Large-Scale Event Safety and Security: A Novel Edge-AI Approach

Cognitica AI, Pvt. Ltd. and MemryX, Inc.

Abstract:

Organizers of public events with large numbers of attendees, including many spiritual, sports, cultural, political, and other types of events, are tasked with providing a **safe and secure environment** for audiences and other participants alike. This task can often be very challenging, and typically grows exponentially with the audiences' head count, and there are many examples of situations where traditional approaches have failed to meet those all important goals.

History has shown that traditional security approaches such as static perimeter control, manual crowd monitoring, and reactive emergency response are often insufficient for large-scale events. Incidents at events like the Hillsborough disaster highlight how crowd mismanagement, infrastructure limitations, and inadequate real-time coordination can lead to unfortunate outcomes - despite a full security presence - because **dangerous density patterns went undetected until it was too late.**

> Addressing these challenges in a novel way, **Cognitica AI and MemryX** have joined forces to create a flexible, scalable, and efficient platform based on **Edge-AI principles** and leveraging Cognitica AI's extensive experience with large-scale, high-throughput Edge-AI systems coupled with MemryX powerful, yet energy efficient, **best-of-breed AI Accelerator technology.**

The following is a description of the platform, including functional and technical specifics of the implementation of a large-scale Proof of Concept (POC) deployment at a spiritual event hosting a very large audience with head count reaching multiples of six figures.

The Challenge:

It is well-known that many deep Learning AI initiatives that work well on paper and in small-scale "toy" installations fail when deployed at scale in the real world. To avoid this pitfall it was decided to take a **"moonshot" approach** to the challenge of creating a robust implementation of a large-scale Edge-AI based event safety and security system.

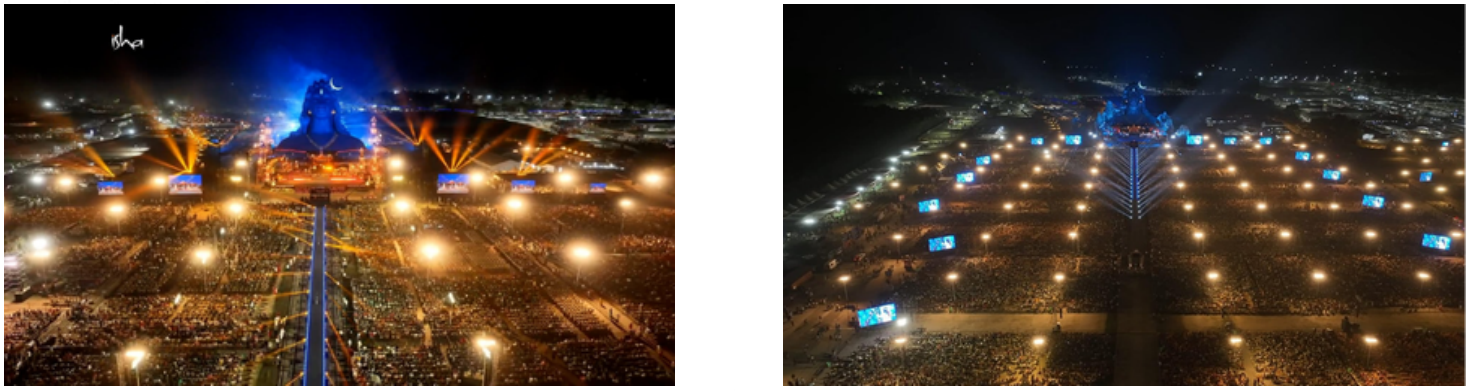


Figure 1. Mahashivratri festival at the Isha Yoga Center in Coimbatore, India. The event attracts hundreds of thousands of participants, creating a complex environment for large-scale safety monitoring and logistics coordination.

First, a suitable event that would offer a level of non-trivial difficulty was selected for the POC. **Isha's annual Mahashivratri festival** proved to be an ideal candidate event from that viewpoint. This spiritual celebration, honoring Adi Yogi Shiva, is organized by Isha and is held at Coimbatore, Tamil Nadu, India. The festival regularly attracts a very large audience, including many high-profile celebrities, notable social and political personalities.

The specific use cases for the POC were determined in close consultation with Isha's event officials. Although Cognitica AI's platform with the associated Deep Learning AI models deployed on MemryX AI accelerators are capable of addressing an extensive range of use cases spanning many safety and security scenarios, the event officials suggested that **AI-enabled logistics**, such as real-time tracking of human and vehicle movements, counts of individuals in specific areas, and availability of parking spaces, would be the most beneficial from their perspective.

A dedicated task-force was assembled consisting of Cognitica AI's software- and hardware engineers, including senior technical staff, supported by engineers from MemryX. Finally, a time schedule was set. **The deadline turned out to be extremely aggressive** by any measure, and in particular by "moonshot" standards: Given that the time of the event was fixed and wholly determined by the requirements of the spiritual ceremonies, the solution had to be designed, implemented and ready to go in a **little over four weeks**.

The Functional Scope:

Based on the event officials' input the main functional scope for the POC was determined to include the following:

- Crowd Density & Flow Management - As attendance increases, controlling ingress, egress, and internal movement becomes critical. Bottlenecks, insufficient exits, or sudden surges can escalate quickly into dangerous situations.
- Maintaining and tracking cumulative occupancy counts for specific areas in real-time.
- Real-time tracking of motor vehicles entering and leaving specific areas and checkpoints by vehicle type.
- Maintaining and tracking availability of of parking spaces across multiple parking lots in real-time.
- Display of the above, along with continuous updates of statistics.
- Logging of the above in SQL database for post-event analysis.

In addition to the main functionality a large number auxiliary and supportive scopes were identified and implemented. Many of these address exceptions and deviations from the initial base assumptions. For example, in a crowded area, such as the event site, there is a risk of double counting individuals, or not accurately tracking partially hidden individuals, and thus functionality was implemented to take such matters into account. Also, in spite of best efforts people might choose to take shortcuts or use other "unofficial" access paths, and therefore the monitoring must be able to easily be adjusted accordingly. The system was designed to run over a 24 hour period, and therefore must be able to **adapt to varying lighting conditions**, and temporary changes in illumination, such as car headlights, light-shows and similar non-continuous variations of light levels.

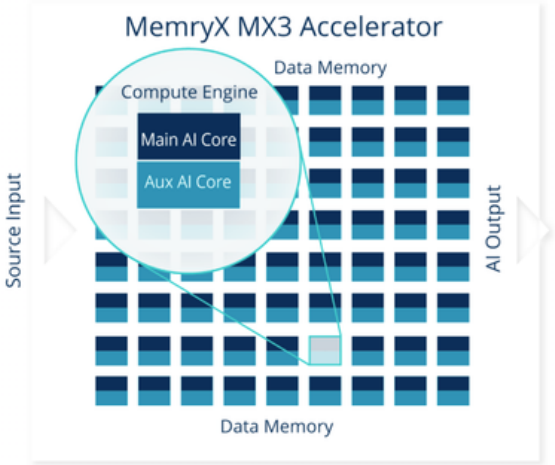
Some AI-capabilities were excluded from the POC deployment for policy- and privacy reasons. For example, AI-models for facial recognition, gender- and age-tracking, and license plate scanning were not activated. Also, only cars, trucks and buses were tracked and included in the vehicle counts, since event officials felt that motorcycles and similar vehicles do not require and occupy individual parking spaces to the same extent as larger vehicles.

Finally, as a fallback mechanism in case of a non-recoverable failure, the system must be able to display non-AI enhanced video feeds from a large number of cameras.

Architectural Objectives:

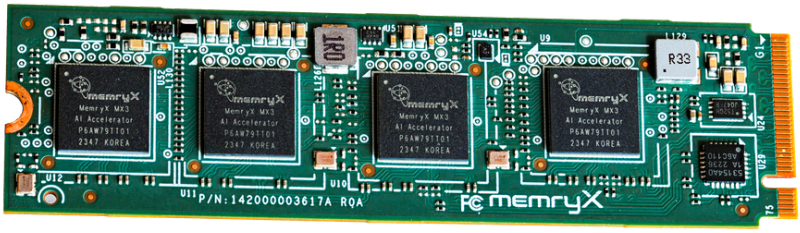
The overarching architectural design goal for the POC was to create a **fully self-contained Edge-AI installation**. Thus, there were to be no dependencies on Internet, cloud servers, hosted AI-models or other external systems not physically present on the premises. This constraint was **absolute and non-negotiable**.

Furthermore, given the critical role the POC system plays in monitoring and managing the logistic aspects of the event, single points of failure were to be eliminated to the greatest extent possible. This approach led to a **non-monolithic node-based architecture**. An additional benefit of this type of architecture is that it can seamlessly scale up or down as required by the specific nature of different events.



The **MemryX MX3** was an attractive choice for the AI workloads for several reasons. Unlike traditional GPUs and competing AI-accelerators that use complicated on-chip data management schemes, the MX3's uses and **at-memory architecture** that minimizes data transfer to and from the processing units. In simple terms, once the AI-model weights are loaded onto the MX3 the only communication with the host system is receiving input data and returning the model's output.

This stands in stark contrast to the operation of a typical GPU-based architecture, where input data and model weights are continuously transferred from system RAM to the GPU, a process that puts heavy demands on the host system's CPU and memory sub-systems, resulting in AI throughput becoming non-deterministic and highly dependent on overall system load.



An important feature of the MX3 is a pipe-lined data-flow architecture that decouples the AI-workload's data flow from that of other tasks, leading to a fully deterministic execution of streaming inputs, which is a clear advantage over GPU/CPU or other, control-flow dependent accelerator approaches to video-AI.

Using the MemryX MX3 frees up system resources that can be utilized by other tasks, such as I/O and CPU intensive applications processing. This allowed the POC to use hosts with processors based on the ubiquitous x86 64-bit architecture, specifically industrial computers using single Intel Core i7 CPUs.

One way GPU vendors work around memory bottlenecks is to include additional processing units and VRAM, which in turn leads to excessive power consumption, heat generation and increased demand for cooling. The MemryX module used up in the POC system combines four MX3 chips in a single module compatible with industry standard M.2 Key M slots. Each such module ships with a passive heat sink. Most GPUs that offer comparable performance require full PCIe v3 slots and active cooling. By taking the MX3 approach the power consumption is kept at a minimum, never exceeding 10W at full load.

The Technical Solution:

The input to the system consisted of cameras streaming high-definition video across IP connections in real-time. The event organizers provided access to existing cameras and associated networking equipment already in use on the event site. Initially access was granted to 400 cameras, but due to some policy- and security concerns that number was subsequently reduced to approximately 100 cameras.

The video streams were accessed by the POC setup through Ethernet and fed to a number of AI nodes. An **individual AI node** consisted of an industrial-rated host utilizing an Intel i7 multi-core processor with 32GB DRAM running Cognitica AI's software on a Linux operating system. Each node hosted a dedicated **MemryX MX3 AI Accelerator module** operating in multi-stream mode responsible for handling all inference tasks for the AI-models delegated to the node.

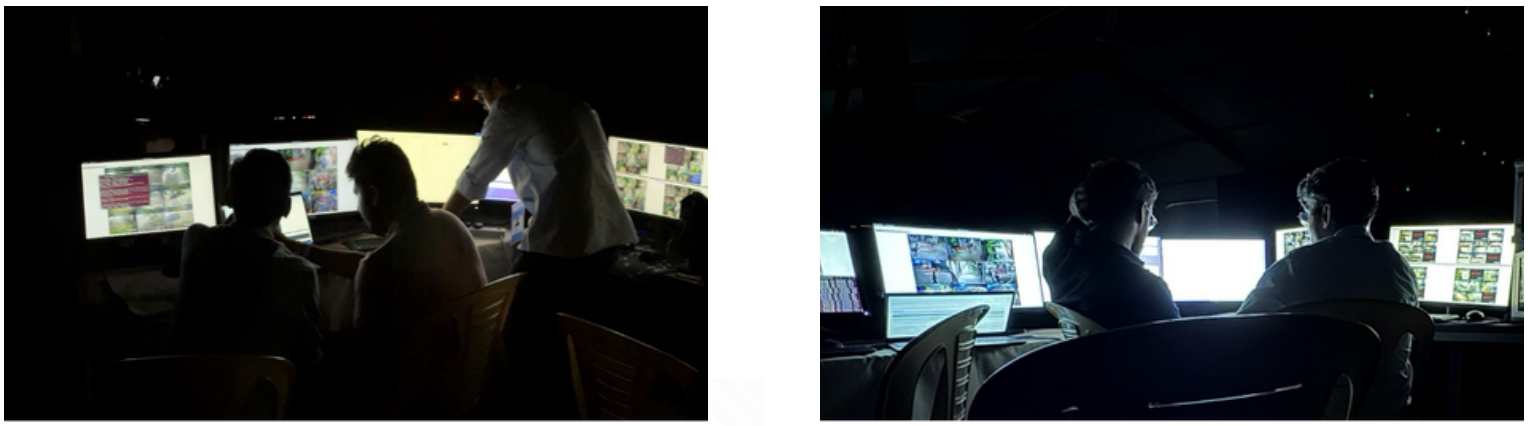


Figure 2. Operations team monitoring live camera feeds and analytics generated by the Edge-AI system during the Mahashivratri event.

The final installation consisted of **ten AI nodes**, each receiving streaming input from nine cameras. This amount of cameras was very conservative. In a laboratory setting Cognitica AI tested nodes with 1**5 cameras streaming at 30 frames per second for 20 hours** without experiencing any adverse events. Only the severe time constraints placed on the POC prevented testing with even more cameras for longer time periods, thus the true upper limit is not known at this time. In any case, the test is a clear indication of the high-performance capabilities of the Cognitica AI platform in conjunction with MemryX's powerful MX3 accelerator.

In addition to the active AI-nodes the POC included two additional processing nodes dedicated to the SQL database and video display, and two standby nodes for the evntuality of a failure taking an AI-node off-line. Nodes were housed together in custom rugged enclosures. Video was displayed on flat-screen monitors, each monitor serving four nodes through HDMI-multiplexers.

Finally, as an additional safety precaution given the oftentimes extremely high ambient temperatures at the event site, active cooling for the CPUs and MX3 modules was provided. The POC installation was running for over 20 hours straight at core temperatures in the 50-60C range, without signs of overheating.

Results and Conclusion:

From a functional perspective the POC system met or exceeded the expectations, in that it achieved all functional and architectural design goals. In addition, Cognitica AI and MemryX believe that it more generally fulfilled all the criteria for a self-contained, high-performance, large-scale event monitoring Edge-AI system.

In operation the POC system proved to be utterly reliable and ran uninterrupted for the full duration of the Mahashivratri celebration with no failures or unplanned outages. On a couple of occasions an AI-node had to be taken off-line for a short duration of time for recalibration of detection zones or to compensate for extreme changes in illumination levels, but normal operation was immediately resumed when the node was brought back in service.

> **The Mahashivratri deployment demonstrated that a fully self-contained, high-performance Edge-AI system can be designed, built, and operated at scale under real-world conditions - and delivered on that promise.**

Looking Ahead:

Heading into the future we're looking forward to adding enhancements in the form of additional innovative features and functionality, new, even more capable AI-models and increased performance.

The same platform, with no fundamental architectural changes, is **readily deployable** across a wide range of large-scale environments - from stadiums and concert venues to transportation hubs, political gatherings, and major religious events such as the Hajj. The node-based, cloud-independent design means scaling to larger venues or more complex use cases requires adding nodes and activating additional AI models, nothing more.

Beyond logistics, the platform supports a broader set of safety and security scenarios - real-time crowd density monitoring, perimeter breach detection, anomaly identification - use cases intentionally deferred for this POC but well within the system's capabilities. **As event organizers worldwide face growing pressure to demonstrate duty of care to audiences, regulators, and insurers, a proven, scalable, privacy-conscious Edge-AI solution addresses a genuine and growing market need.** Cognitica AI and MemryX are committed to continued development of the platform across new events, markets, and geographies. Organizations interested in exploring a deployment are encouraged to reach out - **we are ready to engage**.

Acknowledgments:

Cognitica AI and MemryX would like to thank Isha for giving us the opportunity to put our products to the test in an exciting and challenging environment, and for gracefully placing their faith and trust in us by allowing us to participate in the 2026 Mahashivratri event. We feel deeply indebted to Isha, and we cannot express our gratitude enough.

And of course, we are indebted to the engineers who unselfishly worked long hours for weeks on end to make this Proof-of-Concept reality. Your efforts are noted and greatly appreciated.

More Information:

About Cognitica AI Private Limited:

Cognitica AI is a leading innovator in high-performance computer vision, dedicated to the mission of achieving total situational awareness in complex environments. By leveraging a sophisticated hybrid AI architecture, Cognitica combines the lightning-fast, real-time responsiveness of Edge AI. Beyond the industrial shop floor, Cognitica has expanded its expertise into premises security and public safety, deploying intelligent monitoring solutions for events, retail spaces, and corporate facilities. Whether enforcing safety compliance in a warehouse or managing crowd dynamics and asset protection in commercial zones, Cognitica's technology bridges the gap between raw visual data and actionable, proactive safety intelligence.

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About MemryX Inc.:

MemryX Inc. is a fabless semiconductor company focused on AI inference acceleration, with a production-proven "at-memory" dataflow architecture that delivers superior efficiency for edge and upcoming data center applications. Backed by $44M in Series B funding from investors including HarbourVest, NEOM Investment Fund (NIF), Arm IoT Fund, eLab Ventures, M Ventures, and Motus Ventures, MemryX is driving the next wave of AI hardware innovation from its headquarters in Ann Arbor, Michigan.

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