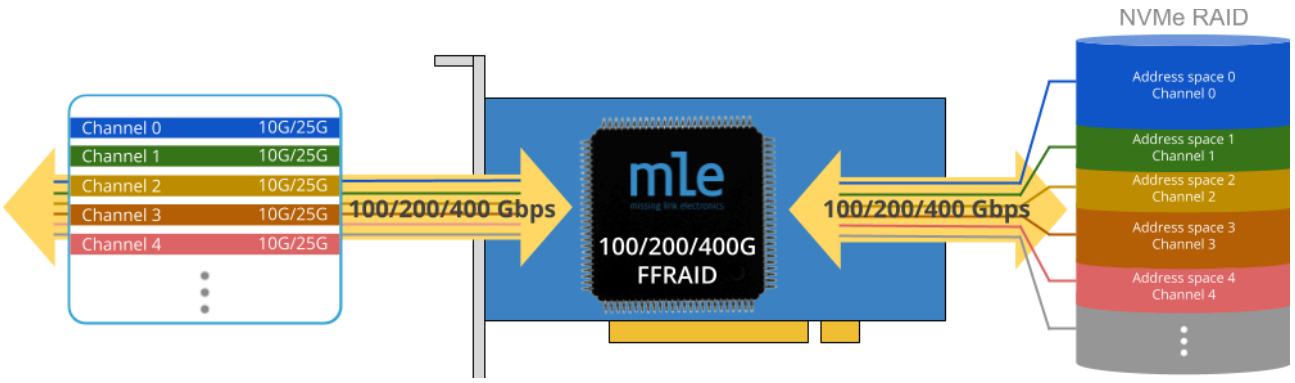
NVMe Fast FPGA RAID Accelerator Product Brochure

High-Speed Data Acquisition Systems require storing massive data in non-volatile memory. When read/write data rate exceeds the capabilities of single high-performance NVMe SSDs, or an off-the-shelf NAS system causes gaps during data acquisition, then rely on MLE NVMe FFRAID, a fast and FPGA-based RAID solution for use with NVMe SSDs:



Now, you can transfer bulky data from multiple sensors to a Redundant Array of Inexpensive NVMe SSDs at speeds up to 400 Gbps. MLE NVMe FFRAID implements a channel-based architecture, supports data-in-motion pre- and post-processing and is highly scalable with regards to bandwidth and recording capacity. Multiple systems can further be cascaded via IEEE 1588-2019 (HA) Precision Time Synchronization (PTP) for faster and/or deeper recording.

Availability Choices

- IP Core (for select FPGA devices)
- NVMe FFRAID Card (for select off-the-shelf FPGA cards)
  - AMD Alveo U50 / U55C with Ultrascale+ and HBM
  - AMD Alveo V80 with Versal and HBM
  - Altera Agilex 7 AGF014 with DDR4
- NVMe FFRAID Recorder (a turnkey system appliance)

Channel-Based Architecture

MLE NVMe FFRAID implements a channel-based architecture where each data source/sink can be associated with a dedicated RAID engine and a dedicated storage space. Each channel can have **10/25/50/75/100 Gbps**, or combinations thereof.

Adaptable signal front-ends support many different I/O standards in a “mix & match” fashion.

This channel-based architecture along with the combination of FPGA NVMe Recording Stack plus a well-tuned PCIe setup, delivers a best-in-class price/performance ratio for high-speed data acquisition, recording and replay. MLE’s multi-core NVMe Host Controller Subsystem supports dedicated NVMe queues per SSD in a PCIe Peer-to-Peer communication.

Applications

- Autonomous Vehicle Path Record & Replay
- Automotive / Medical / Industrial Test Equipment
- Broadcast Recording
- High-speed Radar / Lidar / Camera Data Acquisition & Storage
- Network Telemetry and Analytics
- Very Deep Network Packet Capture of Ethernet or IPv4 or TCP/UDP Data

Key Features

- Scalable from 100Gbps to 400Gbps
- Cascade of multiple systems with time-synchronization
- Start-Pause-Stop Data Recording
- Pre-trigger Data Recording using circular buffers
- Adaptable signal front-ends
- Striping mode (RAID 0)
- Striped and mirrored mode (RAID 0+1)
- Read/write compatible with Linux Software-RAID
- Compatible with TCG OPAL

Scalability

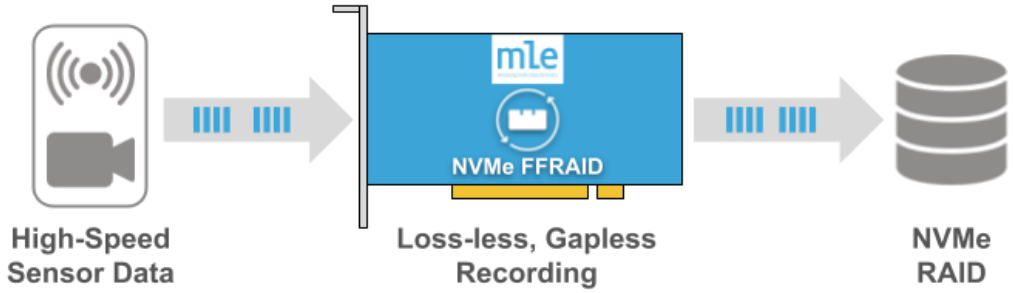
MLE NVMe FFRAID supports a wide range of NVMe SSDs and can be scaled from M.2 SSDs for small and light-weight embedded systems up to large 19” racks using high-performance U.2 or U.3 SSDs. Scalability also includes selecting from different SSD capacities and Drive-Writes-per-Day (DWPD) models. Here a table of possible recording times in minutes:

	Recording Speed (Gbps)						
Storage (TiB)	100	150	200	250	300	350	400
5	7.2	4.8	3.6	2.9	2.4	2.0	1.8
10	14.3	9.5	7.2	5.7	4.8	4.1	3.6
15	21.5	14.3	10.7	8.6	7.2	6.1	5.4
20	28.6	19.1	14.3	11.5	9.5	8.2	7.2
25	35.8	23.9	17.9	14.3	11.9	10.2	8.9
50	71.6	47.7	35.8	28.6	23.9	20.5	17.9
80	114.5	76.4	57.3	45.8	38.2	32.7	28.6
100	143.2	95.4	71.6	57.3	47.7	40.9	35.8
200	286.3	190.9	143.2	114.5	95.4	81.8	71.6
500	715.8	477.2	357.9	286.3	238.6	204.5	179.0

Data Acquisition Pre- and Post-Processing

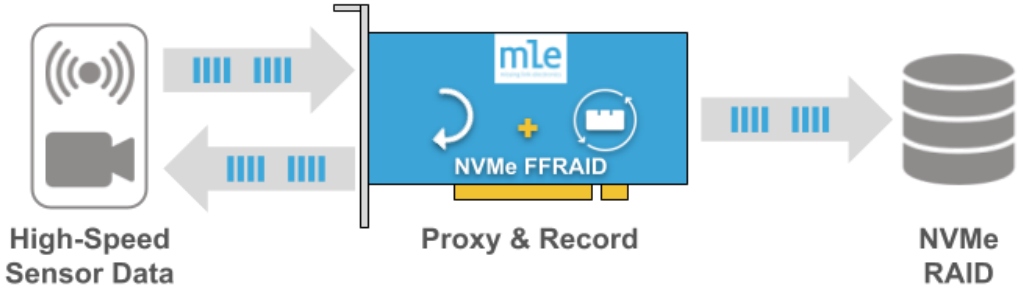
Besides record/replay of raw data MLE NVMe FFRAID Accelerator supports data-in-motion pre- and post-processing that enables you to add your custom algorithms for indexing and metadata generation, on-the-fly data decimation, or running in “spy-mode” as a transparent data proxy.

Plain Recording, Loss-Less and Gapless



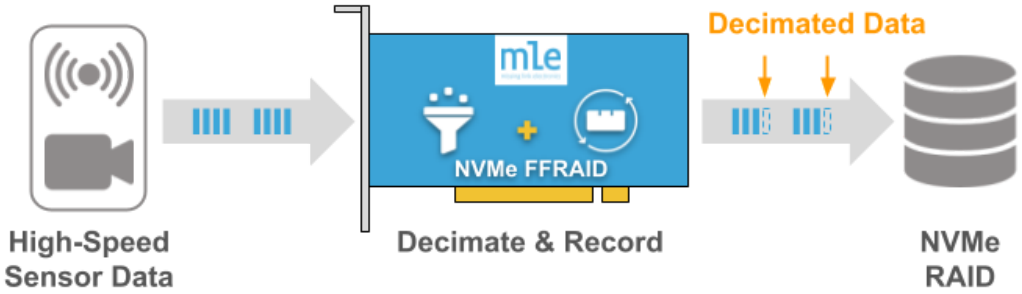
Ingress data from the high-speed sensors are transferred and recorded at-speed and as-is onto the NVMe Fast FPGA RAID.

Data Proxy & Record



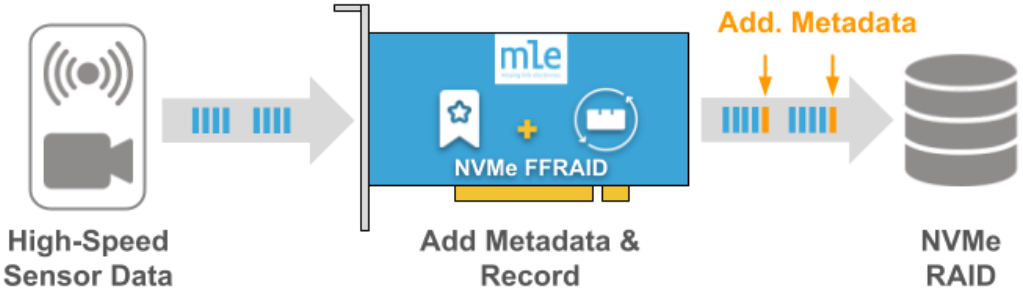
Communication from a high-speed data source can be transported to a data sink while this data is also recorded at-speed.

Data Decimation & Record



Unwanted pieces of the ingress data is removed on-the-fly prior to storage. This can, for example, be a selection of certain regions-of-interest (ROI).

Adding Meta-Data & Record

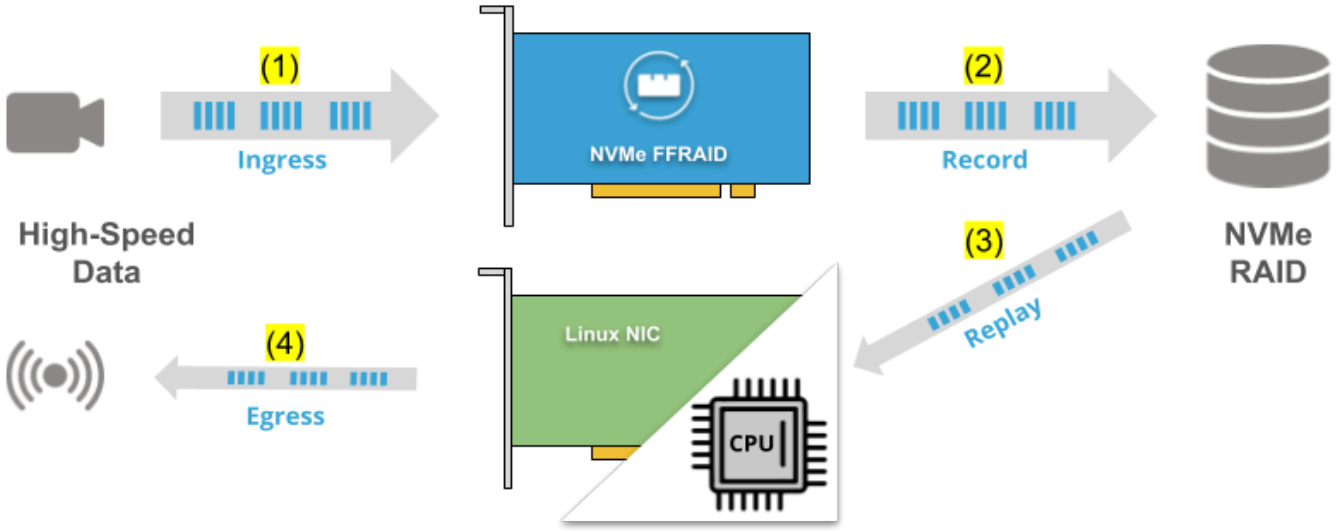


Ingress data can be analyzed on-the-fly to generate indexing information for later search, for example. This metadata is then recorded along with the ingress data. Metadata can, for example, be: Hardware timestamps, regions-of-interest, search indexes.

Accessing NVMe FFRAID via Linux Software

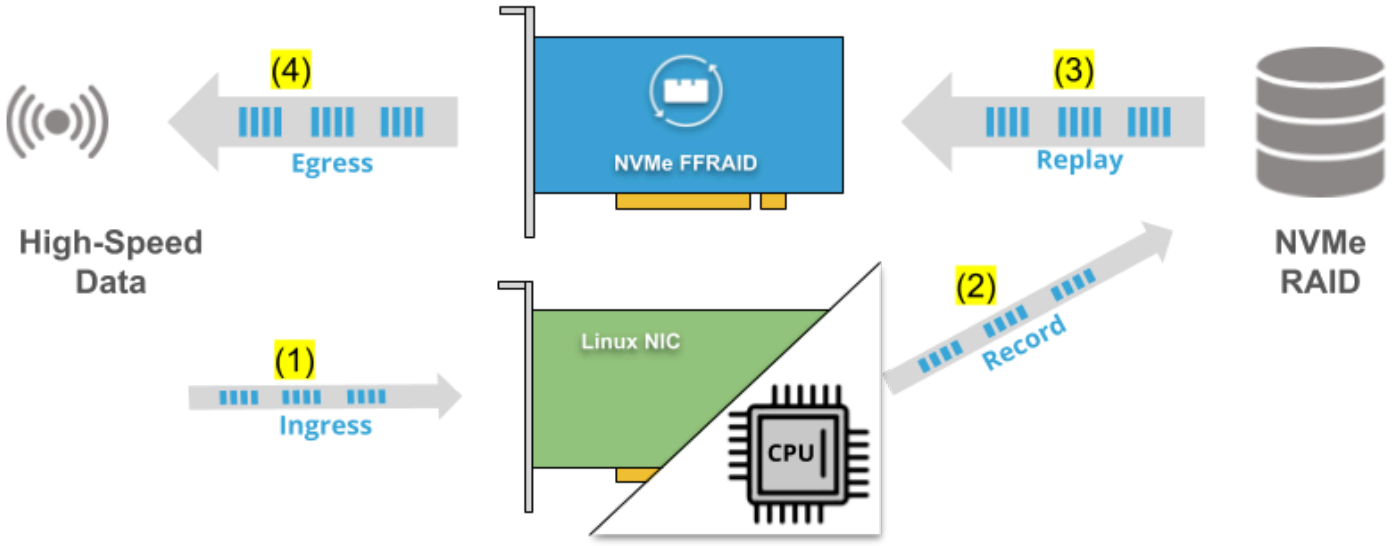
MLE NVMe FFRAID is **fully compatible with Linux Software-RAID** (via the Linux MD driver). This allows recording at high data rates and replaying at slower speeds, or vice versa. For performance reasons, MLE NVMe FFRAID stores your data as so-called Linux block storage, i.e. no filesystems are used which slow down data acquisition and/or retrieval. Hence, you can record via FFRAID and replay data from Linux, and vice versa:

"Simplex Record"



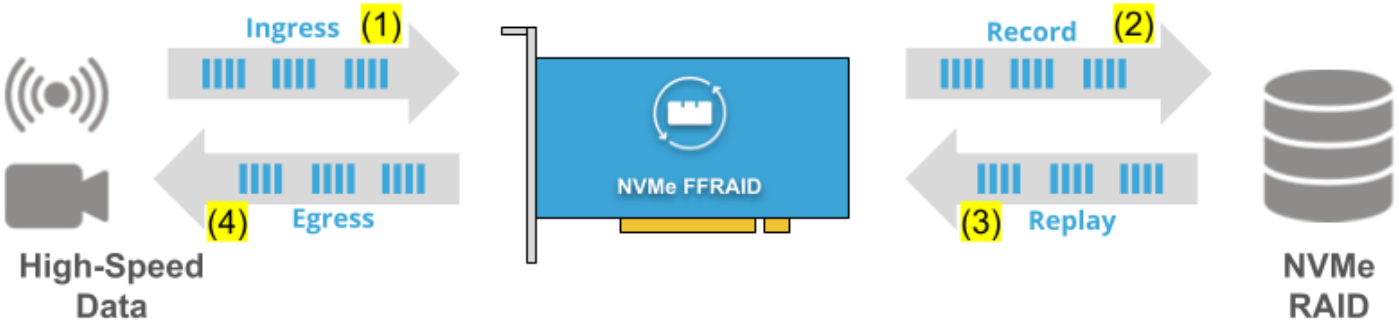
Ingress data (1) is recorded at high-speed using MLE NVMe FFRAID acceleration (2). Once recording is done the MLE NVMe FFRAID releases the SSD RAID and Linux opens this as an MDRAID. Then data can be replayed via Linux (3), typically at lower speeds, and, for example sent out via a Linux network connection (4).

"Simplex Replay"



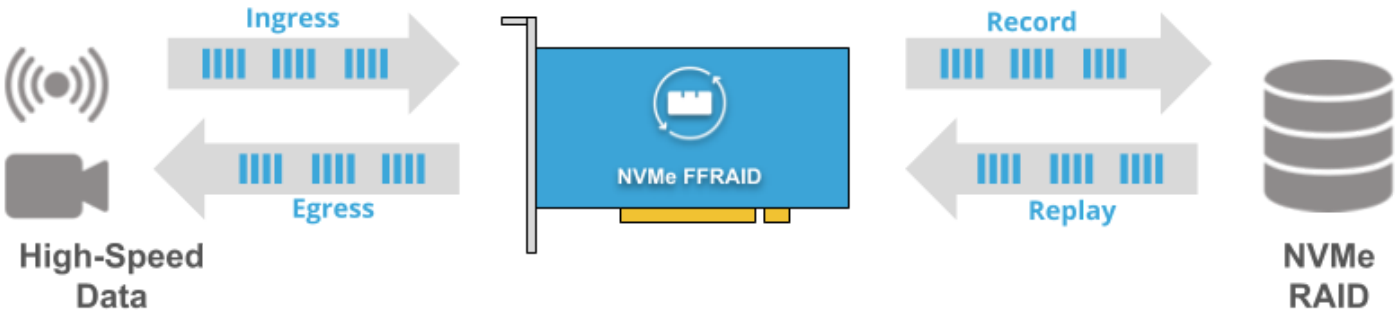
Ingress data (1) comes in via a Linux NIC, or any other Linux userspace software, for example, and is recorded onto a Linux MDRAID (2). Once recording is done, Linux releases the SSD RAID and the MLE NVMe FFRAID then opens it. Then data can be replayed via MLE NVMe FFRAID (3) and be streamed-out at high data rates (4).

"Half-Duplex Record & Replay"



Ingress data (1) is recorded at high-speed using MLE NVMe FFRAID acceleration (2). Once recording is done, then data can be replayed via MLE NVMe FFRAID (3) and be streamed-out at high data rates (4). Because you operate the NVMe SSDs purely in sequential read (ex-or write), this features best performance.

“Full-Duplex Record & Replay”



Ingress data is recorded at high-speed using MLE NVMe FFRAID acceleration. At the same time, while recording, data is replayed from the MLE NVMe FFRAID and be streamed-out at high data rates. Because typical NVMe SSDs deliver less performance when writes happen parallel to rads, you will experience less performance in this mode.

Contact Information

For more details regarding the MLE NVMe FFRAID solutions please refer to the MLE Technical Brief 20251016 “NVMe Fast FPGA RAID Accelerators” or visit the product website at https://missinglinkelectronics.com/FFRAID

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