NOBUGS 2022, Paul Scherrer Institute, poster #48

Synchronization of commercial camera data at the European XFEL

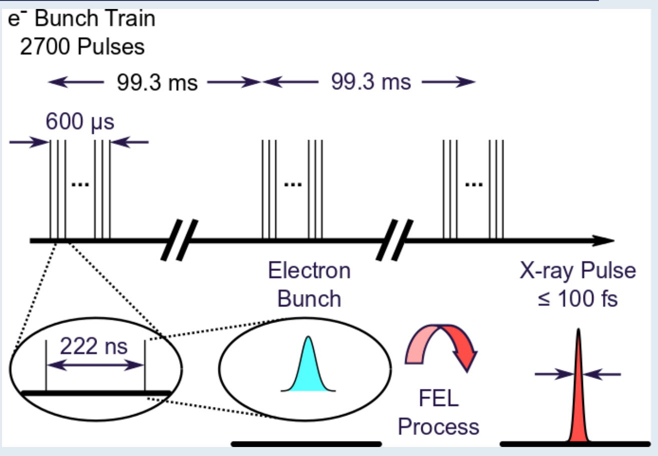
Andrea Parenti, Valerii Bondar, Riccardo Fabbri, Gabriele Giovanetti, Steffen Hauf

European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld, Germany

Introduction

- Commercial cameras are extensively used at the European XFEL, by the scientific instruments and for beam diagnostics.
- In order to correlate the data coming from different sources, the train ID is used as a primary key; the train ID counts the number of X-Ray trains supplied since the beginning of the facility operation, is monotonically increasing with a period of 100 ms, and is uniquely defined for the entire facility.
- Unfortunately, the train ID information coming from the XFEL timing system can generally not be injected into the timing information provided by the commercial cameras in use at the facility
- In this contribution, a reliable and reproducible solution to tag images received from Ethernet cameras with the correct train ID is described.

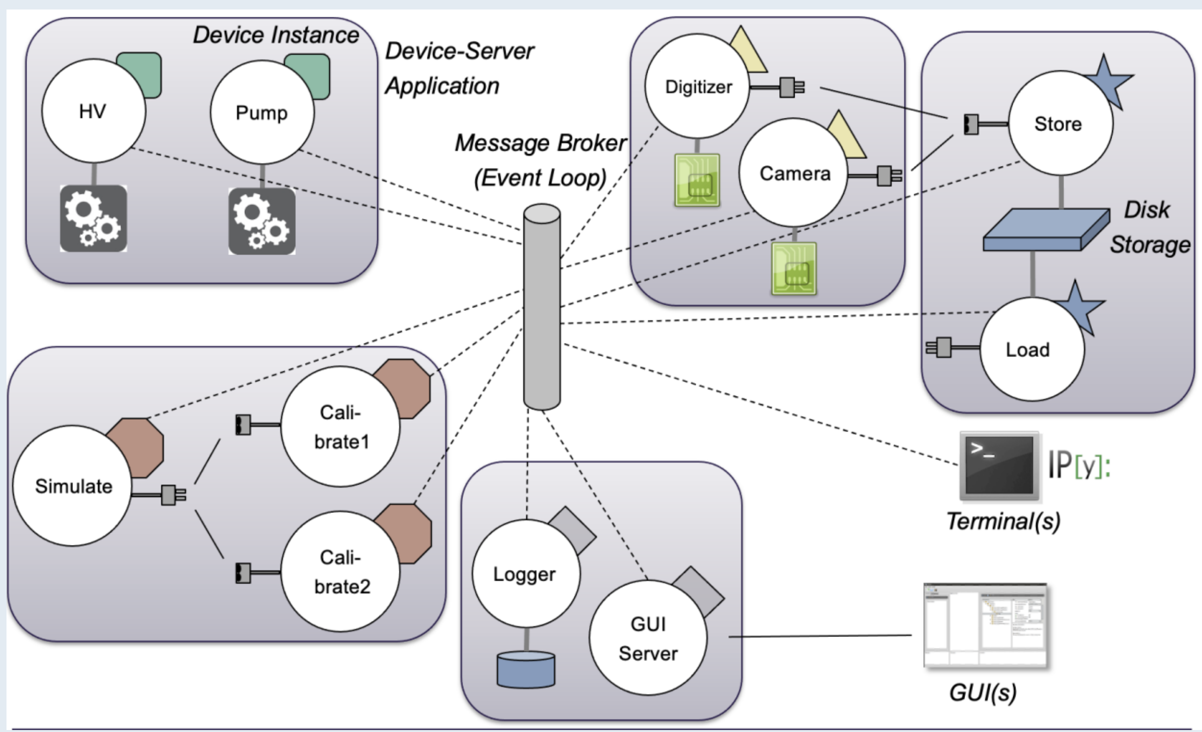
Data Structure



- The European XFEL generates coherent and intense X-ray pulses by bunches of up to 2700 pulses repeating every 100 ms.
- The data generated by instruments and detectors for each of these pulses are distributed at 10 Hz, which corresponds to the pulses train structure.
- One train data container from custom detectors (e.g. AGIPD, LPD, DSSC) consists of many images taken for different pulses in a train. The detector is connected to the XFEL timing system and injects the train ID in the data stream.
- Commercial cameras are usually operated at 10 Hz. They can be triggered by the XFEL timing system, but cannot inject the train ID into the data stream.

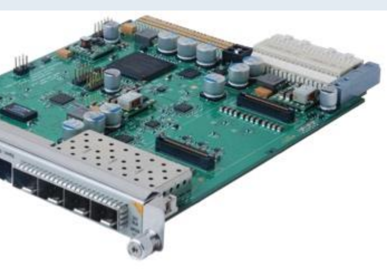
Karabo in a Nutshell

- Karabo is designed to provide supervisory control and data acquisition for the European XFEL [1].
- Hardware devices and system services are represented by Karabo devices distributed among various control hosts.
- Devices communicate via a central message broker using language (C++ and Python) agnostic remote procedure calls (RPC).
- The Karabo design is event-driven, offering subscription to (remote) signals to avoid polling for parameter updates.
- Large data from detectors is transported via flexible data pipelines using direct TCP connections.



The Karabo Timeserver Device

- The timeserver is a Karabo device that runs on a MicroTCA [2].
- The device receives train IDs and timestamps from a timing board (x2timer) [3], and distributes them via broker to all the Karabo devices in the system.
- To reduce the number of broker messages, the train ID is distributed once per second; the correct train ID is then extrapolated based on the train ID period.


X2timer board

Why Synchronization of an Ethernet Camera is Needed?

- When an Ethernet camera receives a trigger, it starts to acquire an image…
- After the exposure time is over, the pixels are read-out…
- Image processing is possibly done on the camera…
- The data are transferred in chunks via UDP/IP…
- Packet resends are sometimes necessary.
- Only when the whole image is available, the SDK passes it to the Karabo device.
- This chain of events can take longer than 100 ms! Moreover this image latency cannot be predicted, as it depends for example on the camera settings and the network load.
- As a consequence, a reliable solution is needed to tag images with the correct train ID.

Ethernet Camera Synchronization

- At the European XFEL, a solution to synchronize GenICam [4] / GigE Vision [5] compliant Ethernet cameras has been implemented.
- Ethernet cameras (e.g. Basler [6], Photonic Science [7]) have internal timestamp counter. Its update interval (tick_period) is normally 1-8 ns.
- The camera is configured to tag images with the internal timestamp corresponding to the start of exposure (internal_image_time).
- The counter can be accessed any time from the Karabo device via ‘TimestampLatch’ command and ‘TimestampLatchValue’ feature [8]; this value (internal_reference_time) is stored, together with the corresponding Karabo timestamp (karabo_reference_time). This procedure is repeated regularly to avoid time drifts.
- Once an image is received, its internal timestamp is converted to a Karabo timestamp: karabo_image_time = karabo_reference_time + (internal_image_time – internal_reference_time) * tick_period and the image is tagged with this.

Results

- Before the train ID correction was implemented, it has been reported that image data were sometimes late by a few train ID.
- Fig. 1 compares the beam intensity [Arbitrary Units] measured on a Basler camera and by a X-ray beam monitor (XGM). The XGM gets train IDs from the XFEL timing system. No clear correlation of the two measurements is visible.
- After the train ID correction has been implemented, a good correlation can be seen of the measured intensities (see Fig. 2)

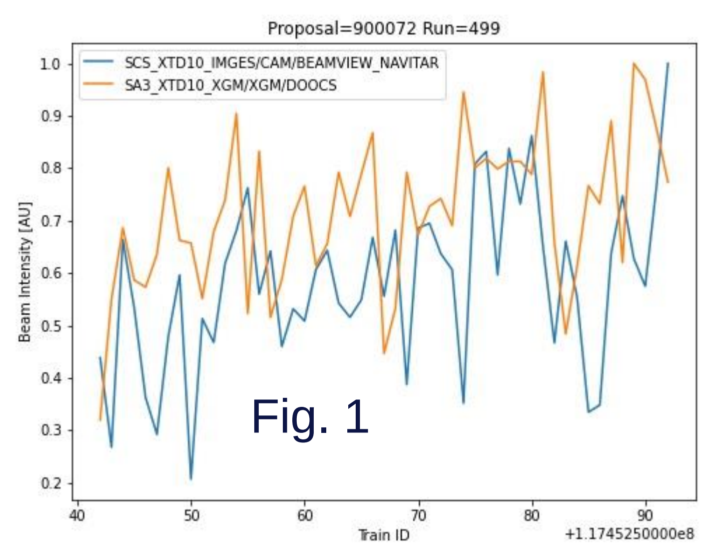


Fig. 1

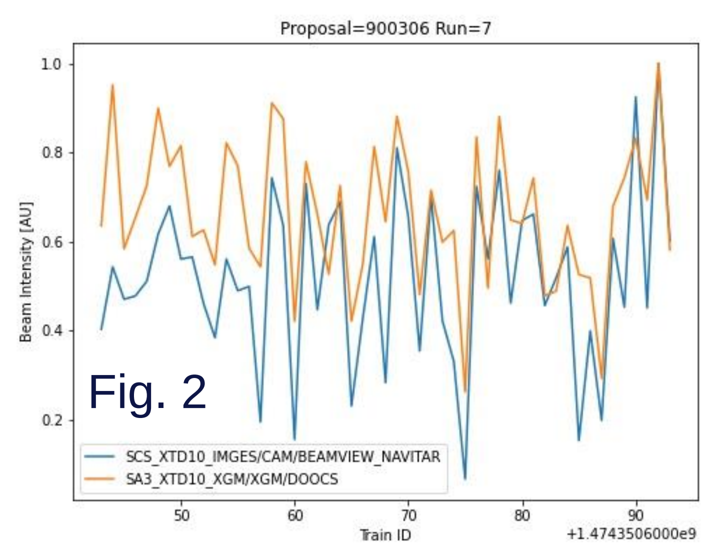


Fig. 2

References

[1] S. Hauf *et al.*, “The Karabo distributed control system”, DOI: 10.1107/S1600577519006696
[2] https://techlab.desy.de/
[3] https://techlab.desy.de/products/amc/x2timer/index_eng.html
[4] T. Maltezopoulos *et al.*, “Operation of X-ray gas monitors at the European XFEL ”, DOI: 10.1107/S1600577519003795
[5] https://www.emva.org/standards-technology/genicam/
[6] https://en.wikipedia.org/wiki/GigE_Vision
[7] https://www.baslerweb.com/en/
[8] https://photonicscience.com/
[9] https://www.emva.org/wp-content/uploads/GenICam_SFNC_v2_7.pdf

European XFEL GmbH, Andrea Parenti, Holzkoppel 4, 22869 Schenefeld, Germany, Phone +49 40 8998-6945, Fax +49 40 8998-1905, andrea.parenti@xfel.eu
www.xfel.eu

ENLIGHTENING SCIENCE