European

Software Development for High Speed Data Recording and Processing

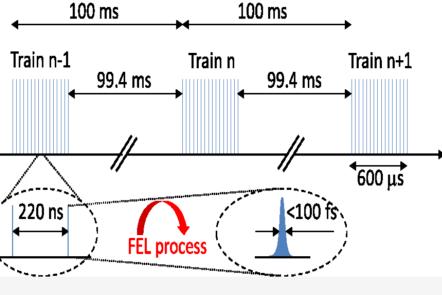
D. Boukhelef *, J. Szuba, K. Wrona, C. Youngman WP76, DAQ & Control Systems, European XFEL GmbH, Hamburg, Germany



More information

1. Control and DAQ System at European XFEL

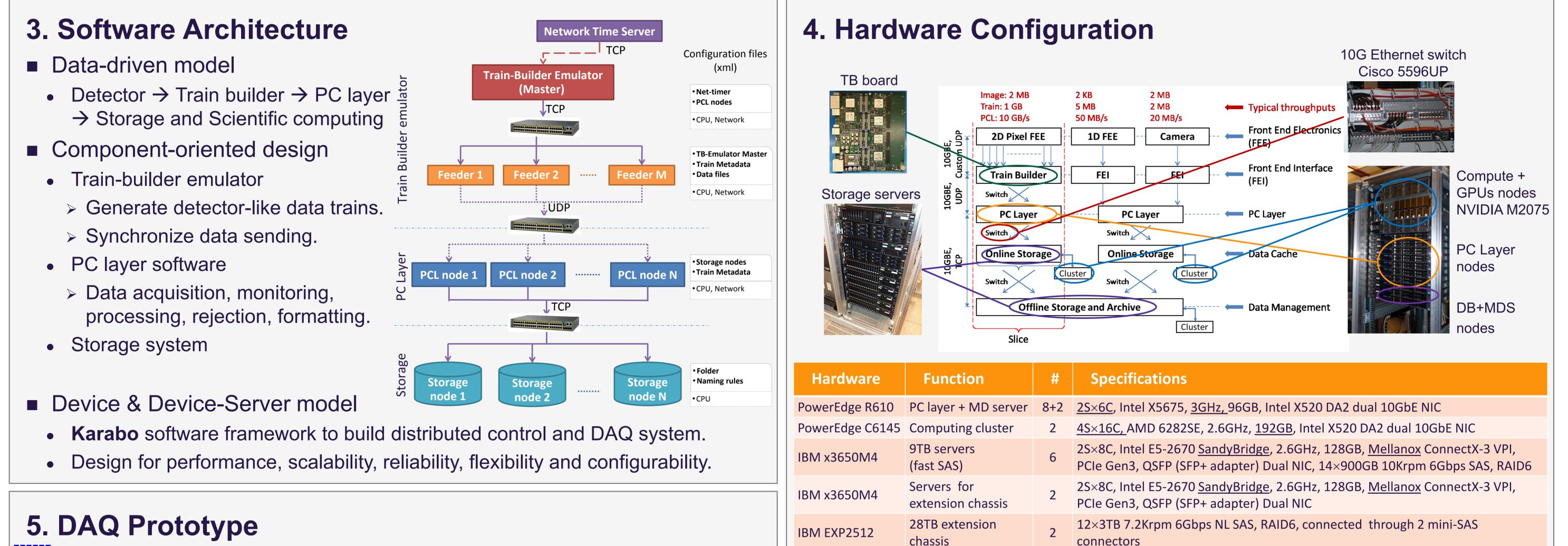
- Fast 4.5 MHz pulse rate, 10 Hz train rate instruments
 - 2D cameras: 16×10GE links, 1Mpx, ≤512 images/train=10GB/s
 - TOF, VMI, APD, etc.: Digitizer (2-7GS/s), Fast-ADC (125Mhz)
- Slow 10Hz instruments
 - Commercial cameras, positioning motors, vacuum systems, etc.

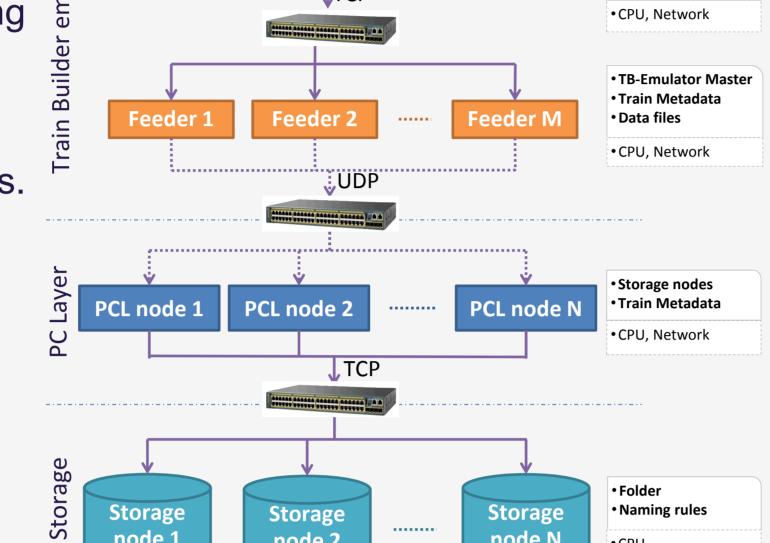


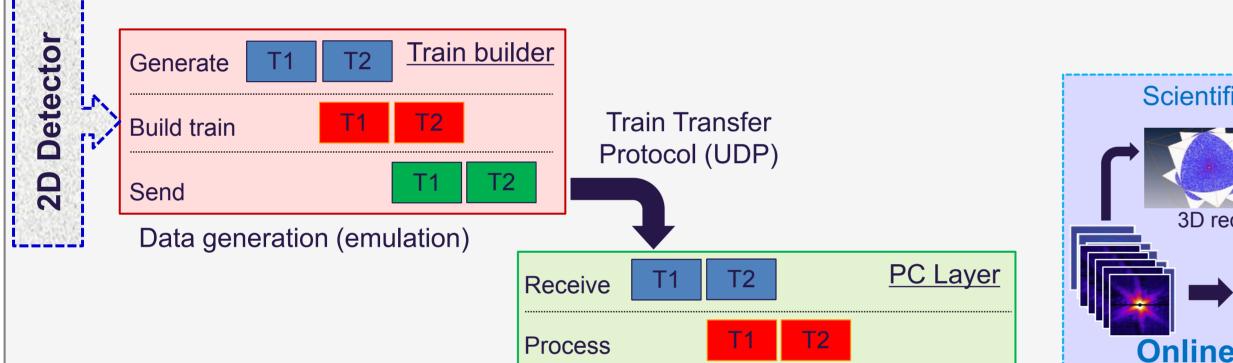
XFEL bunch structure

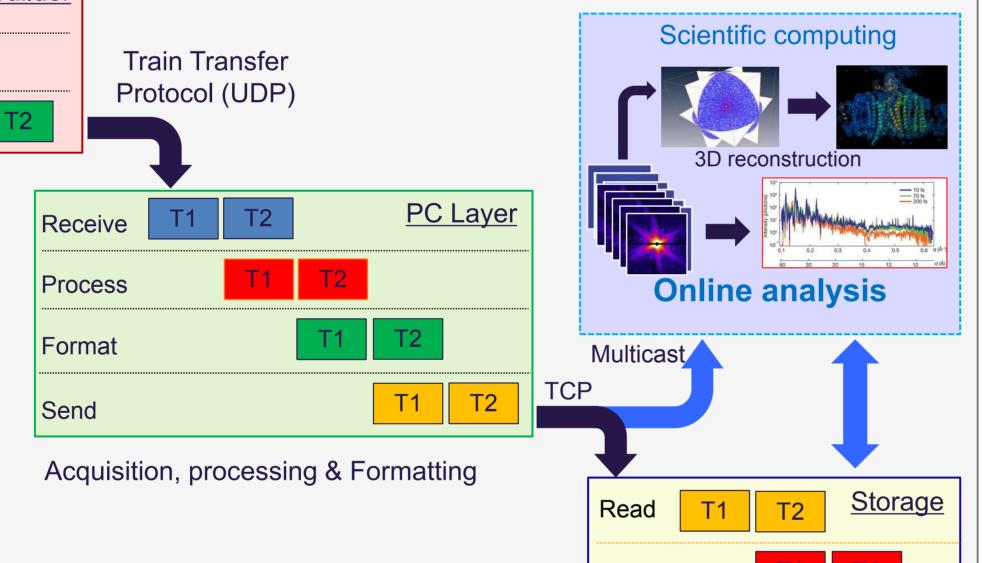
2. Scope and Objectives

- Select, install, and tune hardware, and develop software for control, data acquisition, processing and management.
- Data and system monitoring.
- Data rejection, pre-processing, formatting, storage and archiving.
- Scientific computing framework.



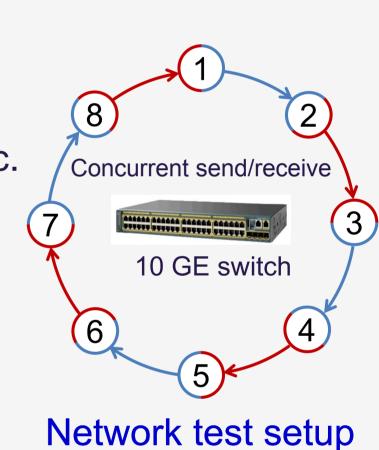






6. Preliminary Results

- Tuning for performance
 - Kernel (SL6): kernel buffers, IRQ affinity, NAPI driver, etc.
 - Application: CPU binding, socket buffers, etc.
- Successful test with train-builder(TB) board



Data acquisition and processing Pipeline

Acquisition

- Each train is handled by one PC
- Read UDP stream
 reconstruct train data
- Check for transfer errors, missing data, etc.

Processing

- Data monitoring, rejection, reduction, etc.
- Fast data analysis: hit & peak finding, etc.

Formatting

- Convert train data to in-memory HDF5 files
- Stream data files to online storage system via TCP channels

Data source (Train-builder Emulator)

- Feeders generate detector data in train format.
- Master synchronizes data sending to PC layer.

Online analysis & scientific computing

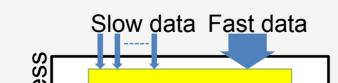
- Advanced algorithms for data processing, analysis, and visualization.
- Sophisticated data reduction algorithms.

Storage

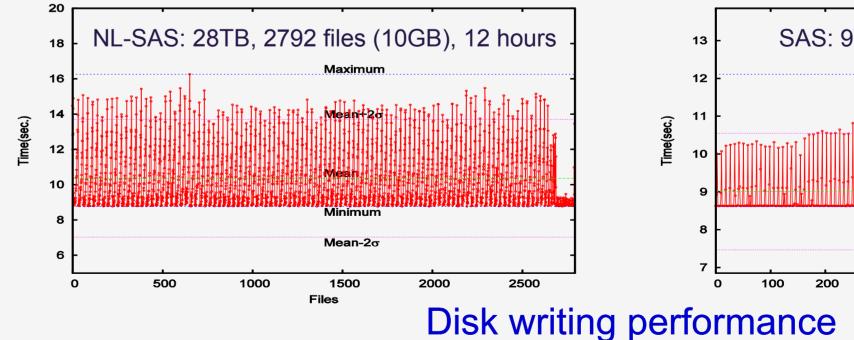
Fast data writing to disks, merging small files.

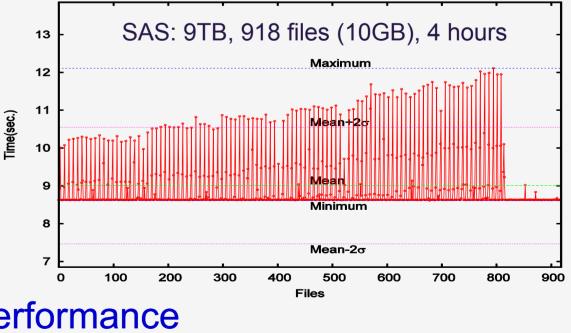
PC Layer Node

- Primary process
- Performs critical tasks such as data receiving, formatting, and job scheduling.



- Test the physical layer of TB, decode packets.
- Successfully received full data train for few seconds.
- Measurements
 - **Network:** TB Emulator \rightarrow PC layer
 - > Typical run for more than one hour $(3.5 \times 10^8 \text{ packets})$
 - > Long run for more than 17 hours $(5 \times 10^9 \text{ packets})$
 - > No packets loss were observed except sometimes at the beginning of some runs (ramp-up).
 - > Network bandwidth: \approx 9.94 Gbps (99.4% of wire speed)
 - > **Train switching:** each time a feeder sends new train data to different PC layer node \rightarrow No packet loss, no ramp-up at each train.
 - **Storage:** PC Layer (Dell) \rightarrow Storage boxes (IBM)
 - Sustained disk write speed/10GE channel: 0.97 ~1.1 GB/s.
 - > TCP data streaming: \approx 9.8 Gbps



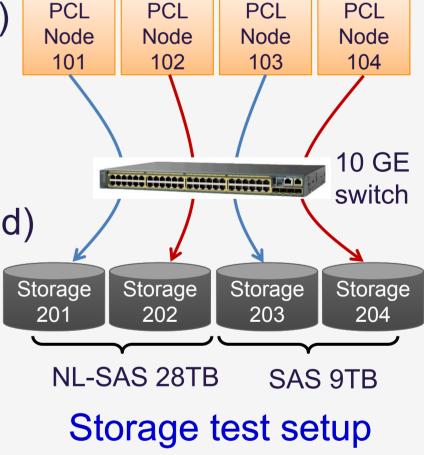


CRISP

DESY

HELMHOLTZ

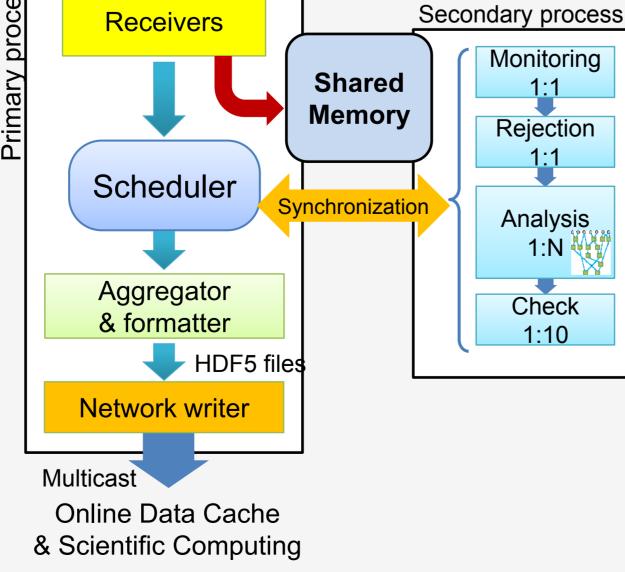
ASSOCIATION



- Requires super-user privilege.
- Secondary processes
- Load and run users' algorithms (plugins).
- Implement the concept of PC Layer pipeline.

Scheduler

- Monitors tasks and data status
- Coordinates threads activities
- Data exchange via shared memory IPC
- Holds train envelopes (identified by train Id).
- An envelope stores original raw data, calculated results, rejection decisions, etc. associated with one received train. It keeps also track of all processing activities on the train until it is saved.



7. Summary and Outlook

- Full-fledged DAQ software system
 - Use real data and implement real monitoring and processing algorithms.
 - Software deployment, run configuration and control: start/stop runs, etc.
- Soak and stress tests
 - Performance (IO, network, etc.) and behavior (bugs, memory leaks, etc.)
 - Reliability and stability of the system under big workload over long time period.
- Data management: data & file structure, access control, metadata, etc.
- Storage system: Local storage manager vs. cluster file system.
- Scientific computing framework.

www.xfel.eu * djelloul.boukhelef@xfel.eu **ICALEPCS 2013 - TUPPC045**