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Outline

- Data logging in the event-driven Karabo control system
- **Mapping** Karabo to InfluxDB
- InfluxDB backend setup
- **Hiccups** on the way
- Conclusions

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Karabo Data Logging

Main use cases:

- ► Historic data for trendlines: scalar property vs time.
- Historic configurations: all device properties at a point in time
- Base of "Config & Recovery" (project in beta stage)





Current value on device Value

[]

Π

30.0 s

False

2.0 Hz

Information

A configuration has arrived!

['AValue']

1.0 s

[]

False

2.0 Hz

10 1036831949 ...

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Karabo: Event-Driven Broker Communication

- Cross device signal/slot subscription
 - Devices subscribe slots to a remote "signal".
- When signal is "emitted", all subscribed slots are called.
 - Single message to the broker
 - Avoids publishing overhead for "popular" devices
 - Regular **polling obsolete**.
- Used by Data Logger Devices
 - Logging task distributed among a handful of "loggers"
 - Each logger subscribes to the "property update" and "schema update" signals of its share of devices
- Logged are
 - Properties
 - Configurations (e.g. hardware port)
 - Conditions (e.g. values read from hardware like a temperature)
 - Self-description (schema)
 - Timestamps as published by device



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Karabo Data Logging: How?

- Original, custom-made solution from 2014:
 - Ascii file backend (one directory per logged device)

20200719T184128.573059Z|1595184088.573059|804227972|actualPosition|FLOAT|35.91043||VALID

- Drawbacks
 - ► Human readable data does not scale well: routine access only for 3 months
 - ► Indexing (for fast retrieval) needed custom implementation
 - No support for statistical treatment
 - (data reduction by simple down sampling: e.g. every 2nd data point only)
 - Reading back data can be slow
- Time series database is better suited to event-driven Karabo:
 - Logging to InfluxDB:
 - ► Karabo prototype in 2018
 - Serious development in 2019 and 2020
 - ► In production since summer 2020
 - Migrated all data from January 2020 onwards



Mapping Karabo to InfluxDB

- Karabo device → InfluxDB measurement
- Device property → InfluxDB field
- Fields must have unique type within a *shard* (i.e. time period) in InfluxDB
 - Karabo device self-description may in principle change any time
 - append type to field name INF/NAN cannot be stored as float
 - → extra field framerate.actual-FLOAT_INF

Timestamps are received from the Karabo device
 Store millisecond precision in InfluxDB
 If device provides, EuXEEL photon train ID stored

If device provides, EuXFEL photon train ID stored as well

InfluxDB Measurement:

time	camerald- STRING	framerate. actual-FLOAT	
2022-09-16T10:54:04.12Z	192.67.56.13	0.	
2022-09-16T10:57:05.42Z		10.23554	
2022-09-16T10:57:15.45Z		10.34765	

Types: Karabo

BOOL

- FLOAT, DOUBLE
- [U]INT8, ... [U]INT32, INT64

UINT64

- STRING
- VECTOR_[U]INT8, ...
- VECTOR STRING

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Boolean

- Float (special NaN treatment)
- Integer
- Integer re-interpreted as int64
- String (mangling escape characters)
- Comma separated string
- Base64 encoded JSON string

- CHAR, VECTOR_CHAR (raw data), VECTOR_HASH (table),
- Base64 encoded (Karabo) binary

Karabo-

specific

SCHEMA (self-description)

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Enhancement of Operational Experience with Karabo

- Can provide much longer data availability than previously (was 3 months) 3 years retention period to be become active end of 2022
- Can provide averaging instead of "random" down sampling if data reduction needed More uniform view of data if requested for two slightly different intervals Spikes short in time do not slip unnoticed
- Much faster retrieval of historic trendline data, irrespective how recent (within the 3 years) About 1 second for data of 1 week that updates every 5 seconds (incl. averaging)
- Availability of data for Grafana web frontend opens doors beyond the control system Many visualization options for detailed data analysis New use case: Facility monitoring in Data Operation Centre Data available for monitoring with about 30 seconds delay



Enabling Centralised Monitoring

EuXFEL Data Operation Centre: **DOC**

Unified monitoring and support as a co-effort
 Controls, Electronics, Data Analysis,
 IT & Data Management, Detector Operation

Monitors overall system health via many Grafana dashboards

An unforeseen use case when developing InfluxDB logging



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Hiccups on the Way

- Beware! Influx is a "sharded" time series database:
 - Data with future (wrong) timestamp compromises performance
 - Had a case with timestamps months in the future:
 - Delayed data availability:
 - > 1 hour instead of 30 seconds
- Out of a sudden", Telegraf failures happened from time to time
 - 1 → 3 Telegraf instances
 - separate beam lines
 - Still happened
 - at least with partial outage only





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Monitor InfluxDB

50 Mb/s

50 Mb/s

100 Mb/s

150 Mb/s

200 Mb/s

00:00

04:00

0 Mb/s

Metrics of involved servers monitored Network, memory, CPU, etc.



Analyse Existing Data

Before the system goes down, some data is stored!

Flux queries in Grafana allow programming advanced queries:

Schema data of a device had a rate of >13 MB/s, averaged over 1 minute!



Findings, Fixes and Protections

- InfluxDB could not cope with data rate from Telegraf
 - Replied with http error to Telegraf which tried to send data again, and so on...
 - New data arrives at Telegraf and fills its data buffer
 - ► Note: data in buffer is lost if process restarted

Traced two bugs that together caused very high data rates to storage backend
 Karabo device level: code updated device schema N=180 times in a loop
 should publish once outside the loop when all information is gathered
 Karabo data logger *appended* to a buffer that stores the serialized schema
 data was sent N²/2 times – note: single schema can easily be 500 kB

- should fill buffer from scratch
- Incidents showed vulnerability of event driven data logging
 - A single ill-behaving device compromised the logging system
 - New protections on Karabo logger ingestion service:
 - ▶ refuse vectors longer than 4 * 2700 elements
 - ► refuse property or schema if update rate surpasses 5 MB/s (averaged over 5 seconds)
 - Keep track of refusals to identify ill-behaving devices
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InfluxDB @ EuXFEL in Numbers

- Each Telegraf instance receives roughly 10 Mb/s
 Duplicated (but zipped) output rate of about 3.5 Mb/s
 - Less when summer maintenance period started (end of June)
- > 240 billion property updates stored in InfluxDB
 Increase per month: ~ 10 Billion property updates
 - 25 TB per InfluxDB node (Sept. 2022)



Future Steps

- Split cluster into individual nodesTelegraf directly writes to all three
- Reduced data retention (6 months) for InfluxDB dedicated to monitoring
 Full 3 years available for analysis
- Upgrade to InfluxDB 1.9 enterprise edition
 - Same version everywhere, incl. test instances
 - Quick InfluxData support response
 - May move indexing from RAM to disk
- Grafana visualization consolidated
 Upgrade to cluster of 3 nodes





Conclusions

- Since 2020, EuXFEL's beam line and instrument control logs slow control data to InfluxDB
 - Both configurations and conditions
 - 3 * 25 TB of influx data on disk, current data input rate about 3 * 10 Mb/s
 - Data access experience:
 - Quick retrieval of historic trendline data
 - Availability in Grafana for monitoring enabled EuXFEL to setup its Data Operation Centre
- Logging data to InfluxDB fits well Karabo's event driven approach
 - Automatically logging only when data changes
 - But needs protection against ill-behaving noisy devices

► And - no bugs,



please...

Logging to InfluxDB boosted availability, accessibility and usage of historic control data at the European XFEL

Authors

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BACKUP

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The Home of Karabo: European X-ray Free Electron Laser (XFEL):

- Linear electron accelerator
 10 Hz of "trains" of up to 2700 pulses
 run by DESY
- Undulators creating X-ray laser photons





Photon beam steered
through 3 tunnels
to 6 instruments

Karabo: Designed and developed for control, data acquisition, analysis

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Karabo Communication Patterns

- Request/reply
 - Device registers methods as "slots".
 - Call from remote
 - with up to four arguments and return values.
- Publish/subscribe
 - Devices subscribe slots to a remote "signal".
 - When signal is "emitted",
 - all subscribed slots are called.
 - ► No publishing overhead for "popular" devices
 - Karabo framework is completely event-driven: regular polling obsolete.







InfluxDB – Estimate of EuXFEL Needs Before Installation

Load	Field writes per second	Queries per second	Unique series
Low	< 5 thousand	< 5	< 100 thousand
Moderate	< 250 thousand	< 25	< 1 million
High	> 250 thousand	> 25	> 1 million
Probably infeasible	> 750 thousand	> 100	> 10 million

From https://docs.influxdata.com/influxdb/v1.7/guides/hardware_sizing/#general-hardware-guidelines-for-a-single-node