OpenVX™ for automotive systems

Cano Raphael-Robert Bosch GmbH

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Agenda

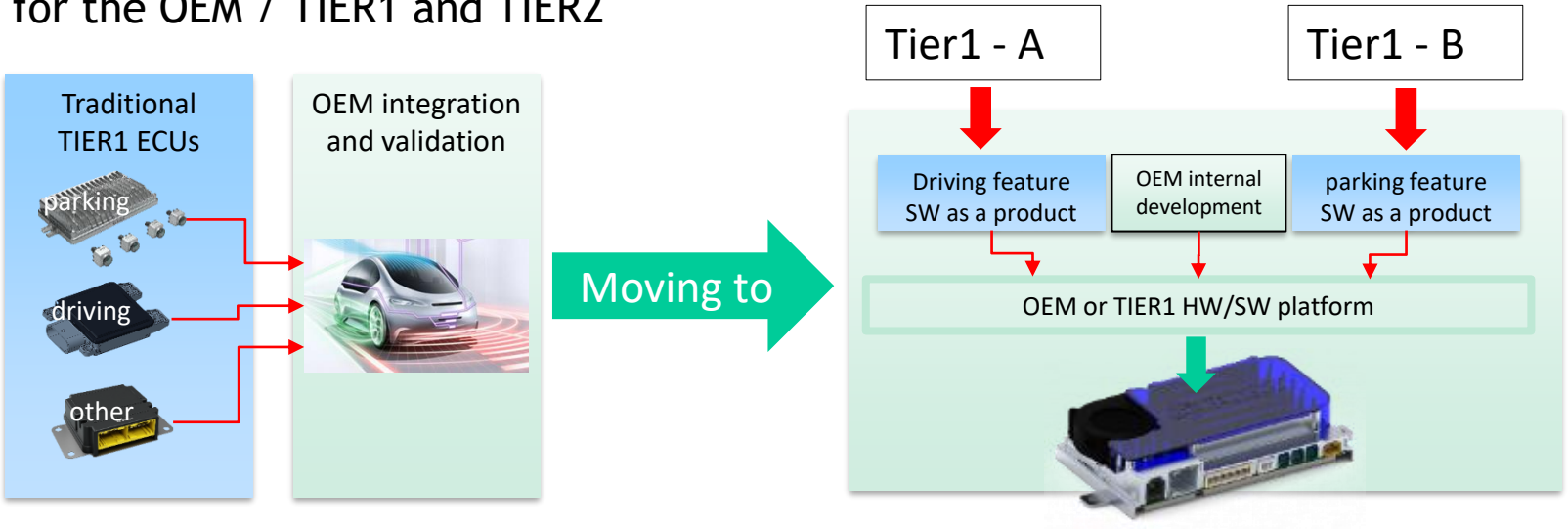
- Automotive technologies and complex use cases
- Automotive: A new business model
- How can OpenVX help TIER1 and OEMS (and SoC vendors) ?
- OpenVX concepts
- The Future of OpenVX: The road to version 2.0

Automotive technologies and use cases

- **Technologies/sensors used in automotive domains**
  - Ultrasonic, radar, lidar and video sensors
- **Automotive use cases cover a lot of different situations which can be split into these domains**
  - Manoever-Stack
  - Driver monitoring / interior camera
  - Convenient cameras like trailer / tailgate etc.
- **All these functions require different image pipelines like:**
  - Video streams suited for computer vision (different ISP setting and formats)
  - Video streams suited for human vision (different ISP settings and formats)
  - Different stream based on different type of sensor (IR stream)

A New business Model for the Automotive Industry

- Over the past few years and the emergence of the **SW defined vehicle**, the market has shifted from multiple dedicated (black-box) ECUs for parking, driving, and other functions to a centralized ECU that consolidates these functionalities.
- This transition has led to a restructuring of the development and integration models for the OEM / TIER1 and TIER2



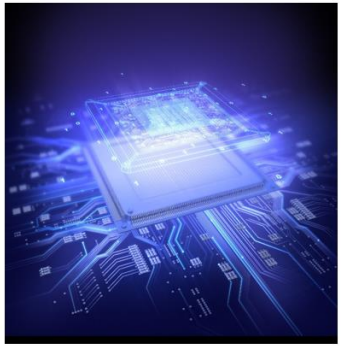
Bosch Adaptation to this New Situation

Tailored computing solution

Our approach enables customer tailored computing solutions based on the underlying modular construction kit

No SoC lock-in

Based on our flexible electronic concept we can integrate SoCs of various vendors to avoid SoC lock-in effect



ECU and system competence

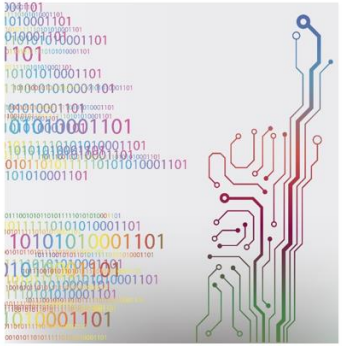
We as Bosch bring in comprehensive know-how and series-proven experience both on ECU and system level

Modular electro-mechanic concept

Based on our modular electro-mechanical concept we can offer single ECU solutions as well as multi-ECU rack integration

Customer and 3rd party SW support

Our flexible integration platform supports Bosch SW as well as customer and 3rd party SW solutions



How does OpenVX help TIER1 and OEMS ?

- Royalty-free open standard API that is reliably accelerated by hardware vendors and tightly defined conformance tests.
- Targeted at low-power, real-time applications including mobile and embedded platforms.
- Portability across diverse heterogeneous processors, including ISPs, dedicated hardware, DSPs and DSP arrays, GPUs, multi-core CPUs, and more.

OpenVX™

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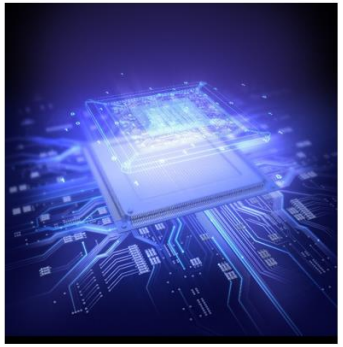

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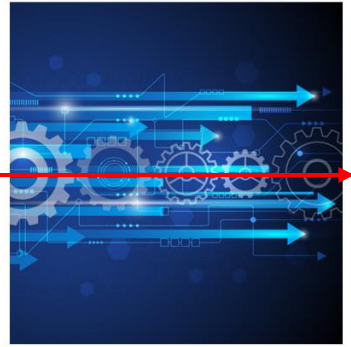

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party SW support

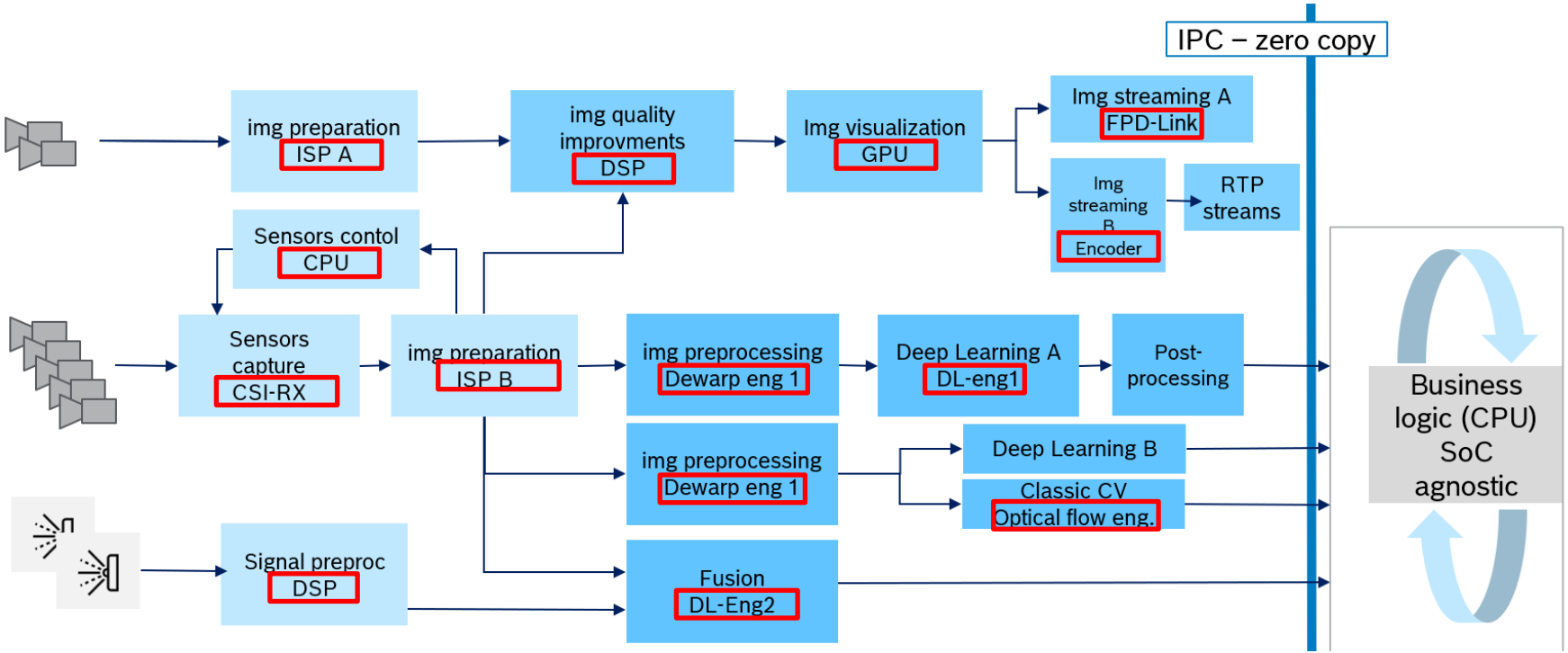
Our flexible integration platform supports Bosch SW as well as customer and 3rd party SW solutions

Automotive technologies and use cases

- **No Soc lock-in**
  - For TIERx: Ability to (fast) transition to a new hardware platform based on OEM requirements.
  - For OEMs: Flexibility to switch (fast) to a new SoC, enabling cost savings and dual sourcing.
  - For SoC vendor: Provides a platform to showcase hardware capabilities within the same ecosystem.
- **Customer and third-party SW integration**
  - Facilitates integration by providing a standardized interface.
  - Library Integration: Enables validation and testing processes for library integrations.
  - Reduced Complexity: Mitigates and reduces integration complexity
- **Cross-Generation Compatibility:** Builds and capitalizes across system generations by providing mechanisms and standards to avoid reinventing the wheel when switching to another SoC. Re-use all quality artefacts (req., test coverage etc.)

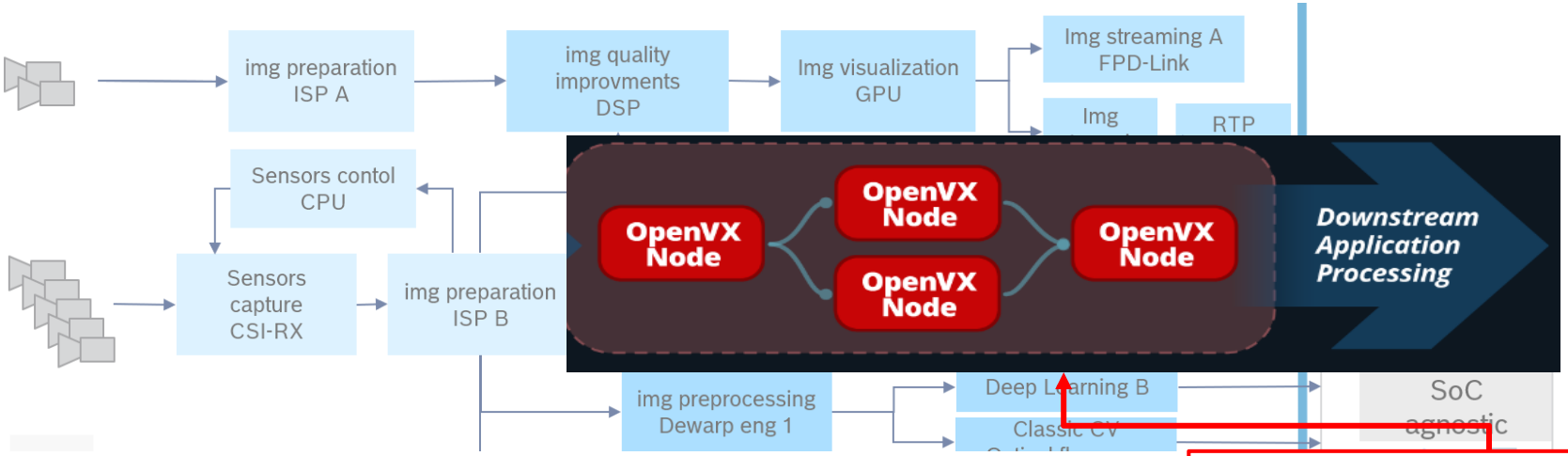
See next slide for a typical automotive use case and how we solve it using OpenVX

Typical data pipelines used in our projects



Data pipelines are spread across various HWAs, cores, and subsystems

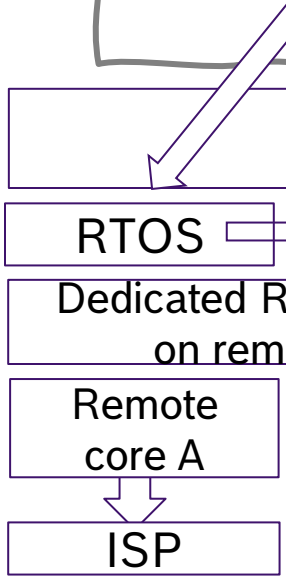
OpenVX Concepts: Nodes and Graphs



All needs fullfiled by OVX

- Each block is a compute unit and
  - Uses different hardware accelerators (HWAs)
  - Runs on host or different remote systems
- All blocks/nodes may run in parallel and form a graph
- All computations run fast with minimal interactions with the host (CPU) system

OpenVX concepts: No SoC lock-in / ease of integration



- **No Soc lock-in !**
  - Pipelines (graphs) remain the same across different SoC (same “functional” need)
  - Only kernels implementation differs (if needed)
- **Decomposing data pipelines into nodes allows for:**
  - Supplier Flexibility: Nodes can be delivered by different suppliers.
  - Independent Validation: Each node can be validated separately, outside of the entire graph.
  - IP Protection: IP can be protected by using binaries if necessary.

OpenVX concepts: Capitalize across system generations

Every automotive applications (and beyond) should

- Meet safety and security goals
- Be portable by re-using the same code base / documentation and quality artefacst
- Be robust and reliable
- Offer mechanisms for error detection and recovery

You can have the best AI algo, if the data are not availble it does not help!

These requirements are complex and time consuming to develop!

Reusing these concepts across SoC and system generations is a smart approach.
OpenVX provides the API and a stable platform to achieve this!

OpenVX concepts: Capitalize across system generations

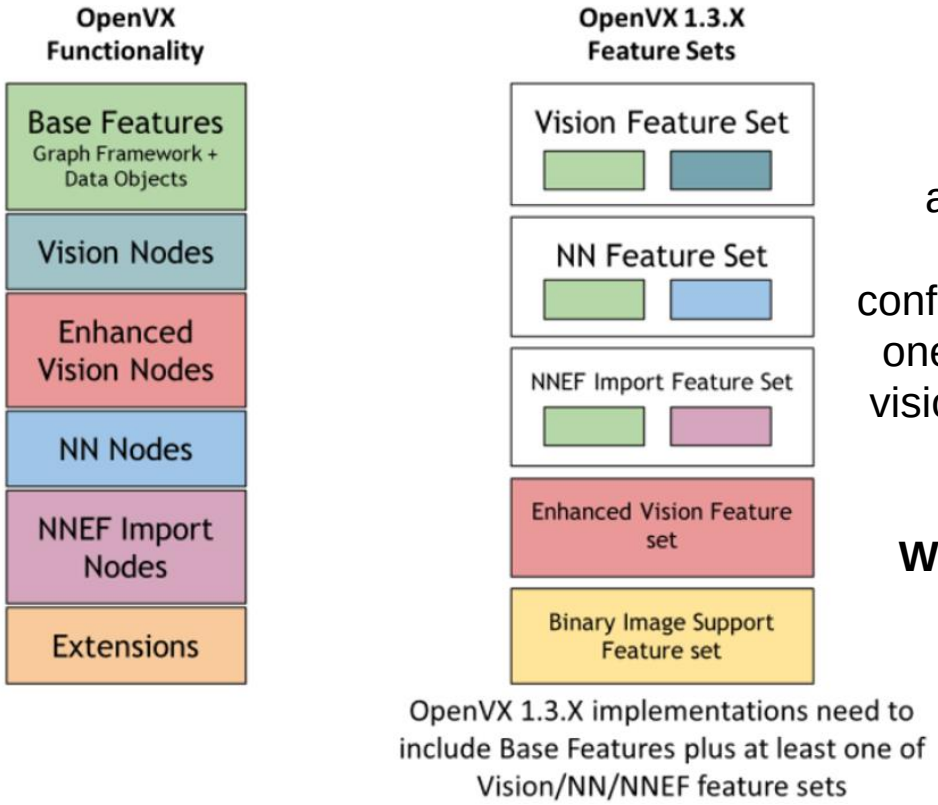
Here are a few examples of OVX features that help achieve safety and security goals

- ***Lightweight Implementation:*** OVX can be lightweight, making it suitable for ASIL validation.
- ***Conformance Tests:*** OVX provides conformance tests to ensure the robustness and correctness of the framework.
- ***Clear Separation:*** There is a clear split between the framework and the application, ensuring freedom from interference.

To provide reliability:

- ***Standardized API:*** The standardized API allows you to build on a stable foundation, enabling code improvement across product generations and SoCs.
- ***Error Detection and Recovery:*** OVX offers various mechanisms for error detection and recovery, including node errors, graph timeouts, latency checks, and node diagnostics.
- ***Custom Extensions:*** You can create your own extensions and propose them to the Working Group!

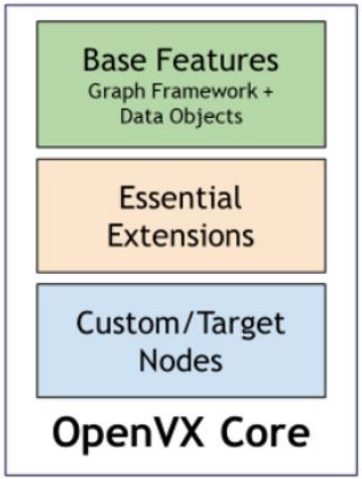
The Future of OpenVX: Current Situation



OpenVX 1.3.x already offers various conformance models. However, to achieve conformance, you must implement at least one of the additional packages (such as vision nodes or NN nodes) along with the base features.

With version 2.0, we aim to simplify this model

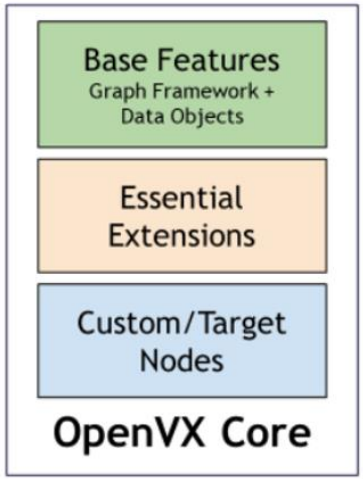
The Future of OpenVX: Version 2



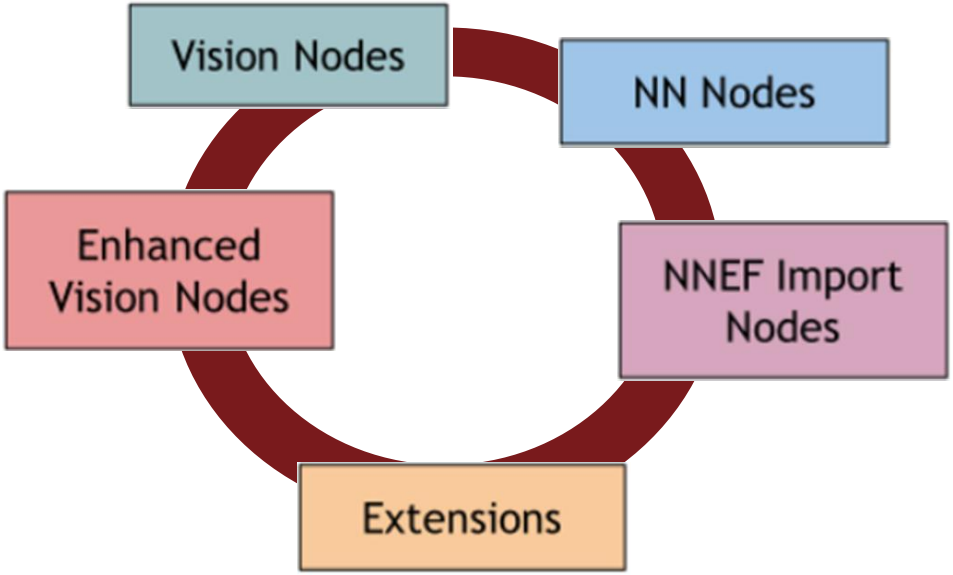
By simplifying and reducing the conformance process OVX2.0 focusses on the framework feature ONLY: the OpenVX core

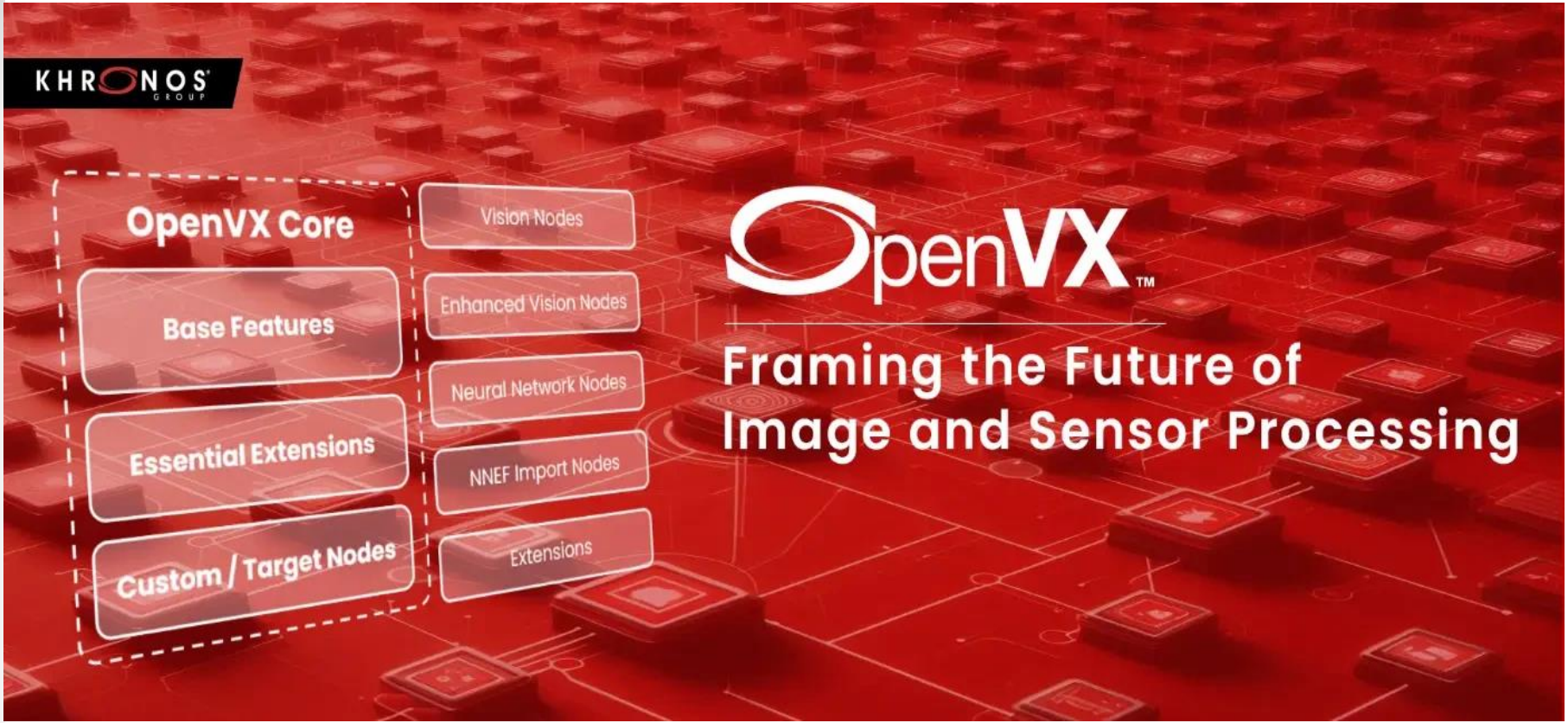
- **Core Framework Improvements**: Building on OpenVX 1.3.1 by integrating essential extensions within the core spec
- **Focus on User-Defined and Generic Workloads**: Not focusing on video but on any kind of sensor data and HWAs processing, the vision nodes and other features being removed from the core
- **Low Barrier to Entry**: streamline the conformance process, enabling faster adoption for developers and hardware vendors alike. *(and why not proposing a portable refence implementation of it)*
- **Extensive Conformance Testing**: OpenVX 2.0 will include comprehensive conformance tests to ensure reliability and consistency across implementation(s).

conformance reached
by fullfiling the core API
only



Vendor can choose (or not) the extension of its choice and submit conformance test results (if existing)





blog has been published:
https://www.khronos.org/blog/framing-the-future-of-image-and-sensor-processing-with-openvx

Get Involved: Embrace this standard and contribute to its improvement.

Your involvement is crucial for the industry, not just automotive, to define a framework and standard that enables us to:

Build reliable and secure systems

Reduce time to market and development costs

Enhance systems and features across SoC and product generations

With a robust standard in place, you can focus on innovation!

Any company is welcome to join Khronos to influence standards development

https://www.khronos.org/members/ **or email** memberservices@khronosgroup.org

More information on any Khronos APIs

https://www.khronos.org/