta-data
  - Store audio files
- Designed for the cloud
  - Akka actors for concurrency
  - Distributed

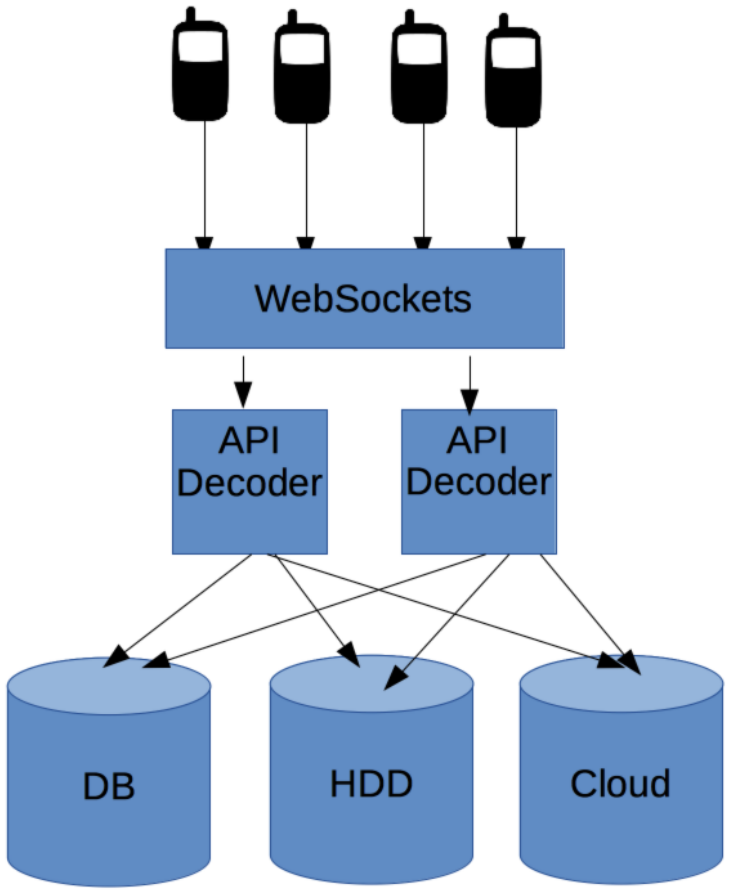


Figure: Data Acquisition

Device Health

Active devices

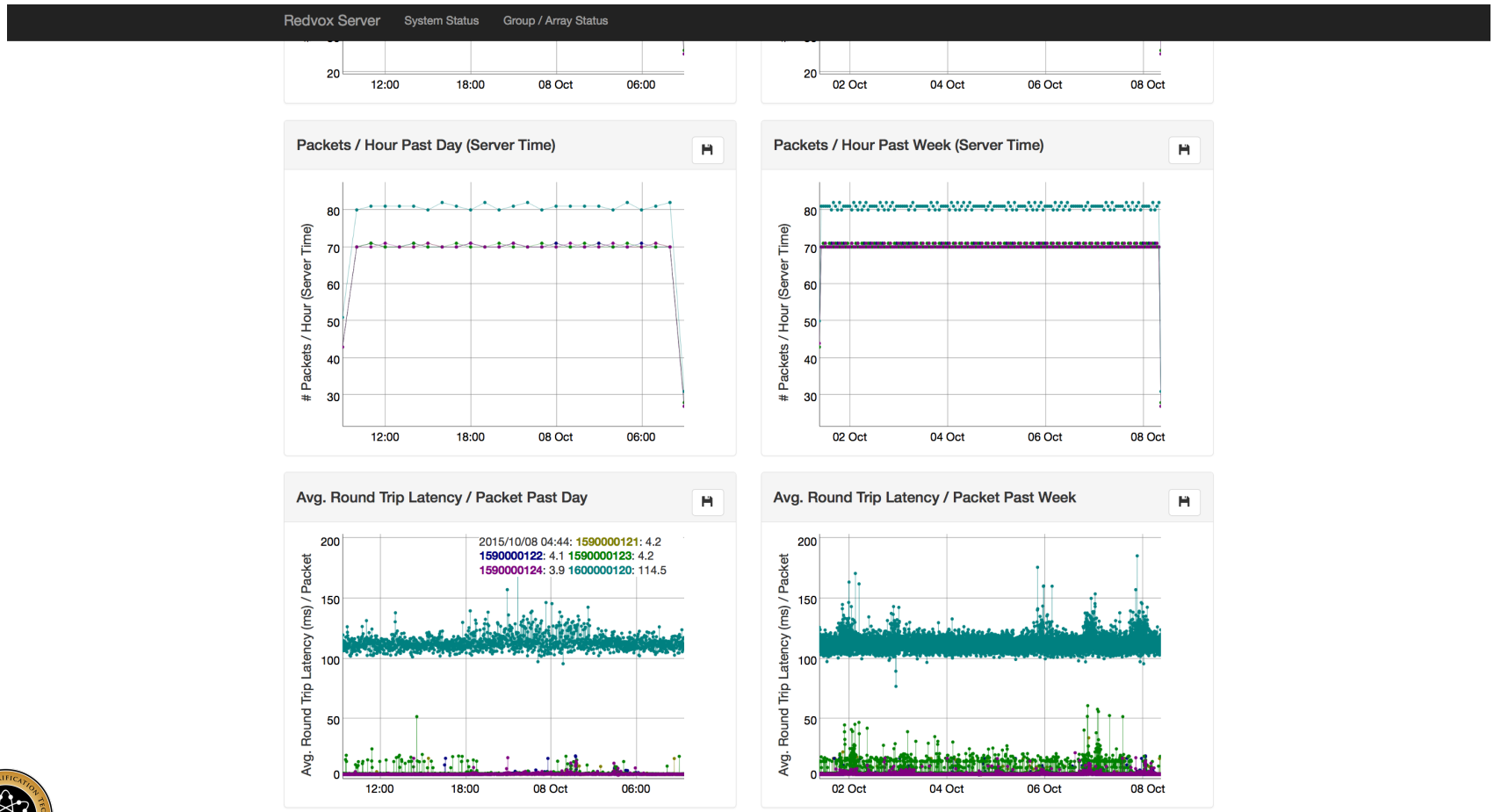
Redvox Server System Status Group / Array Status

Device Health Overview

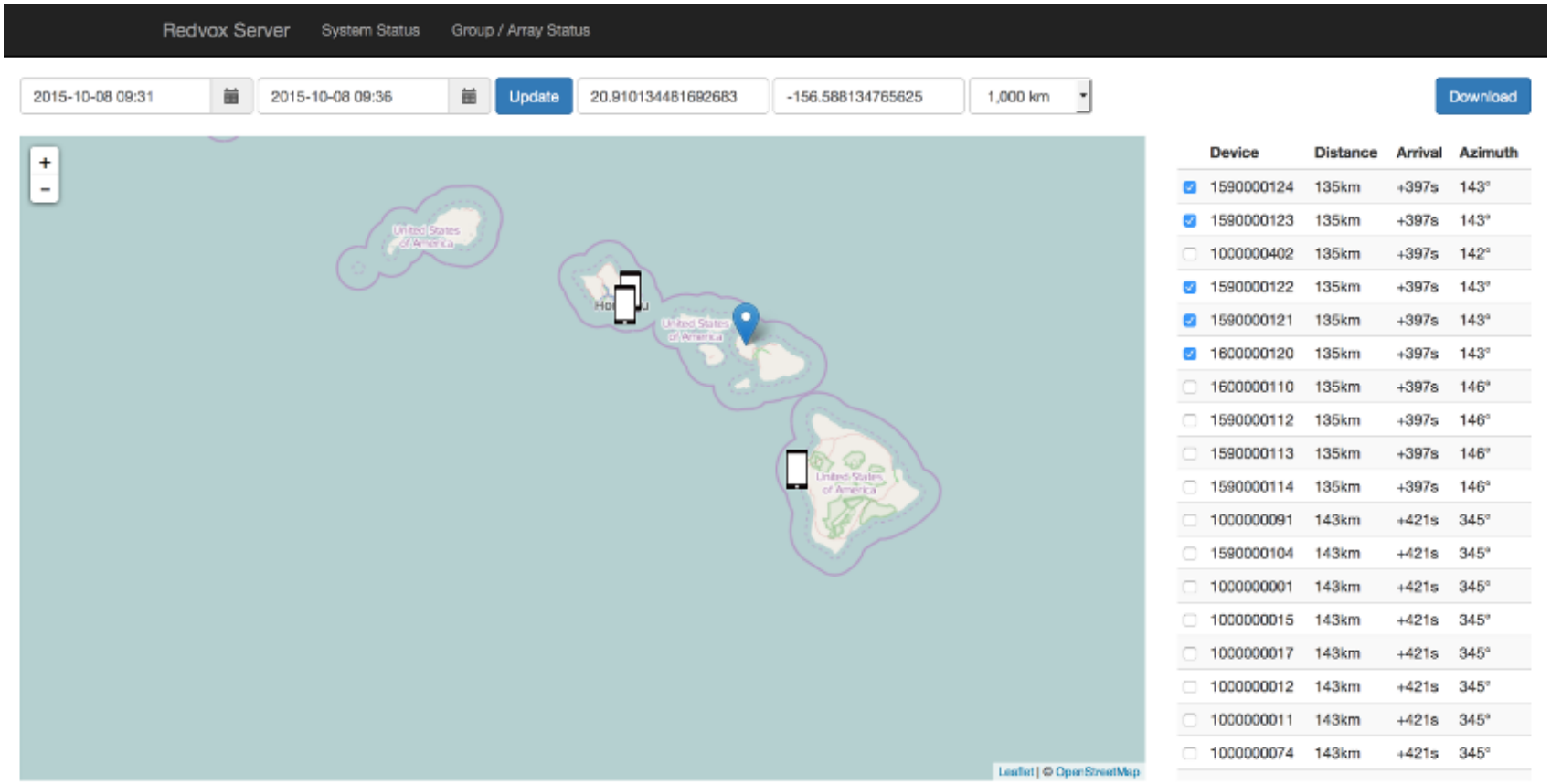
Device Id	Last Received (UTC)	Min Ago	Location	# Mic	# Bar	Sample Rate	API Version	Details
0197023515	2015/10/03 22:55 UTC	6383	36.96281, -122.00066	727	0	80	800	Details
1000000001	2015/10/08 09:17 UTC	1	19.72867, -156.05968	244515	2966	80	800	Details
1000000009	2015/10/08 06:10 UTC	188	48.24333, 16.43651	193364	31617	80	800	Details
1000000011	2015/10/08 09:17 UTC	1	19.72848, -156.05951	234902	0	80	800	Details
1000000012	2015/10/08 09:16 UTC	1	19.72893, -156.05965	228480	0	80	800	Details
1000000015	2015/10/08 09:16 UTC	2	19.72863, -156.0596	168089	0	80	800	Details
1000000017	2015/10/08 09:16 UTC	1	19.72853, -156.05986	176143	0	80	800	Details
1000000062	2015/10/07 02:01 UTC	1877	19.72868, -156.05966	56631	0	80	800	Details
1000000073	2015/10/08 09:16 UTC	1	19.72865, -156.0597	171957	0	80	800	Details
1000000074	2015/10/08 09:16 UTC	2	19.72865, -156.0597	173255	0	80	800	Details
1000000091	2015/10/08 09:16 UTC	1	19.72866, -156.05969	170935	0	80	800	Details
1000000092	2015/10/08 09:16 UTC	1	19.72865, -156.0597	154595	0	80	800	Details
1000000402	2015/10/08 09:16 UTC	1	21.29748, -157.81604	87396	0	80	800	Details
1590000101	2015/10/08 09:17 UTC	1	19.72869, -156.05967	175424	0	80	800	Details
1590000102	2015/10/08 09:16 UTC	1	19.72867, -156.05969	179165	0	80	800	Details
1590000103	2015/10/08 09:16 UTC	1	19.72867, -156.0597	175520	0	80	800	Details

Device Health

Data Quality



Interactive Data Discovery



Device	Distance	Arrival	Azimuth
1590000124	135km	+397s	143°
1590000123	135km	+397s	143°
1000000402	135km	+397s	142°
1590000122	135km	+397s	143°
1590000121	135km	+397s	143°
1600000120	135km	+397s	143°
1600000110	135km	+397s	146°
1590000112	135km	+397s	146°
1590000113	135km	+397s	146°
1590000114	135km	+397s	146°
1000000091	143km	+421s	345°
1590000104	143km	+421s	345°
1000000001	143km	+421s	345°
1000000015	143km	+421s	345°
1000000017	143km	+421s	345°
1000000012	143km	+421s	345°
1000000011	143km	+421s	345°
1000000074	143km	+421s	345°

Time Synchronization

- C++ websocket server
- Constructed message exchange algorithm
- All data is synchronized to master clock
- Relative accuracy 1 ms

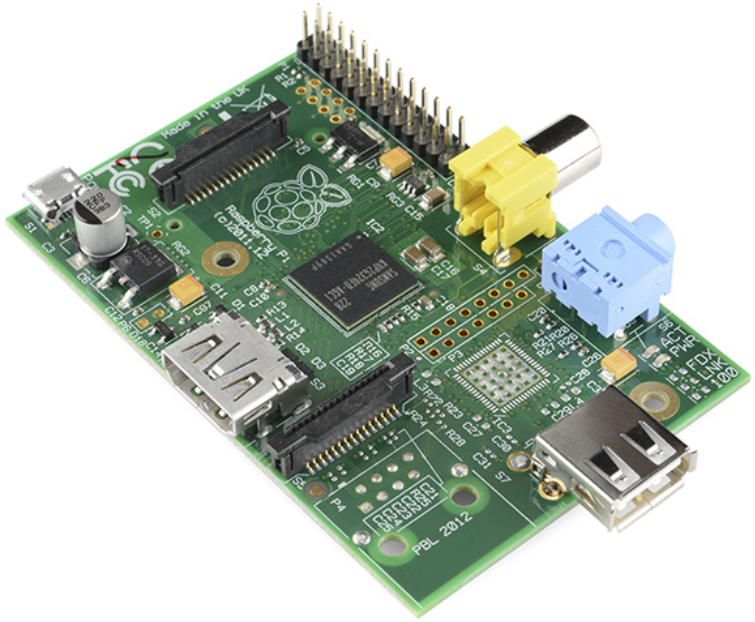


Figure: Raspberry Pi

Head in the Clouds

- Distributed real-time analysis
  - Apache Spark & Spark Streaming
  - Python w/ obspy, scipy, numpy
- Real time event reporting
- Collaboration with LLNL
  - Signature classification
  - Data quality / verification
- Everything is a data source

Thank You

- Questions?