GISC 2025

Global ICT Standards Conference 2025

KHRONOS GROUP

Standards Cooperation for AI and Spatial Computing

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ICT Standards and Intellectual Property:
AI for All

Hosted by Ministry of Science and ICT, Ministry of Intellectual Property
Organised by National Radio Research Agency, TTA, IITP, KEA, kista, ETRI

Khronos Connects Software to Silicon

Founded in 2000
~ 150 Members | ~ 40% US, 30% Europe, 30% Asia
ISO/IEC JTC 1 PAS Submitter

KHRONOS GROUP 25 YEARS

Non-profit Standards Consortium creating open, royalty-free standards

Focused on runtime APIs and file formats for 3D, XR, AI, vision, parallel compute acceleration

Member-driven, open to any company

TTA

Khronos is honored to sign an MOU with TTA today to promote Khronos standards in Korea!

Enabling Markets through Wide Adoption

Relevant to the Metaverse

3D and Compute on Desktop

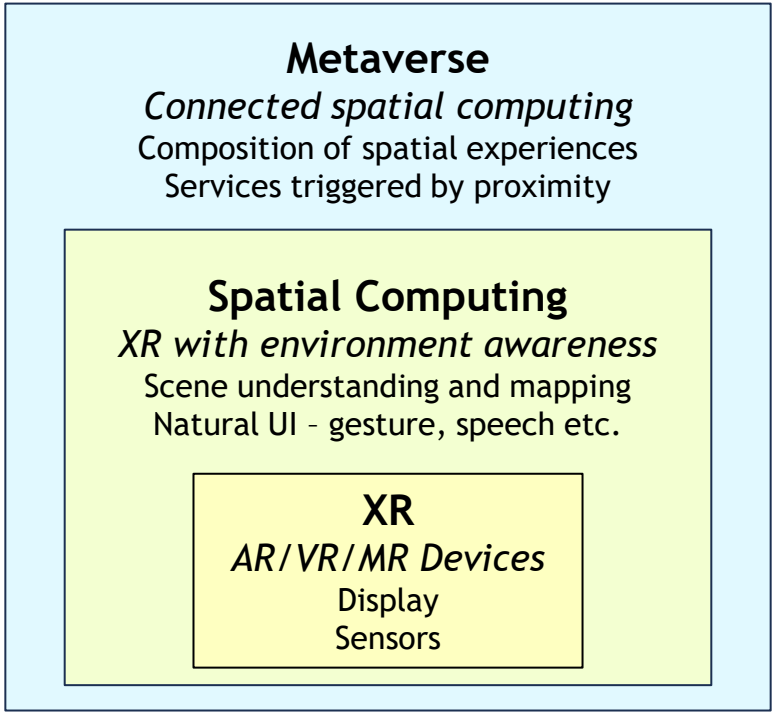
3D on Mobile

3D on the Web

Cross-platform Spatial computing and camera processing

GPU APIs and Languages - including AI Acceleration

What is the Metaverse?



The metaverse provides the infrastructure for:

Multi-user, multi-agent interactions

Persistent placement and interactions with 3D content in virtual AND real spaces

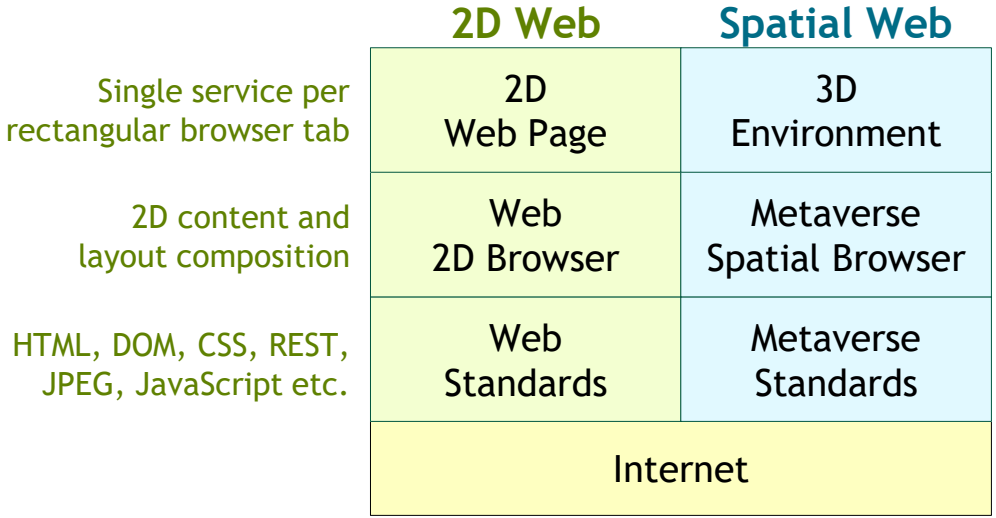
Composited scenes AND services delivered in a location and environment aware browser

The metaverse is the *spatial evolution of the web*
A global standards-based platform

Evolving the Spatial Web

Interoperability will enable a spatial browser to connect to and deliver ANY spatial services and experiences that conform to metaverse standards

Leveraging the same openness and accessibility that underpins today's 2D Web



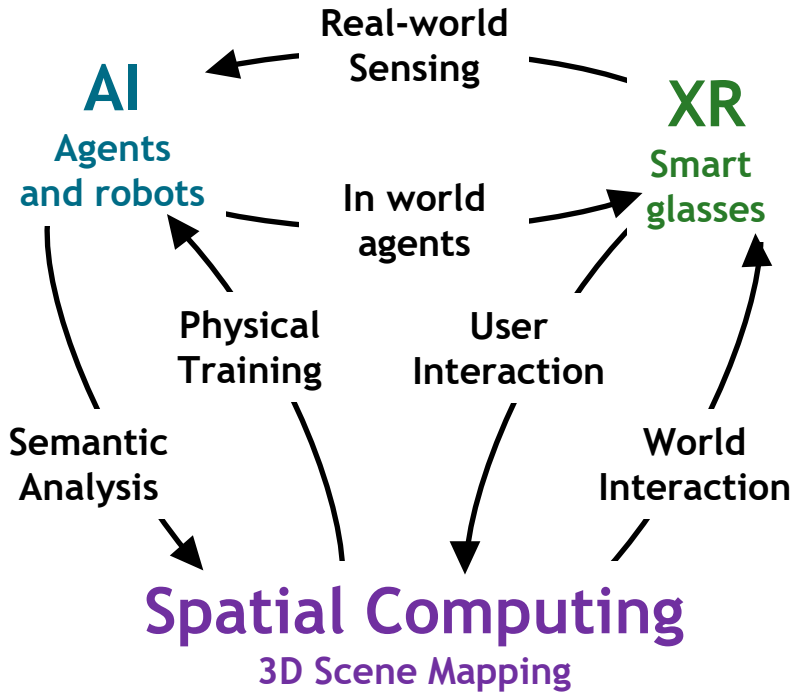
Multiple **users** and proximity-triggered **services** composed into a spatial environment

Realtime 3D world management and display

A new standards-based stack!

- 3D assets, avatar and scene formats
- Scene understanding, semantics and persistence
- APIs and protocols to discover and access spatially aware/positioned services
- Discovering and interacting with AI agents
- Run-time APIs for XR devices and spatial UI
- Security, privacy, and identity
- Many more…

Convergence of AI, XR, and Spatial Computing



Many say the "metaverse is dead"
being replaced by the excitement around AI
BUT AI, XR and spatial computing are
very tightly interconnected

XR will enable entities (users, robots) to
sense their environment

AI will enable entities to semantically
understand their environments

3D environments will be essential to
train physical AI to interact with the real world

Spatial computing through XR devices enable users
to *interact* with real & virtual worlds

'Metaverse' is the best term (so far) for this
revolution in how we will interact with computing

The Metaverse will be the primary user interface to AI in the real world!

The Four AI Pillars for Building the Metaverse

3D Content Creation

Generative Worlds, Scenes, Avatars, Assets
Gaussian Splats
Neural Graphics: Materials, Lighting
Upscaling and Frame Generation

Semantic Understanding

Scenes
Objects
Humans (body, hand, speech),
Translation

Autonomous Agents

AI Agents
Game Non-player Character
Robotics

Oversight

Monitoring, managing, intervening
Content Moderation, Resource
Load Balancing, Digital Twins,
Online Economies

All these were *hard* or *impossible* until the arrival of AI

AI Driven Semantic Scene Understanding

Sensor Processing
Including multiple cameras

▼

Scene Reconstruction
Build model of spatial entities and anchors

▼

Object Semantic Labels
What objects ARE e.g., a mug

▼

Affordance Labels
What objects can DO (e.g., “hold-liquid”, “grasp”)

▼

Actionability Maps
Spatial maps where actions are possible in a scene

Context Unlocks Intent

Agents (e.g., robots, virtual characters, AR assistants) that understand how objects relate, e.g., "a chair facing a desk,” can plan intelligent actions

Without context, agents react; with it, they can anticipate and adapt

The metaverse needs standards for end-to-end pipelines combining perception, reconstruction, semantics, and rendering with cross-platform persistent scene graphs

AI Learns Spatial Interactions in the Metaverse

Real-world data can be difficult or expensive to obtain to train AI in spatial interactions

Synthetic spatial data can scale training cheaply and effectively
Especially when simulating rare/dangerous scenarios

Doesn't replace real world data

Suffers from gaps, errors, assumption and biases

Needs a benchmarking and validation loop

Use real data to validate, tune and correct –
perhaps with human verification

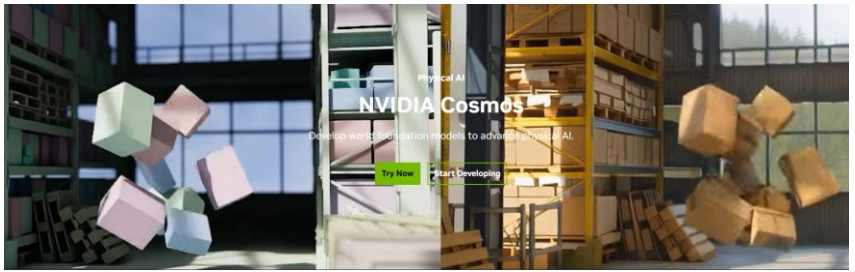
Working towards robust hybrid training systems

Self Supervised Learning to minimize needed input data

Active Learning to steer and optimize the learning process

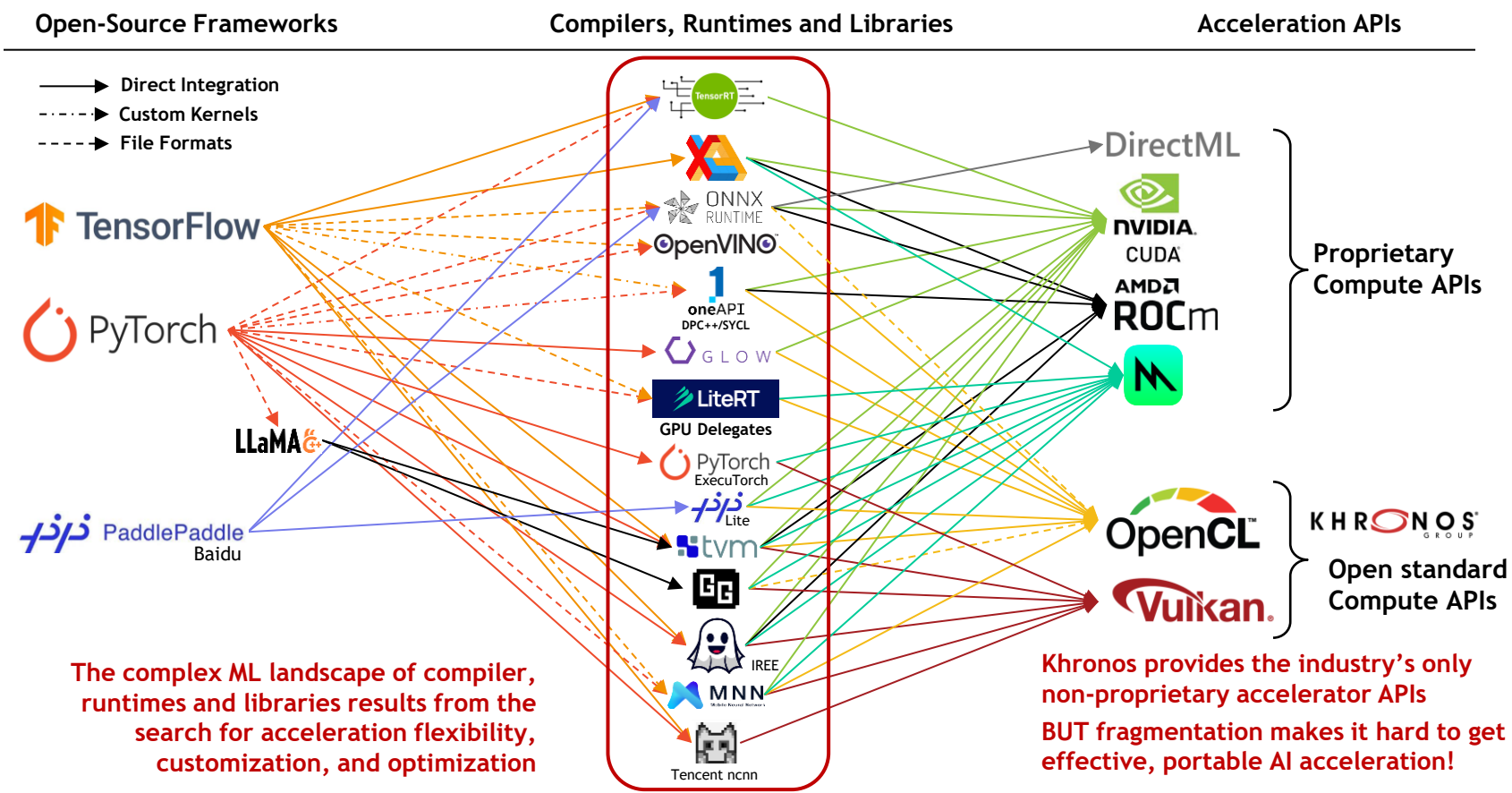
Human in the loop
only where necessary

Synthetic Driving Scenarios



Synthetic Wearhouse Scenarios

Machine Learning Acceleration Complexity



The complex ML landscape of compiler, runtimes and libraries results from the search for acceleration flexibility, customization, and optimization

Khronos provides the industry's only non-proprietary accelerator APIs

BUT fragmentation makes it hard to get effective, portable AI acceleration!

ML Ecosystem Acceleration Inefficiency

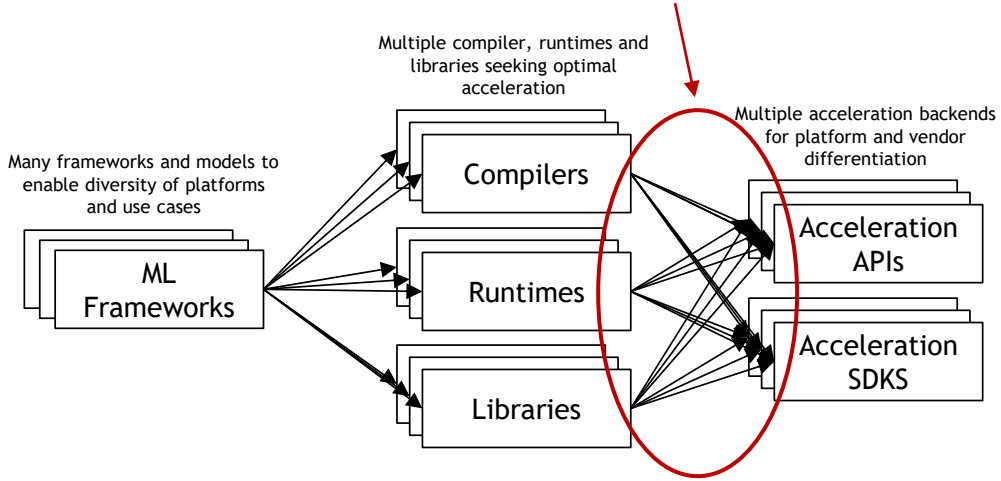
Multiplied porting and support costs

ISVs must support multiple backends

- Increased software complexity and support burden
- Slow adoption of new hardware features
- Fragmented platform support

IHVs must integrate with every framework

Frameworks × # Accelerators



X

Lack of Performance Portability

Speed-of-light performance requires expert interventions for each backend

- Model porting & optimization
- Custom operators
- Graph rewriting & scheduling

=

ML acceleration pain points are slowing innovation!

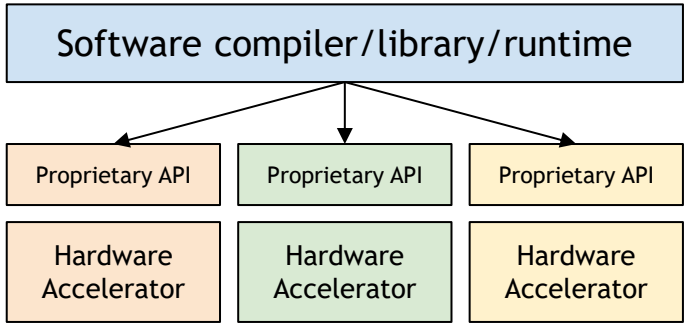
- Expertise bottleneck
- Duplicated effort

= Slow adoption of new acceleration opportunities …

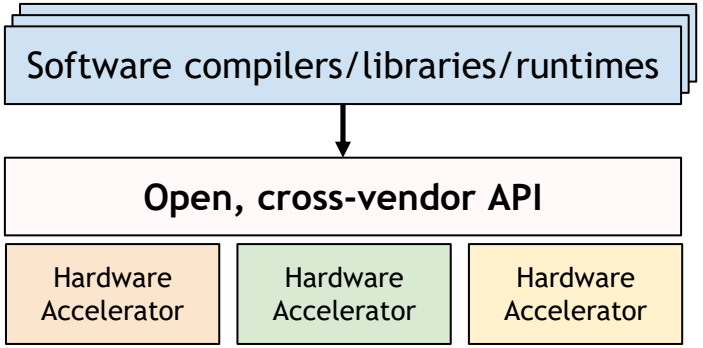
… end users can't run the models they need on the hardware they want!

Can Open Interoperability Standards Help?

- **Open cross-vendor APIs benefit software AND hardware vendors**
  - Software vendors have reduced costs and broder market reach
  - Hardware vendors have access to a broader software ecosystem
  - Robust API design and support with input and investment from multiple companies
- **BUT acceleration standards must be designed with care**
  - Not too soon - only standardize interoperability that is **proven** and **stable**
  - **Extensible** to accommodate technology advances



Custom API per hardware vendor increases software porting and support costs

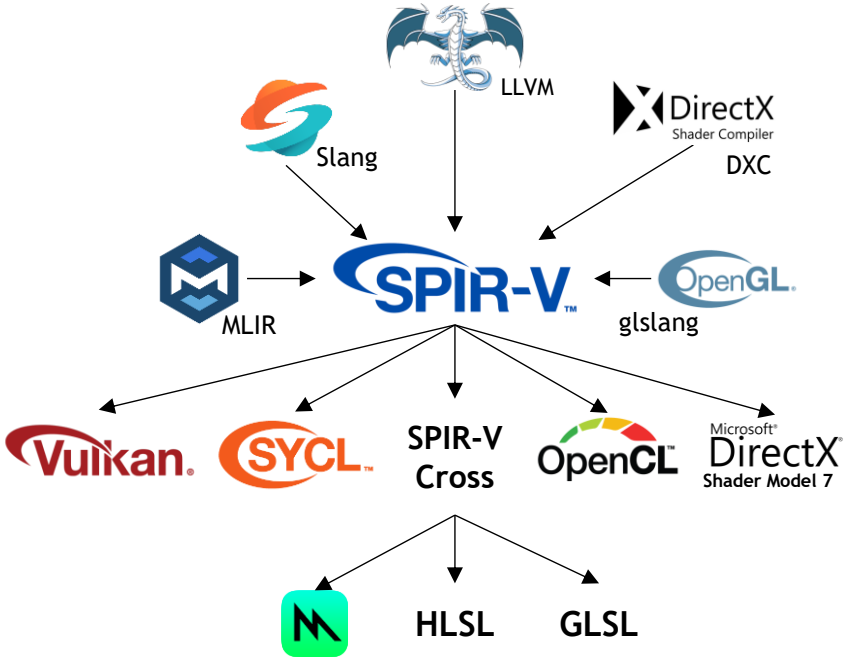


Cross-vendor API streamlines software development and widens market reach

Khronos SPIR-V Intermediate Representation

Sophisticated compilers are the most promising route to ML acceleration portability
Can standards help there too?

- **SPIR-V is the IR for Vulkan, OpenCL and SYCL**
  - Designed to support graphics and compute use cases
  - Simple binary format, easy and fast to parse and analyze
  - Decouples compute and shading language from the API
- **Industry support is widening beyond Khronos APIs**
  - Official LLVM backend since LLVM 20
  - MLIR dialect available
  - Adopted for DirectX Shader Model 7
- **Easily extendible to add new features**
  - Expose innovative features in your hardware
  - Enable the industry to widely adopt them
- **Enables forward compatibility**
  - New tools generate bytecode readable by older drivers
  - Compiler update does need a driver update
- **Extensive SPIR-V open-source tooling**
  - Read, write, validate and transform SPIR-V



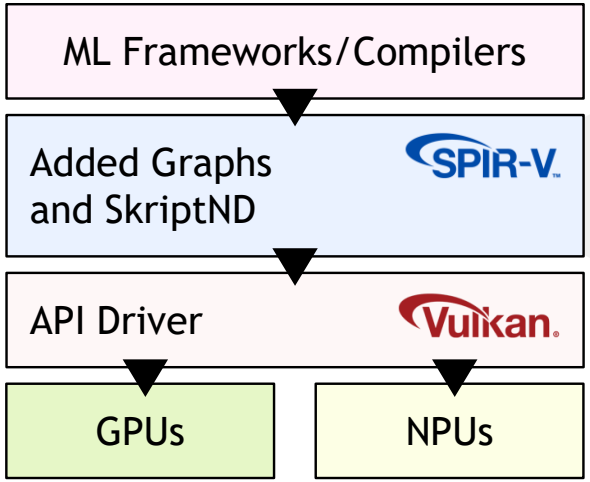
Potential to Leverage SPIR-V for ML

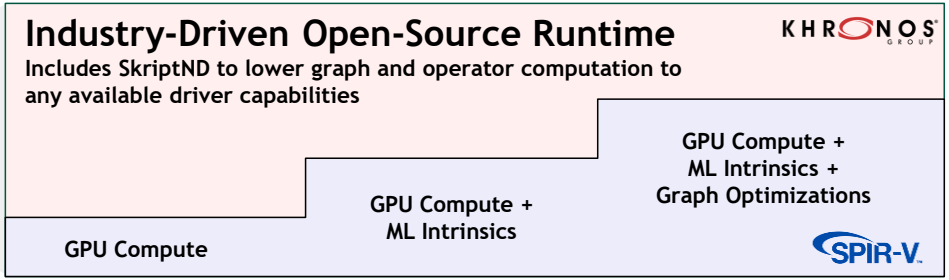
Khronos is considering how to leverage SPIR-V to solve ML acceleration fragmentation

- Adding graphs to SPIR-V enable driver-level graph optimizations and support for NPUs
  - Adding SkriptND scripting language eliminates need for custom operators and flexible lowering to available acceleration

Khronos seeking feedback if this would help solve real-world pain points!

Potential open-source project provides a consistent interface to Frameworks and Compilers while hardware vendors incrementally ship more dedicated tensor acceleration





Ingestion of SkriptND programmed operators and lowering to available driver support

Performance increases as hardware drivers support increased intrinsic and graph operations via SPIR-V

Open Standards and Open Source

Open Standards

INTEROPERABILITY via precisely specified (and conformance tested) COMMUNICATION

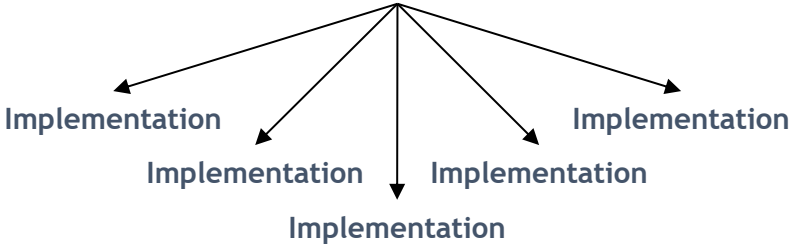
E.g., software to hardware, client to server

Open Source

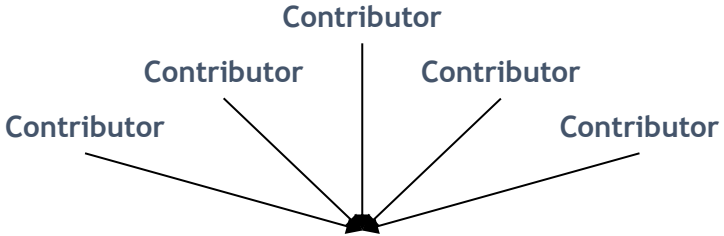
Collective collaboration to share engineering effort

Under a well-defined Contributor License Agreement

Open Standard = Shared Specification



Open Source = Shared Implementation



A technology can be widely deployed to meet multiple market needs without fragmentation

Often used for HARDWARE APIs to enable healthy competition between diverse implementations

Consistency and transparency through a single openly available implementation

Often used for SOFTWARE libraries & compilers when no advantage to competing over multiple implementations

Open standards often use open source for tooling & sample implementations

Contextual AI Agents and Interaction

Intelligent virtual agents for dynamic, responsive, and personalized metaverse experiences

Multimodal agents grounded in physical space with voice, vision, gesture understanding

Learn and adapt based on user behavior and environment

Copilots, tutors, assistants in spatial workflows and education

Use cases:
Manufacturing, retail, healthcare, education, co-presence

Creating interoperable cross-platform experiences like this will need a *constellation* open standards…

3D Assets, APIs for GPU and XR, wireless networking, AI training and deployment, privacy and security, UI and interaction, Agents, scene graphs…

.. Some Needed Metaverse Standards

Spatial and Semantic Context Standards - enable agents to understand and navigate shared environments
Khronos: OpenXR Spatial Entities (e.g., anchors, planes, volumes)
Khronos: Scene graph & spatial hierarchy standards (e.g., glTF + scene extensions, USD with semantics)
OGC: Geospatial interoperability (e.g., 3D Tiles, OGC standards)
W3C: Semantic labeling ontologies (e.g., OpenLabel, RoboOntology, W3C Web of Things ontologies)

Identity, Avatar, and Embodiment Standards - how AI agents are represented and recognized
OpenID / Decentralized Identity (DID) for agent identity
Khronos and VRM: glTF for avatar formats
IEEE P7016 (Ethical AI agent behavior)

Multimodal Input and Intent Standards - to interpret user voice, gesture, and gaze across platforms
W3C Multimodal Interaction Framework
Linux Foundation: Open Voice Interoperability Initiative
Khronos: OpenXR gesture semantics and hand/body hand tracking extensions
W3C: EmotionML Emotion and intent taxonomies

Agent Communication and Behavior Standards - reusable agent reasoning, decision-making, and collaboration
FIPA (Foundation for Intelligent Physical Agents) standards for agent communication
ROS 2 (Robot Operating System) for behavior graph modeling
W3C WoT Scripting / Semantic Web for knowledge graph interaction
OpenDialogue / Rasa interchange formats for conversational intent modeling

Privacy, Ethics, and Trust Standards - to ensure safe, transparent, and user-consented AI behavior
IEEE P7001–P7014 series (e.g., transparency, algorithmic bias)
ISO/IEC 24029 (AI risk management)
ISO/IEC 29100 (privacy framework)
Open Consent standards (e.g., Kantara Initiative)

There are many, many more…

Interoperability Will Drive Metaverse

The metaverse combines the connectivity of the Web with the immersiveness of spatial computing

The next generation of the Web =
Ubiquitous Connectivity + Spatial Computing

Need for diverse enabling technologies to work together:
AI, GPU, XR, Web, Web3, 5G/6G …

Interoperability is foundational to the metaverse!

1) Reliable connected functionality of sophisticated technologies
2) Leveraging of third party products and services – 'you don't have to build everything yourself'
3) Break out of silos for a larger, connected economic opportunity for all!

The Metaverse will require a CONSTELLATION of interoperability standards

and recommendations/guidelines from HUNDREDS of SDOs, consortia, non-profits, companies, universities …

Metaverse
STANDARDS FORUM™

A unique, neutral, and welcoming venue for pragmatic cooperation between the standards community and industry

NOT another standards organization!

KHRONOS GROUP

Assisting Standards Organizations

Pre-standardization Activities

Standards gap analysis

Driving broad industry visibility and consensus

Discovering ‘cross-silo’ cooperation opportunities

Draft specification feedback

2,600 Forum members *assist*ing standards organizations in their mission to enable metaverse interoperability

Use case and requirement insights

Standards Developing Organizations

Testing, tooling and feedback

SDOs gain insights, visibility, adoption, cross-silo cooperation, additional members

Post-standardization Activities

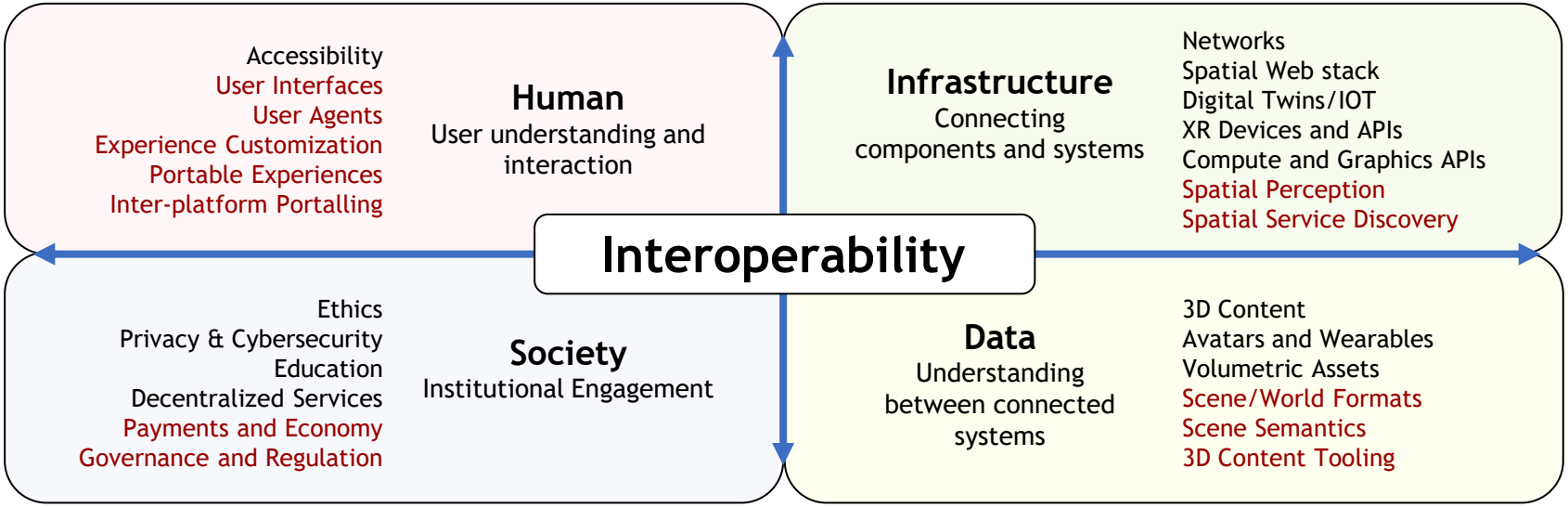
Interoperability testbeds and plugfests

Open source tools development

Educational materials, reports, best practices & guidelines etc.

Focus on urgent ‘pain points’ with short-term impact on the road to an open metaverse
Forum Membership is accessible - no cost or IP licensing

Metaverse Standards Forum Domain Activities

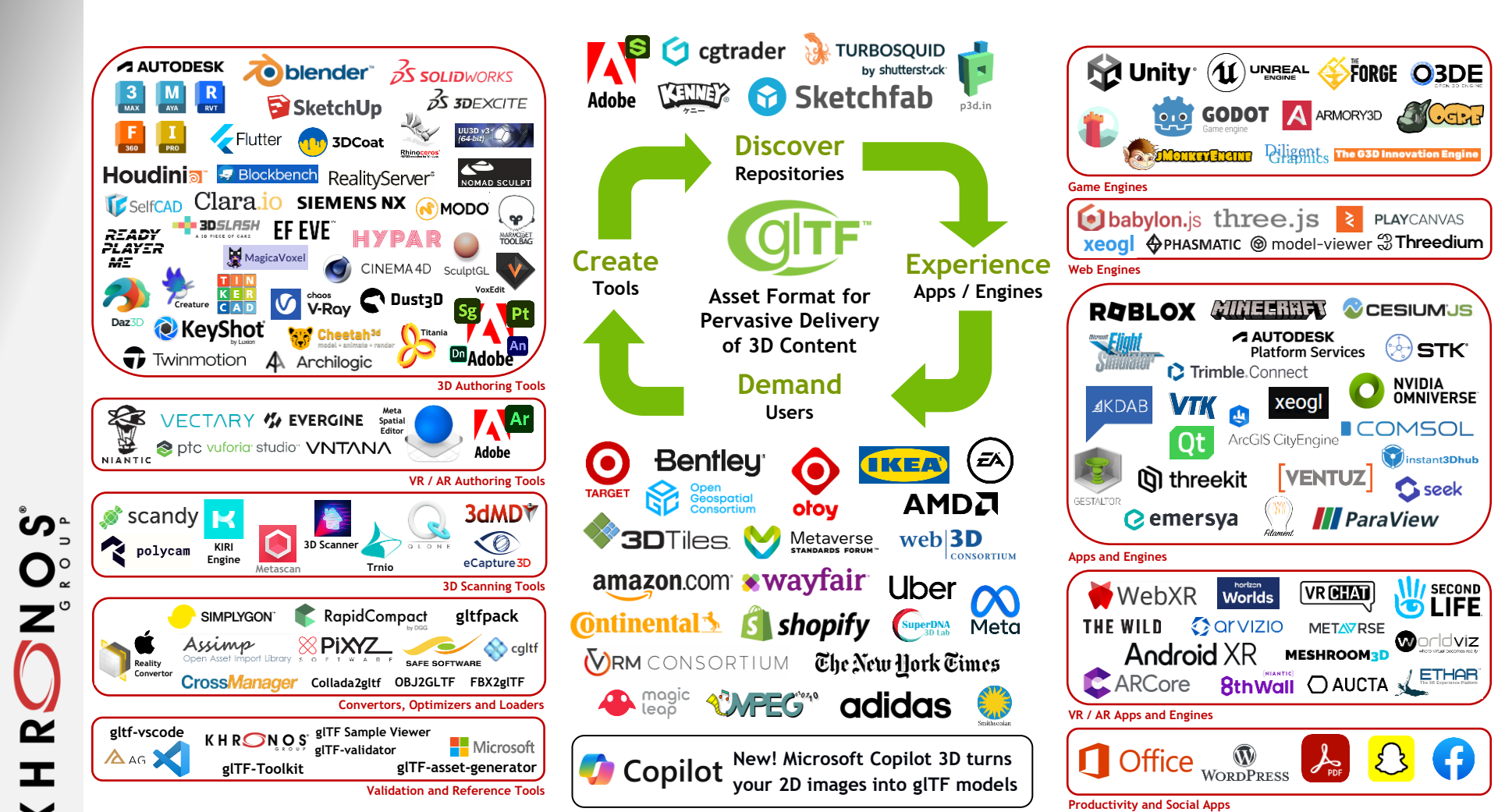


Current | *Needed*

Cross-Domain

Ecosystem Mapping: standards and use case database, terminology

AI: accelerating standardization opportunities at the intersection of AI and the metaverse



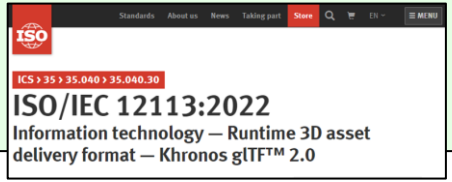
glTF Vertical Market Cooperation

glTF extensibility enables community exploration of new functionality
Accelerate evolution by working with organizations using glTF and avoid duplication and fragmentation

Collaborate to effectively bring widely adopted technology into Khronos specifications to help drive pervasive availability

3D Tiles	VRM	MPEG	X3D	PDF	Vertical Market Segments
3D Geospatial Datasets *glTF extensions*	Avatar Format *.vrm extension*	ISO 23090-14:2023 MPEG-I *.mp4, miv, ivr*	ISO 19775-1:2023 X3D4 *.x3d extension*	ISO/TS 32007 glTF in PDF *.PDF extension*	

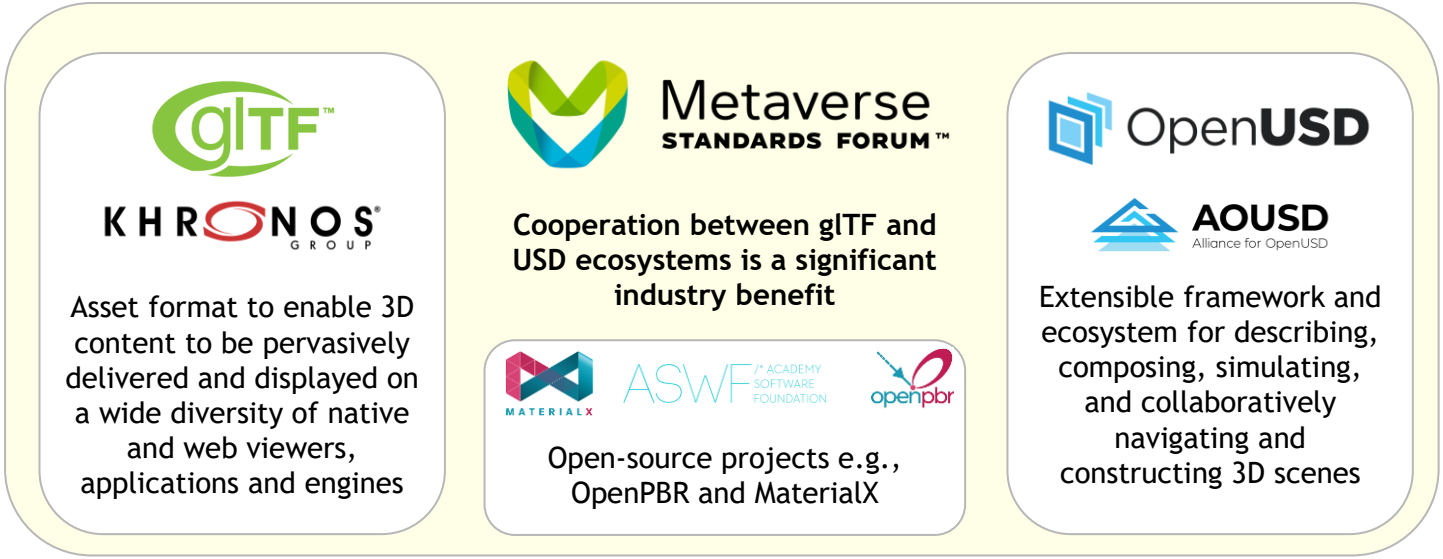
Foundation of Core specification and working group extensions



glTF/USD Interoperability Working Group

Cooperation between glTF and USD ecosystems is a significant industry benefit

Enabling discussions over technologies, requirements and potential roadmap alignments
Wide net for gathering use cases and requirements from industry and creators

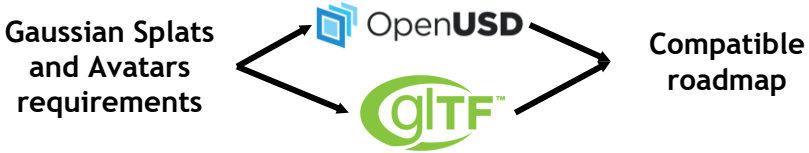


glTF/USD Interoperability Working Group

Pragmatic projects to address immediate, real-world interoperability pain points

Discovery and exploration of interoperability issues

Create USD/glTF recommendations to AOUSD/Khronos standardization bodies

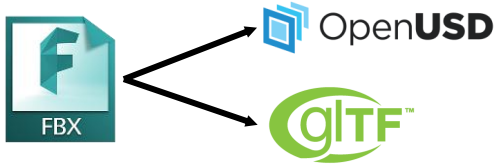


Roadmap Coordination

Medium to long term roadmap cooperation

Materials and PBR Convergence

Coordination of roadmaps and tooling



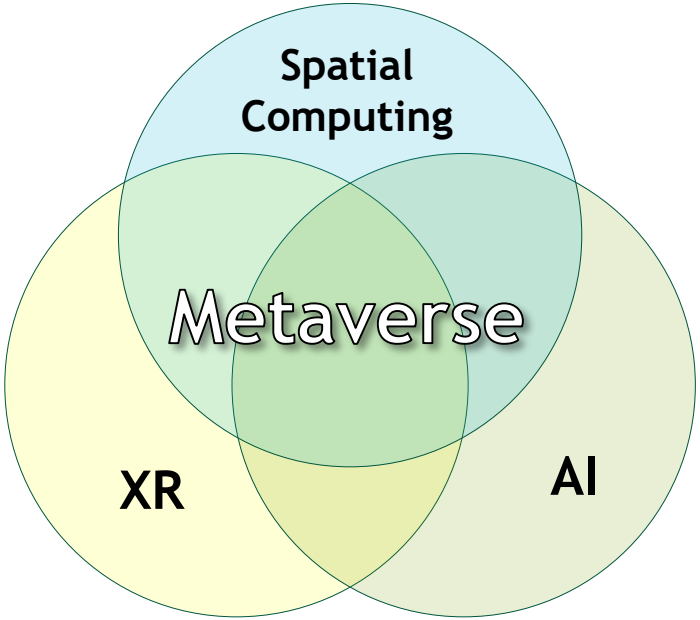
FBX Migration Project

Investigation of roadmap recommendations to Khronos and AOUSD so key toolchains can migrate from FBX dependence

glTF ⇄ USD Conversion

Guidelines and recommendations for alleviating key pain points with associated test assets

AI x Spatial Computing x XR = Metaverse



AI is enabling the metaverse
Solving multiple problems that were previously hard or impossible to solve

The Metaverse will become the primary user interface to AI
Making AI spatially aware and present

Metaverse = spatial evolution of the Web
A new platform built with a constellation of open interoperability standards

The metaverse is a call to action and opportunity for standards organizations *to cooperate* to add significant value to the industry!

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Metaverse STANDARDS FORUM™