

The Capture, Storage & Consumption of the MeerKAT Radio Telescope's Sensor Data

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Objectives

- MeerKAT Telescope
- The Control and Monitoring (CAM) Sub-System
- CAM Tech Stack for MeerKAT
- KATCP
- Sensors & Samples
- Katstore64
- Future Endeavours



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MeerKAT Telescope

- 64-dish Radio Telescope
- Site: Losberg, Northern Cape
- 13.5m Diameter Dishes with Offset Gregorian Config
- 70% Antennas are in the Core (1km)
- Designed and Built by SKA-SA
- Precursor to SKA1
- Currently the most sensitive Radio Telescope in the world



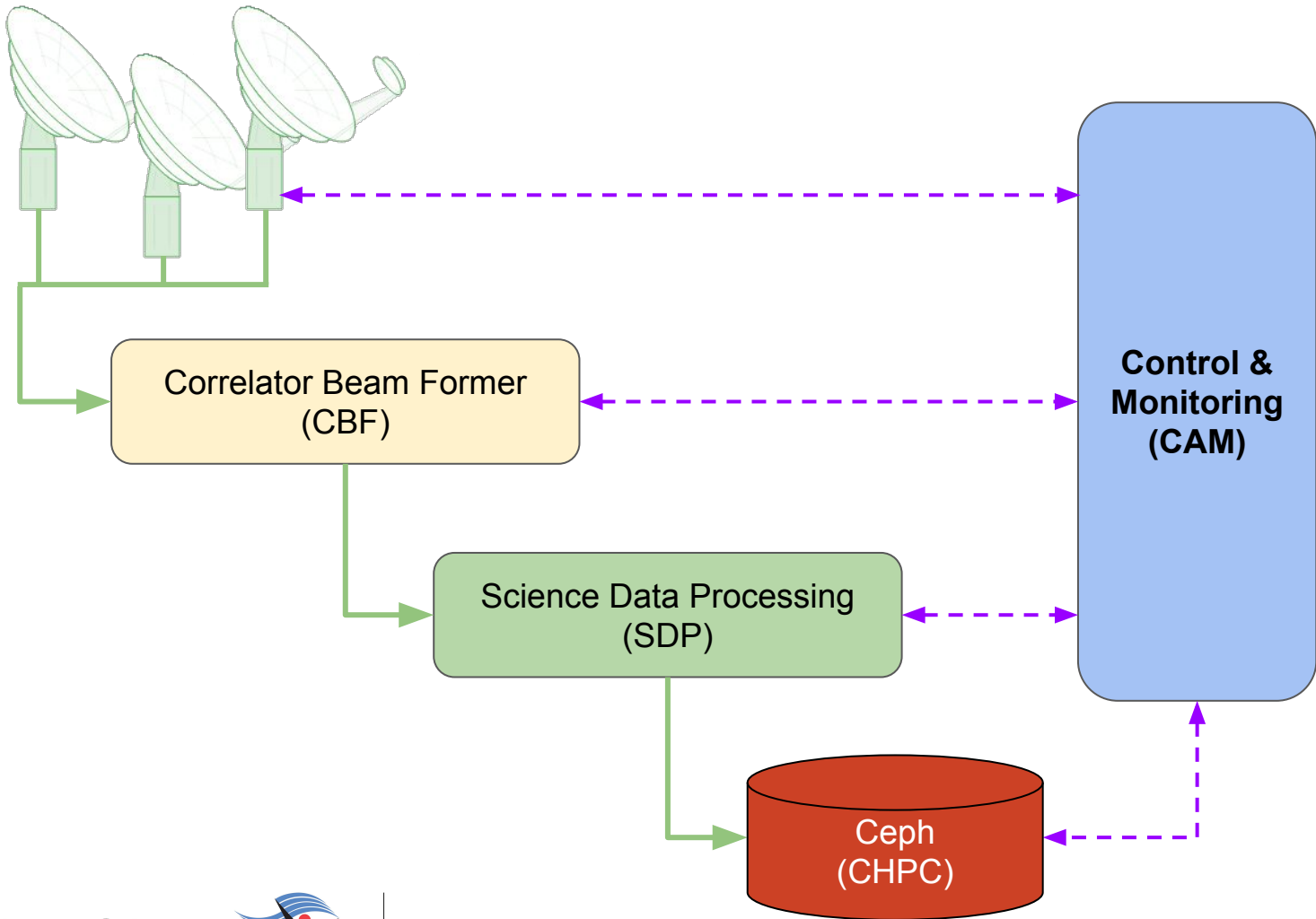
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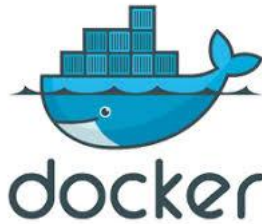
The Control and Monitoring Sub-system



CAM Tech Stack for MeerKAT



PostgreSQL

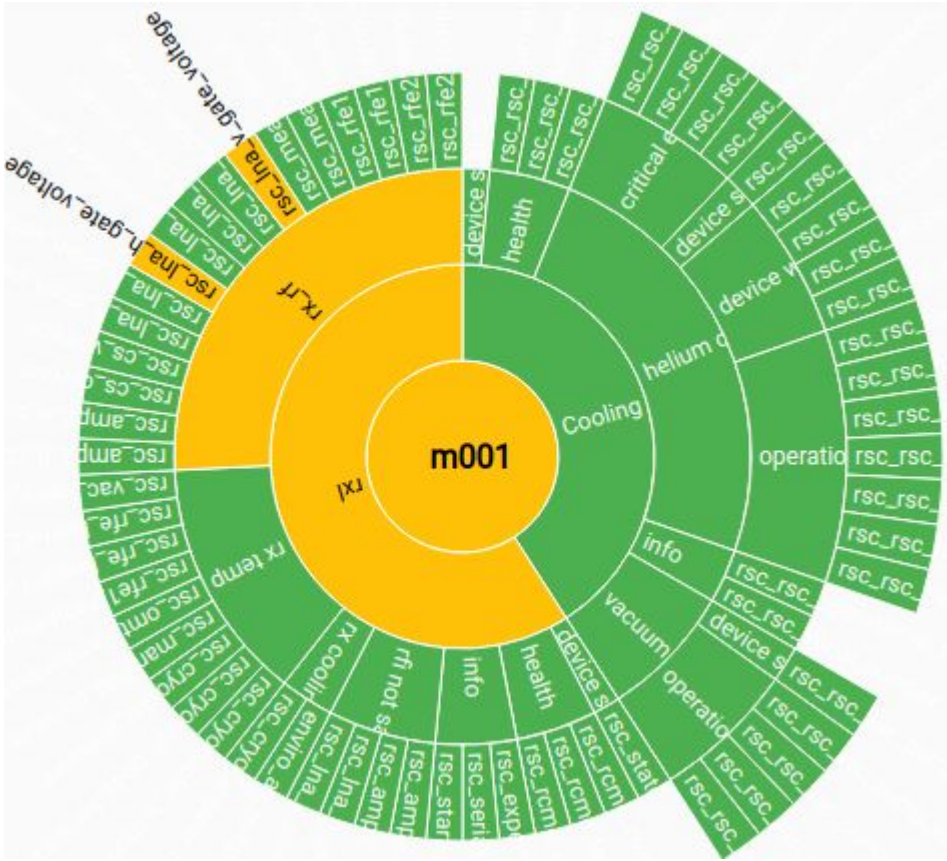


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Receptor Health



Weather

Weather

2:27:41[^] LST 20:16:24 UTC
22:16:24 local



Sensor Values

Historic values at a 30

seconds interval (on average), for the last 8 Hours

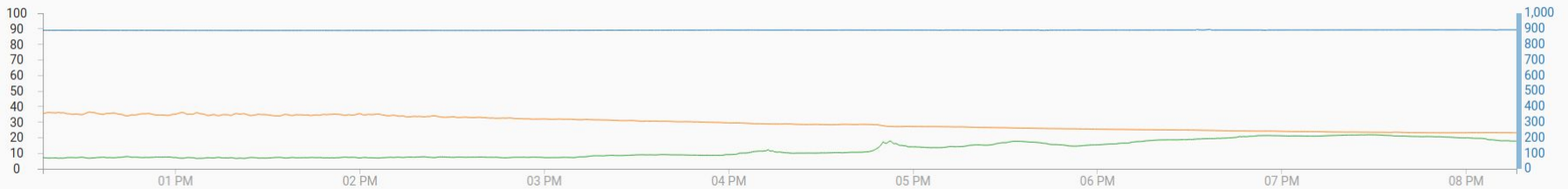
Wind Direction (244.4°)	Sensor	Value	MAX	MAX at
	air_pressure	893.4	893.4	20:15:19
	air_temperature	23.2	23.2	20:15:49
	air_relative_humidity	17.8	17.8	20:15:49
	weather_rainfall			
	gust_wind_speed	6.2	7.4	20:16:05
	wind_direction	244.4	244.4	20:16:23
	mean_wind_speed	6.3	6.3	20:16:13

Wind Speed

Wind Speed Limit: 11.1m.s. - Wind Gust Limit: 16.9m.s.



Pressure, Humidity and Temperature



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KATCP

- Karoo Array Telescope Communication Protocol
- Simple ASCII Protocol
- Layered on top of TCP/IP - Application Layer
- Preferred mechanism for interprocess communication
- Supports flexible, run-time configuration



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KATCP

- Dynamic Discovery
 - Monitoring point -> KATCP Sensor
 - Control command -> KATCP Request
- CAM implements Device Translators for external components that do not have a KATCP Interface
- <https://katcp-python.readthedocs.io/en/latest/>



Sensors

Sensor Types

- Integer
- Float
- Boolean
- Timestamp
- Discrete
- Address
- String

Sensor Statuses

- Unknown
- Nominal
- Warn
- Error
- Failure
- Unreachable
- Inactive



Sensor Samples

- Uniquely identified by sensor name and sample time
- Any additional fields are optional
- JSON format
- Sampling Strategy
 - Period (Fixed Time)
 - Event (Value Change)



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Sample Example

```
{  
  "sensor"      : "anc_mean_wind_speed"  
  "sample_time" : 1568174400.458403,  
  "value"       : 2.1362775,  
  "status"      : "nominal",  
  "value_time"  : 1568174399.487174,  
}
```



Katstore64

- Development began in 2016
 - Deployment to Site in September 2019
-
- Time Series Data Store
 - Fixed Index on Time
 - Data is immutable



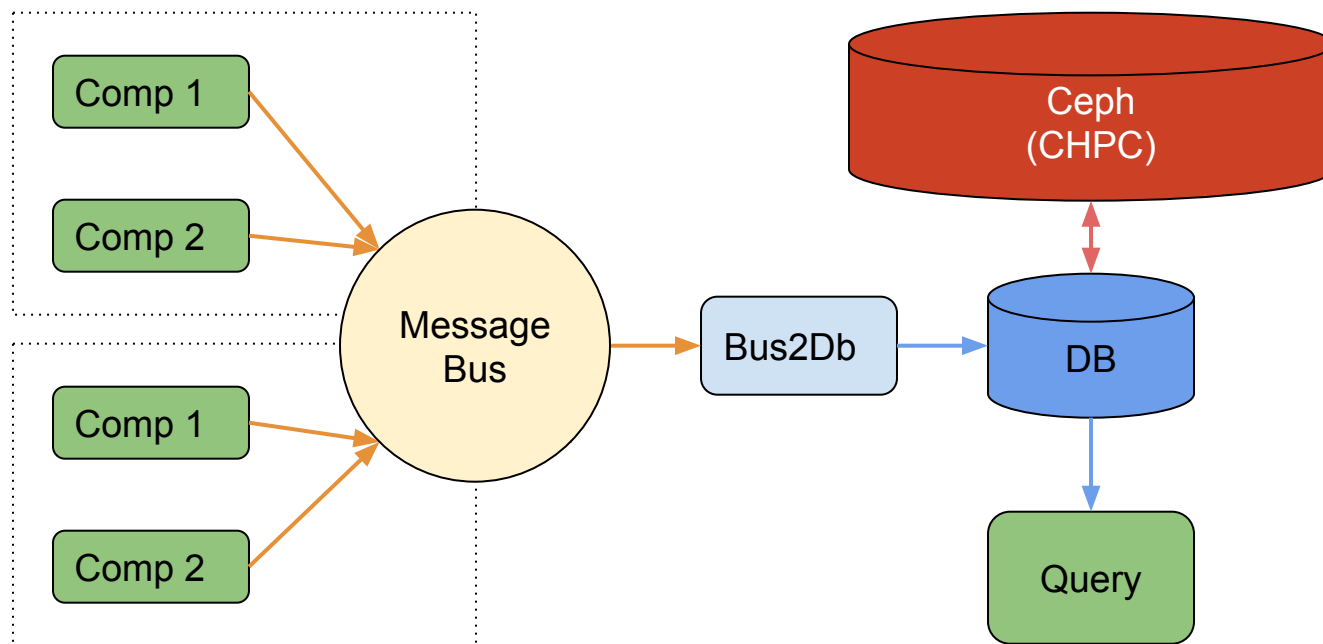
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Katstore64



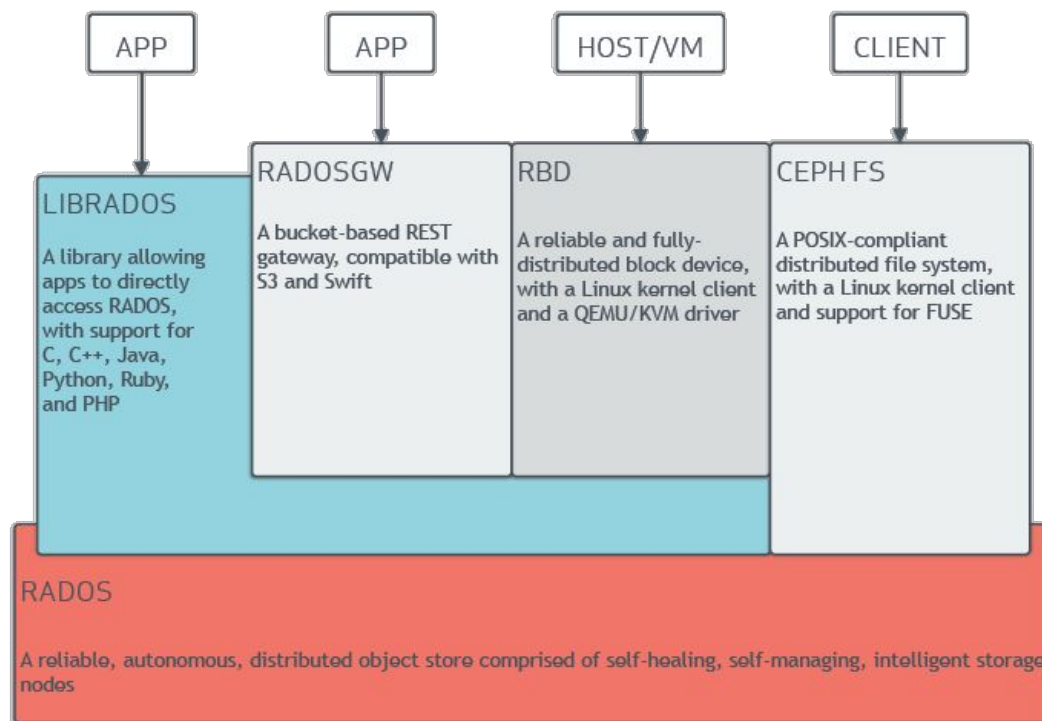
- NATS Messaging System
- A PostgreSQL extension
- FDW & Bus2DB - Python3

- Heavy lifting in PostgreSQL
- librados library
- Consistently process 40K s/s



Librados

- librados provides low-level access to the RADOS service

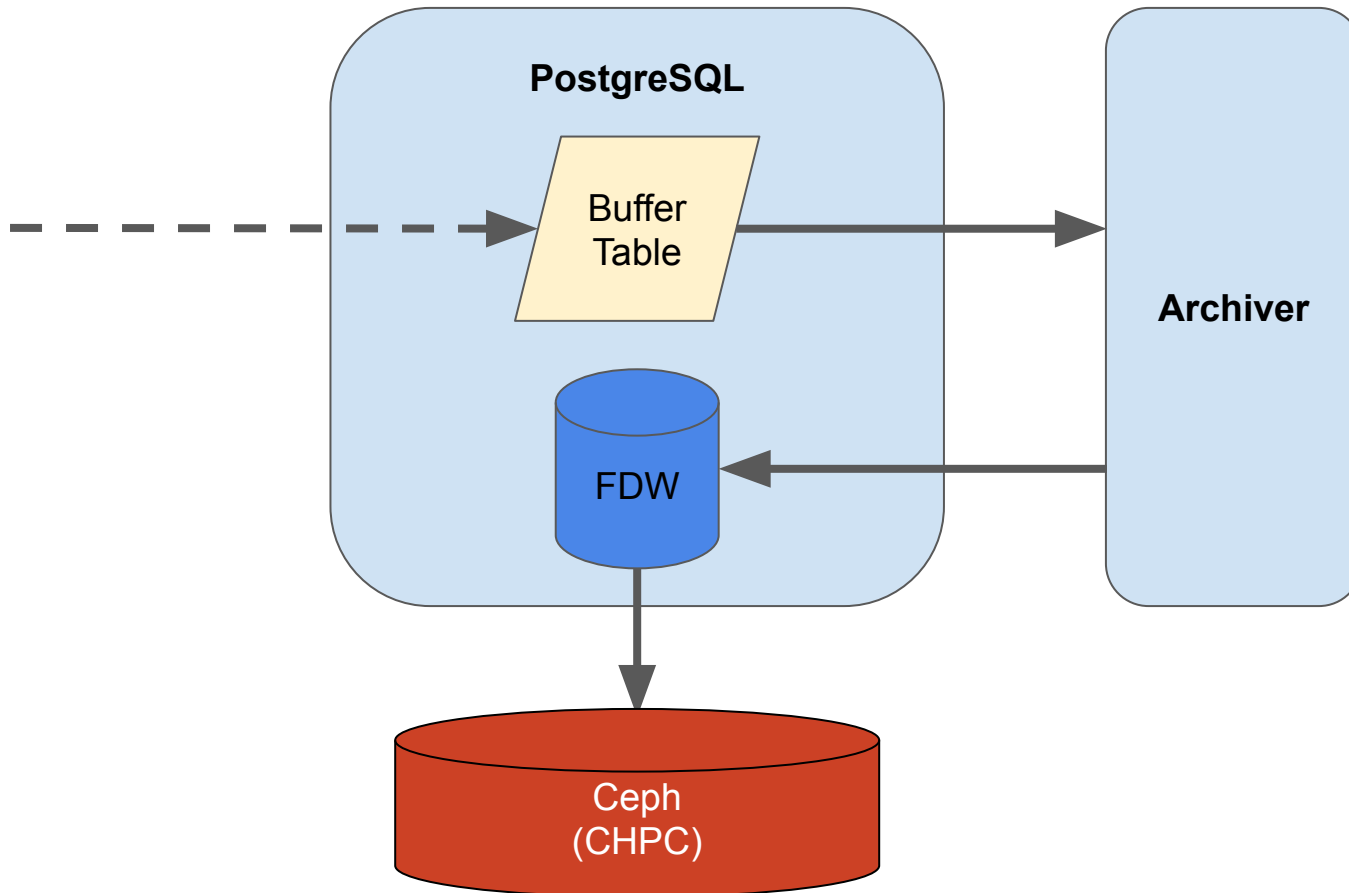


Katstore64 Samples Archive

- PostgreSQL - Short Term Storage
- Ceph - Long Term Storage
 - Distributed Storage System
 - Fault Tolerant
 - One Large Storage System - many hard drives from multiple servers
 - Scalable to several petabytes
 - Leverages Science Archive Tech

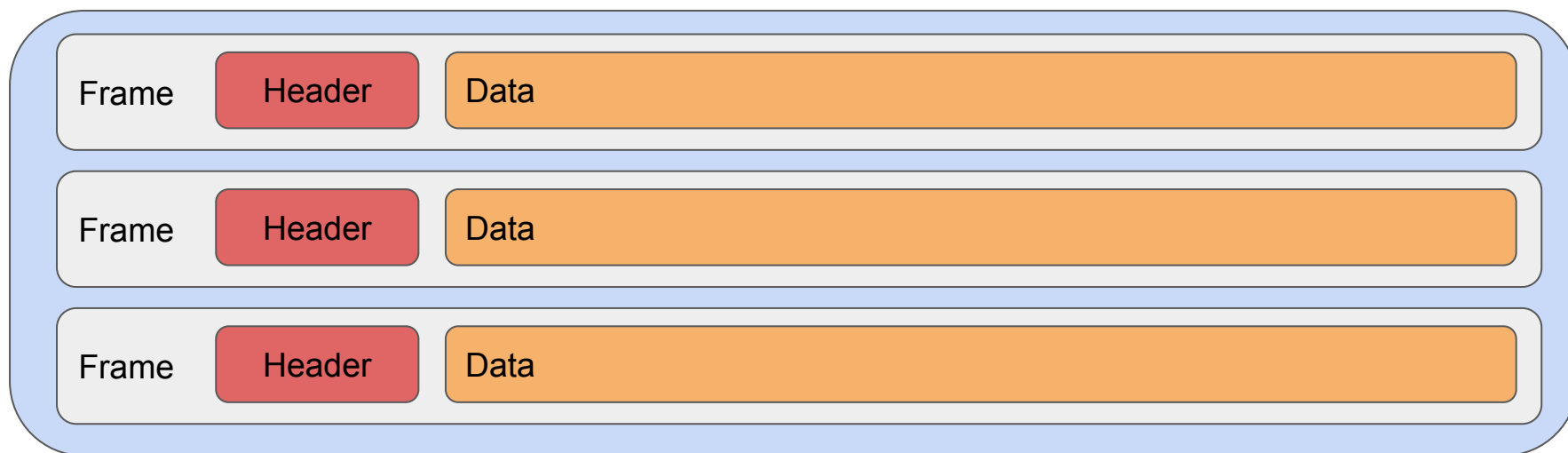


Katstore64 Archive Interface



Structure of Unsynced Data

18233:anc_mean_wind_speed



Storage format:

- CBOR - Concise Binary Object Representation
- Compression: Blosc using zstd

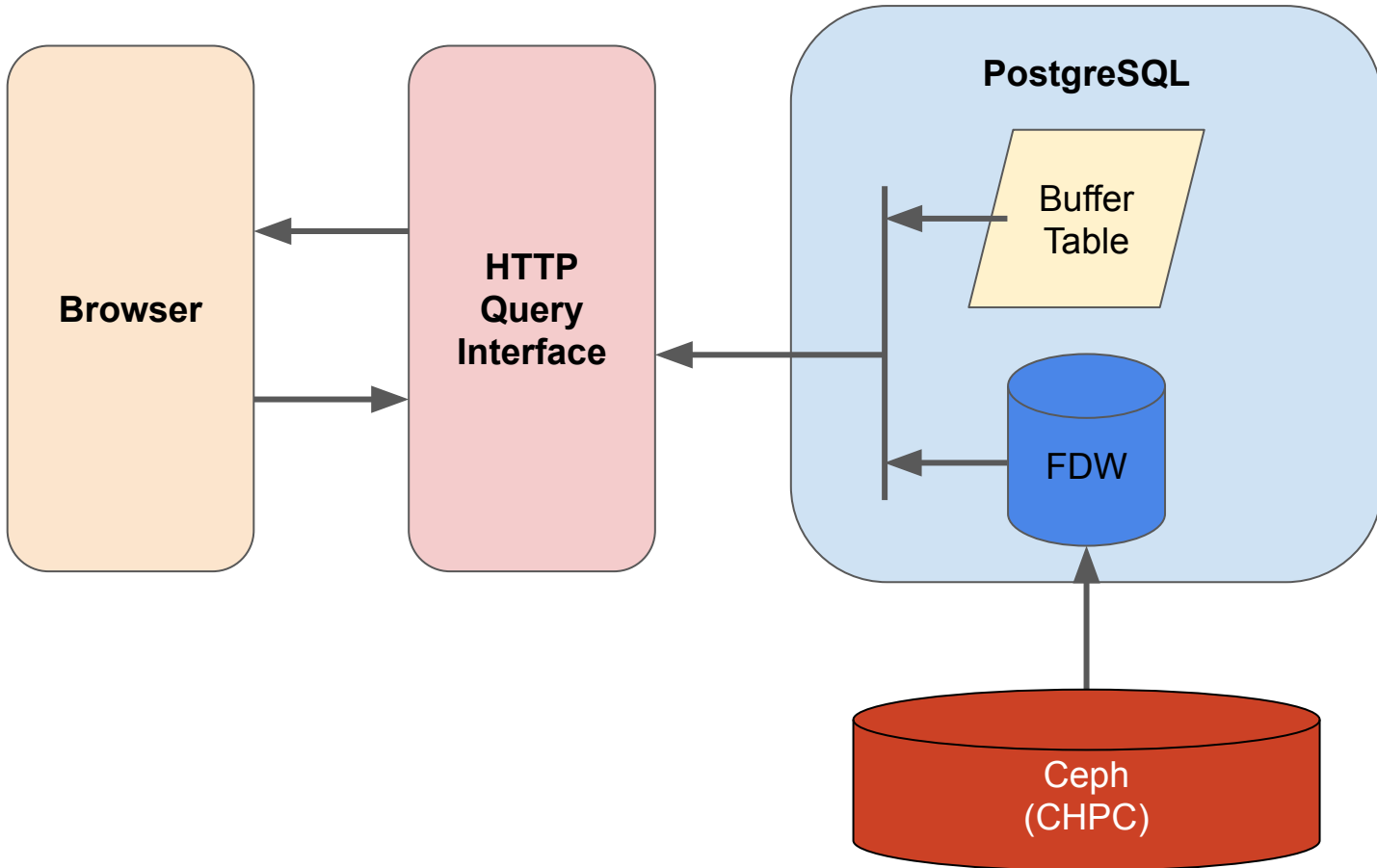


Repacking the Data

18233:anc_mean_wind_speed



Katstore64 Retrieval Interface



Query Interface - Sensor Graph

Sensor Graph

3:53:44^{LST} 21:54:00^{UTC}
23:54:00^{local}

shoosen@ska.ac.za (Monitor Only)



Tools

2019-11-29 00:00:00

2019-11-29 21:50:18

Search Discrete Sensors

Search Old Sensors

Resampling Interval: 10 Minute(s)

anc_mean_wind_speed

anc_mean_wind_speed

Displaying 1 result(s)

Include Live Data

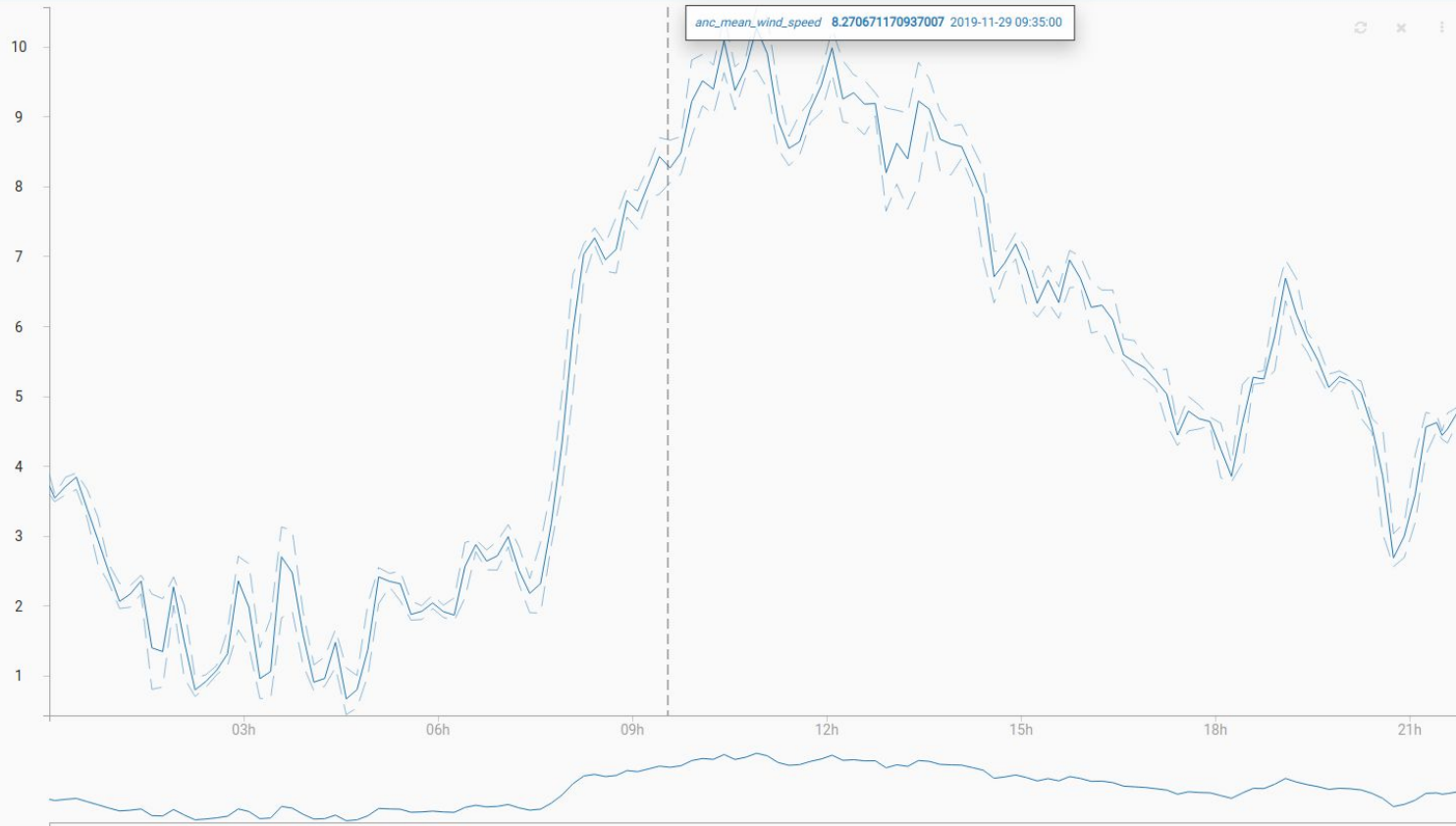
CLEAR SENSOR GRAPH

Use Unix timestamps

Include Value timestamps

DOWNLOAD AS CSV

anc_mean_wind_speed



Interlock State: NONE

MKAT.CAMv25 2019-09-11

2019-11-29_{Date} 2458817.4125_{ID}



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Query Interface - Katstore64 API

```
1 // 20191130000648
2 // http://portal.mkat.karoo.kat.ac.za/katstore/api/query/?include_value_time=True&start_time=1574985600&sensor=anc_mean_wind_speed&end_time=1575065128
3
4 {
5   "title": "Sensors Query",
6   "url": "/katstore/api/query/?include_value_time=True&start_time=1574985600&sensor=anc_mean_wind_speed&end_time=1575065128",
7   "sensor_name": "anc_mean_wind_speed",
8   "data": [
9     {
10      "sample_time": 1574985600.639859,
11      "value": 3.8893429167,
12      "status": "nominal",
13      "value_time": 1574985600.602961,
14      "sensor": "anc_mean_wind_speed"
15    },
16    {
17      "sample_time": 1574985601.640297,
18      "value": 3.8890570833,
19      "status": "nominal",
20      "value_time": 1574985601.602876,
21      "sensor": "anc_mean_wind_speed"
22    },
23    {
24      "sample_time": 1574985602.639827,
25      "value": 3.8883483333,
26      "status": "nominal",
27      "value_time": 1574985602.602997,
28      "sensor": "anc_mean_wind_speed"
29    },
30    {
31      "sample_time": 1574985603.647245,
32      "value": 3.8875546056,
33      "status": "nominal",
34      "value_time": 1574985603.603334,
35      "sensor": "anc_mean_wind_speed"
36    },
37    {
38      "sample_time": 1574985604.646989,
39      "value": 3.8859975,
40      "status": "nominal",
41      "value time": 1574985604.602876.
```



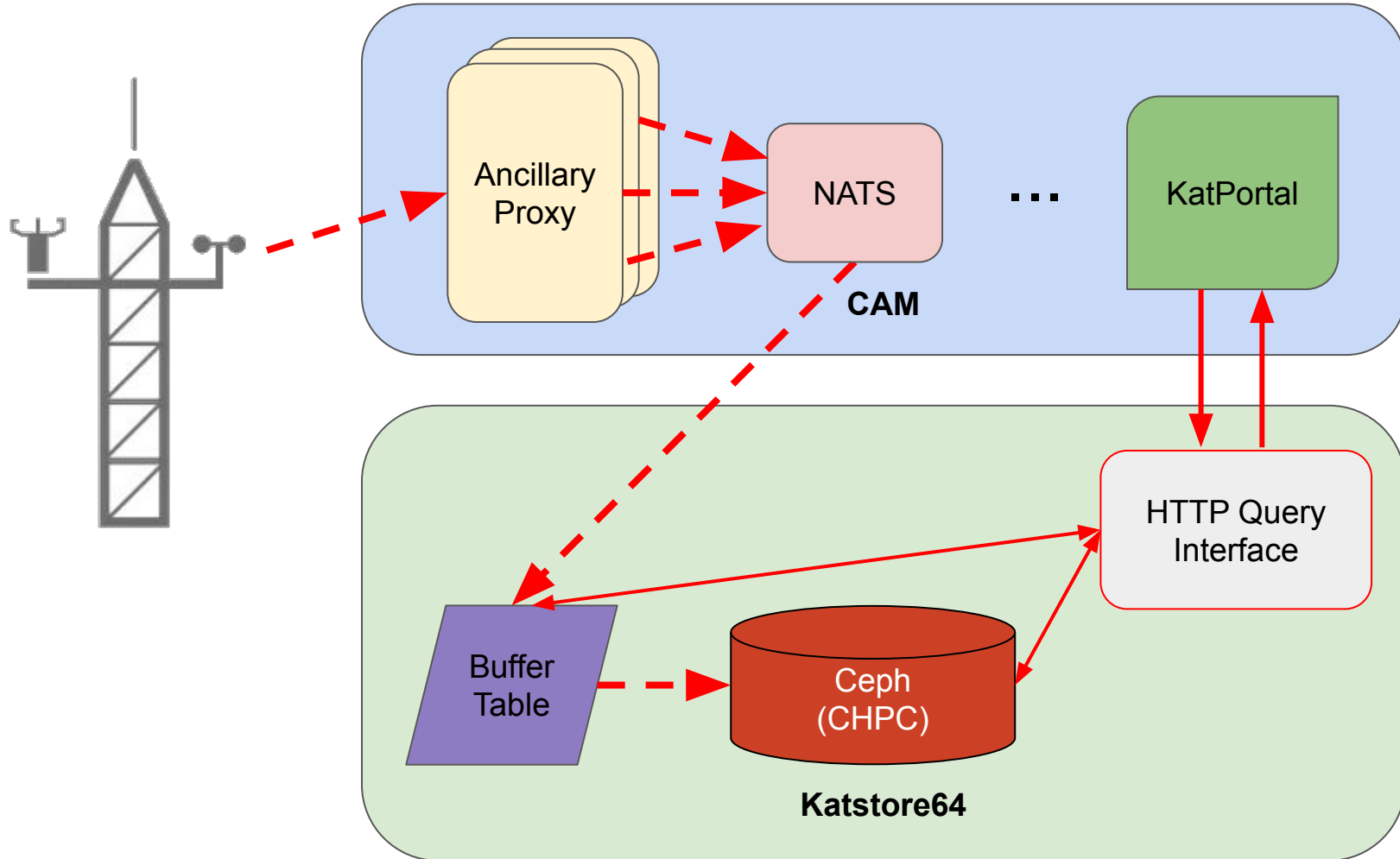
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Sensor Example



Katstore64 Performance

- Samples per Second: 6500, Benchmarked at 40,000
- Simultaneous Queries: 64, Benchmarked on Dev environment
- Return Rate per Second: 90,000 samples

- Karoo to CHPC Throughput Speed : 10 Gbps

- Total Storage Capacity
 - Karoo: 400 TB
 - CHPC: 10 PB



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Future Endeavours

- MeerKAT+ : Adding 20 SKA Dish Antennas to MeerKAT
- Machine Learning Project using sensor data



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Ceph BoF

Hosted by Martin Slabber and Sean February

Time: 15:30

Location: Heathrow



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Info

References:

- <https://katcp-python.readthedocs.io/en/latest/>
- SCALABLE TIME SERIES DOCUMENTS STORE
M.J. Slabber, F.J. Joubert, M.T. Ockards SKA SA, Cape Town, South Africa

Thank you

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