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|  | Moving Picture, Audio and Data Coding by Artificial Intelligencewww.mpai.community |

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|  | **Public Document** |
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| **Target** | MPAI Community |

# Introduction

In recent years, Artificial Intelligence (AI) and related technologies have been applied to a broad range of applications, have started affecting the life of millions of people and are expected to do so even more in the future. As digital media standards have positively influenced industry and billions of people, so AI-based data coding standards are expected to have a similar positive impact. Indeed, research has shown that data coding with AI-based technologies is generally *more efficient* than with existing technologies for, e.g., compression and feature-based description.

However, some AI technologies may carry inherent risks, e.g., in terms of bias toward some classes of users. Therefore, the need for standardisation is more important and urgent than ever.

The international, unaffiliated, not-for-profit MPAI – Moving Picture, Audio and Data Coding by Artificial Intelligence Standards Developing Organisation has the mission to develop *AI-enabled data coding standards*. MPAI Application Standards enable the development of AI-based products, applications and services.

As a part of its mission, MPAI has developed standards operating procedures to enable users of MPAI implementations to make informed decision about their applicability. Central to this is the notion of Performance, defined as a set of attributes characterising a reliable and trustworthy implementation.

For the aforementioned reasons, to fully achieve the MPAI mission, Technical Specifications must be complemented by an ecosystem designed, created and managed to underpin the life cycle of MPAI standards through the steps of specification, technical testing, assessment of product safety and security, and distribution.

In the following, Terms beginning with a capital letter are defined in *Table 1* if they are specific to this Standard and in *Table 2* if they are common to all MPAI Standards.

The MPAI Ecosystem is fully specified in [1]. It is composed of:

* MPAI as provider of Technical, Conformance and Performance Specifications.
* Implementers of MPAI standards.
* MPAI-appointed Performance Assessors.
* The MPAI Store which takes care of secure distribution of validated Implementations.

*Figure 1* depicts the MPAI-AIF Reference Model under which Implementations of MPAI Applic­ation Standards and user-defined MPAI-AIF conforming applications operate.

An AIF Implementation allows execution of AI Workflows (AIW), composed of basic processing elements called AI Modules (AIM).



*Figure 1 – The AI Framework (AIF) Reference Model and its Components*

MPAI Application Standards normatively specify Syntax and Semantics of the input and output data and the Function of the AIW and the AIMs, and the Connections between and among the AIMs of an AIW.

In particular, an AIM is defined by its Function and data, but not by its internal architecture, which may be based on AI or data processing, and implemented in software, hardware or hybrid software and hardware technologies.

MPAI defines Interoperability as the ability to replace an AIW or an AIM Implementation with a functionally equivalent Implementation. MPAI also defines 3 Interoperability Levels of an AIW executed in an AIF:

*Level 1 –* Implementer-specific and satisfying the MPAI-AIF Standard.

*Level 2 –* Specified by an MPAI Application Standard.

*Level 3 –* Specified by an MPAI Application Standard and certified by a Performance Assessor.

MPAI offers Users access to the promised benefits of AI with a guarantee of increased transparency, trust and reliability as the Interoperability Level of an Implementation moves from 1 to 3. Additional information on Interoperability Levels is provided in Annex 3.

The chapters and the annexes of this Technical Specification are Normative unless they are labelled as Informative.

# Scope of the use case

1. Audience interactivity
	1. Capturing the “sentiment”, “behaviour”, “mood”, “intent” (in the following called “sentiment etc.”) of an audience (common or individual, average, variance) including behaviour (gestures, facial), biometric (e.g., heart rate, brainwaves), audiometer (cheering, booing), buttons and controllers at the seats. It is called “Reading the room”. One solution is supervised learning of a machine by feeding it with many instances of labelled “common” sentiments. There is also the possibility of unsupervised learning. If we do it, we would need to define the type of signals that we use to measure the “sentiment, etc.” to train the machine and the human-recognisable categories of “sentiment etc.” and exactly what “sentiment etc.” means. “Sentiment etc.” is dependent on culture. Compared to capturing the “sentiment etc.” of an individual done in MPAI-MMC, here we are measuring the sentiment of a crowd.
	2. Measuring the “response”, “affect”, caused by a known stimulus. This is a system-level problem. We present something that influences a crowd and may influence what is being presented. The result may be adapting the multisensory (e.g., visual audio, aroma, haptic, vibration, fog, special effects, performer’s movement) stimulus based on the sentiment etc. captured.
2. Performer’s interactivity.
	1. Gesture recognition and interpretation of the “meaning” of a performer’s movement, e.g., sign language, dance notation, mudras language are examples of how a stimulus can be captured and interpreted. A machine could be trained with labelled performer movement for the required instances of cultures and contexts.
	2. The trained machine would provide the interpreted gestures. Another machine can be trained to adapt the multisensory stimulus based on the interpreted gesture.
3. VJ interactivity
	1. Gesture capture, recognition and interpretation of the “meaning” of VJ movements and, gestures. A machine could be trained with labelled performer movement for the required instances of cultures and contexts.
	2. Another machine receives the interpreted gestures and is trained to adapt the multisensory stimulus based on the interpreted gesture.
4. Raw data interface to Metaverse. The MV exists with its own platform and its two-way interface (viewing, controlling and receiving a reaction from the MV). User’s multisensory experience (input and output) can include:
	1. Audio, may be the result of preprocessing to get the intended audio
		1. in: speech, my music, spatial audio field;
		2. out: sound from the MV
	2. Visual, may be the result of preprocessing to get the intended visual info
		1. in: my face, my entire body;
		2. out: the entire visual experience of a MV room from the PoV of the avatar; interocular separation, foveation
	3. Gesture
		1. in: kinetic tracking of physical body parts;
		2. out: force feedback from a robot, a subset of haptics
	4. Position, acceleration
		1. in: coordinates+derivative, orientation+derivative in the user’s space
	5. Vestibular feedback
		1. out: 6DoF motion platform
	6. Haptic (out: touch, vibration, haptic vest, glove)
	7. Biometric (in: eye tracking, e.g.,
	8. Headset (in:)
5. Spectator camera control. Not clear what it means. Maybe rendered point of view for remote participants. Could be that Spectator camera control is viewpoint (PoV) selection in the metaverse.
6. Multichannel audio environment management. Multiple audio sources from geographically separated places send their audio through the internet. How to combine the sound signals in such a way that synchronisation with universal time is preserved with an accuracy of 10 ms (to achieve musicality as opposed to a real-time conversation between two remote people).



# Terms specific to MPAI-MCS

*Table 1* defines the Terms used in this Standard whose first letter is capital*.* The Terms of MPAI-wide applicability are defined in *Table 2*.

*Table 1 – Terms and definitions*

|  |  |
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| **Term** | **Definition** |
| Agency | The feeling of free will, intentional action, or motor control within the virtual world. |
| Foveation | Assignement/distribution of pixels to provide higher resolution to the areas of interest. |
| Embodiment | The sense of one’s identification with an avatar as an extension of oneself |
| Puppeteering | The control of an avatar as an entity external to oneself |
| Vestibular System | A sensory system providing the brain with motion, head position, and spatial orientation information thus allowing the body to keep balance, stabilise head and body during movement, and maintain posture. |

# References

## Normative References

## Informative References

# Use Case Architectures

## Reference architecture

## Input/output data

## AI Modules

# Functional Requirements

## I/O Data summary

## Data format requirements

# Annex 1 – MPAI-wide terms and definitions

The Terms used in this standard whose first letter is capital and are not already included in *Table 1* are defined in *Table 2.*

*Table 2 – MPAI-wide Terms*

|  |  |
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| **Term** | **Definition** |
| Access | Static or slowly changing data that are required by an application such as domain knowledge data, data models, etc. |
| AI Framework (AIF) | The environment where AIWs are executed. |
| AI Module (AIM) | A processing element receiving AIM-specific Inputs and producing AIM-specific Outputs according to according to its Function. An AIM may be an aggregation of AIMs. |
| AI Workflow (AIW) | A structured aggregation of AIMs implementing a Use Case receiving AIM-spec­ific inputs and producing AIM-specific inputs according to its Function. |
| AIF Metadata | The data set describing the capabilities of an AIF set by the AIF Implem­enter. |
| AIM Metadata | The data set describing the capabilities of an AIM set by the AIM Implem­enter. |
| Application Programming Interface (API) | A software interface that allows two applications to talk to each other |
| Application Standard  | An MPAI Standard specifying AIWs, AIMs, Topologies and Formats suitable for a particular application domain. |
| Channel | A physical or logical connection between an output Port of an AIM and an input Port of an AIM. The term “connection” is also used as a synonym. |
| Communication | The infrastructure that implements message passing between AIMs. |
| Component | One of the 9 AIF elements: Access, AI Module, AI Workflow, Commun­ication, Controller, Internal Storage, Global Storage, MPAI Store, and User Agent. |
| Conformance | The attribute of an Implementation of being a correct technical Implem­entation of a Technical Specification. |
| Conformance Tester | An entity authorised by MPAI to Test the Conformance of an Implem­entation. |
| Conformance Testing | The normative document specifying the Means to Test the Conformance of an Implem­entation. |
| Conformance Testing Means | Procedures, tools, data sets and/or data set characteristics to Test the Conformance of an Implem­en­tation. |
| Connection | A channel connecting an output port of an AIM and an input port of an AIM. |
| Controller | A Component that manages and controls the AIMs in the AIF, so that they execute in the correct order and at the time when they are needed. |
| Data | Information in digital form. |
| Data Format | The standard digital representation of Data. |
| Data Semantics | The meaning of Data. |
| Device | A hardware and/or software entity running at least one instance of an AIF. |
| Ecosystem | The ensemble of the following actors: MPAI, MPAI Store, Implementers, Conformance Testers, Performance Testers and Users of MPAI-AIF Im­plem­en­tations as needed to enable an Interoperability Level. |
| Event | An occurrence acted on by an Implementation. |
| Explainability | The ability to trace the output of an Implementation back to the inputs that have produced it. |
| Fairness | The attribute of an Implementation whose extent of applicability can be assessed by making the training set and/or network open to testing for bias and unanticipated results. |
| Function | The operations effected by an AIW or an AIM on input data. |
| Global Storage | A Component to store data shared by AIMs. |
| Identifier | A name that uniquely identifies an Implementation. |
| Implementation | 1. An embodiment of the MPAI-AIF Technical Specification, or
2. An AIW or AIM of a particular Level (1-2-3).
 |
| Internal Storage | A Component to store data of the individual AIMs. |
| Interoperability | The ability to functionally replace an AIM/AIW with another AIM/AIW having the same Interoperability Level |
| Interoperability Level | The attribute of an AIW and its AIMs to be executable in an AIF Implem­en­tati­on and to be: 1. Implementer-specific and satisfying the MPAI-AIF Standard *(Level 1)*.
2. Specified by an MPAI Application Standard (*Level 2)*.
3. Specified by an MPAI Application Standard and certified by a Performance Assessor (*Level 3)*.
 |
| Knowledge Base | Structured and/or unstructured information made accessible to AIMs via MPAI-specified interfaces |
| Message | A sequence of Records. |
| Normativity | The set of attributes of a technology or a set of technologies specified by the applicable parts of an MPAI standard. |
| Performance | The attribute of an Implementation of being Reliable, Robust, Fair and Replicable. |
| Performance Assessment | The normative document specifying the procedures, the tools, the data sets and/or the data set characteristics to Assess the Grade of Performance of an Implementation. |
| Performance Assessment Means | Procedures, tools, data sets and/or data set characteristics to Assess the Performance of an Implem­en­tation. |
| Performance Assessor | An entity authorised by MPAI to Assess the Performance of an Implementation in a given Application domain |
| Port | A physical or logical communication interface of an AIM. |
| Profile | A particular subset of the technologies used in MPAI-AIF or an AIW of an Application Standard and, where applicable, the classes, other subsets, options and parameters relevant to that subset. |
| Record | Data with a specified structure. |
| Reference Model | The AIMs and theirs Connections in an AIW. |
| Reference Software | A technically correct software implementation of a Technical Specific­ation containing source code, or source and compiled code.  |
| Reliability | The attribute of an Implementation that performs as specified by the Application Standard, profile and version the Implementation refers to, e.g., within the application scope, stated limitations, and for the period of time specified by the Implementer. |
| Replicability | The attribute of an Implementation whose Performance, as Assessed by a Performance Assessor, can be replicated, within an agreed level, by another Performance Assessor. |
| Robustness | The attribute of an Implementation that copes with data outside of the stated application scope with an estimated degree of confidence. |
| Scope | The domain of applicability of an MPAI Application Standard |
| Service Provider | An entrepreneur who offers an Implementation as a service (e.g., a recommendation service) to Users. |
| Specification | A collection of normative clauses. |
| Standard | The ensemble of Technical Specification, Reference Software, Confor­man­ce Testing and Performance Assessment of an MPAI application Standard.  |
| Technical Specification | (Framework) the normative specification of the AIF.(Application) the normative specification of the set of AIWs belon­ging to an application domain along with the AIMs required to Im­plem­ent the AIWs that includes:1. The formats of the Input/Output data of the AIWs implementing the AIWs.
2. The Connections of the AIMs of the AIW.
3. The formats of the Input/Output data of the AIMs belonging to the AIW.
 |
| Testing Laboratory | A laboratory accredited by MPAI to Assess the Grade of Performance of Implementations.  |
| Time Base | The protocol specifying how Components can access timing information |
| Topology | The set of AIM Connections of an AIW. |
| Use Case | A particular instance of the Application domain target of an Application Standard. |
| User | A user of an Implementation. |
| User Agent | The Component interfacing the user with an AIF through the Controller |
| Version | A revision or extension of a Standard or of one of its elements. |
| Zero Trust | A cybersecurity model primarily focused on data and service protection that assumes no implicit trust. |

# Annex 2 - Notices and Disclaimers Concerning MPAI Standards (Informative)

The notices and legal disclaimers given below shall be borne in mind when [downloading](https://www.mpai.community/resources/) and using approved MPAI Standards.

In the following, “Standard” means the collection of four MPAI-approved and [published](https://www.mpai.community/resources/) documents: “Technical Specification”, “Reference Software” and “Conformance Testing” and, where applicable, “Performance Testing”.

Life cycle of MPAI Standards

MPAI Standards are developed in accordance with the [MPAI Statutes](https://mpai.community/statutes/). An MPAI Standard may only be developed when a Framework Licence has been adopted. MPAI Standards are developed by especially established MPAI Development Committees who operate on the basis of consensus, as specified in Annex 1 of the [MPAI Statutes](https://mpai.community/statutes/). While the MPAI General Assembly and the Board of Directors administer the process of the said Annex 1, MPAI does not independently evaluate, test, or verify the accuracy of any of the information or the suitability of any of the technology choices made in its Standards.

MPAI Standards may be modified at any time by corrigenda or new editions. A new edition, however, may not necessarily replace an existing MPAI standard. Visit the [web page](https://mpai.community/resources/) to determine the status of any given published MPAI Standard.

Comments on MPAI Standards are welcome from any interested parties, whether MPAI members or not. Comments shall mandatorily include the name and the version of the MPAI Standard and, if applicable, the specific page or line the comment applies to. Comments should be sent to the MPAI Secretariat. Comments will be reviewed by the appropriate committee for their technical relevance. However, MPAI does not provide interpretation, consulting information, or advice on MPAI Standards. Interested parties are invited to join MPAI so that they can attend the relevant Development Committees.

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The Reference Software of an MPAI Standard is released with the [MPAI Modified Berkeley Software Distribution licence](https://mpai.community/about/licence/). However, implementers should be aware that the Reference Software of an MPAI Standard may reference some third party software that may have a different licence.

# Annex 3 – The Governance of the MPAI Ecosystem (Informative)

**Level 1 Interoperability**

With reference to *Figure 1*, MPAI issues and maintains a standard – called MPAI-AIF – whose components are:

1. An environment called AI Framework (AIF) running AI Workflows (AIW) composed of inter­connected AI Modules (AIM) exposing standard interfaces.
2. A distribution system of AIW and AIM Implementation called MPAI Store from which an AIF Implementation can download AIWs and AIMs.

|  |  |
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| Implementers’ benefits | Upload to the MPAI Store and have globally distributed Implementations of* AIFs conforming to MPAI-AIF.
* AIWs and AIMs performing prop­rietary functions executable in AIF.
 |
| Users’ benefits | Rely on Implementations that have been tested for security. |
| MPAI Store’s role | * Tests the Conformance of Implementations to MPAI-AIF.
* Verifies Implementations’ security, e.g., absence of malware.
* Indicates unambiguously that Implementations are Level 1.
 |

**Level 2 Interoperability**

In a Level 2 Implem­entation, the AIW must be an Implementation of an MPAI Use Case and the AIMs must con­form with an MPAI Applicati­on Standard.

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| Implementers’ benefits | Upload to the MPAI Store and have globally distributed Implementations of* AIFs conforming to MPAI-AIF.
* AIWs and AIMs conforming to MPAI Application Standards.
 |
| Users’ benefits | * Rely on Implementations of AIWs and AIMs whose Functions have been reviewed during standardisation.
* Have a degree of Explainability of the AIW operation because the AIM Func­tions and the data Formats are known.
 |
| Market’s benefits | * Open AIW and AIM markets foster competition leading to better products.
* Competition of AIW and AIM Implementations fosters AI innovation.
 |
| MPAI Store’s role | * Tests Conformance of Implementations with the relevant MPAI Standard.
* Verifies Implementations’ security.
* Indicates unambiguously that Implementations are Level 2.
 |

**Level 3 Interoperability**

MPAI does not generally set standards on how and with what data an AIM should be trained. This is an important differentiator that promotes competition leading to better solutions. However, the performance of an AIM is typically higher if the data used for training are in greater quantity and more in tune with the scope. Training data that have large variety and cover the spec­trum of all cases of interest in breadth and depth typically lead to Implementations of higher “quality”.

For Level 3, MPAI normatively specifies the process, the tools and the data or the characteristics of the data to be used to Assess the Grade of Performance of an AIM or an AIW.

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| Implementers’ benefits | May claim their Implementations have passed Performance Assessment. |
| Users’ benefits | Get assurance that the Implementation being used performs correctly, e.g., it has been properly trained. |
| Market’s benefits | Implementations’ Performance Grades stimulate the development of more Performing AIM and AIW Implementations. |
| MPAI Store’s role | * Verifies the Implementations’ security
* Indicates unambiguously that Implementations are Level 3.
 |

**The MPAI ecosystem**

The following *Figure 2* is a high-level description of the MPAI ecosystem operation applicable to fully conforming MPAI implementations:

1. MPAI establishes and controls the not-for-profit MPAI Store.
2. MPAI appoints Performance Assessors.
3. MPAI publishes Standards.
4. Implementers submit Implementations to Performance Assessors.
5. If the Implementation Performance is acceptable, Performance Assessors inform Implementers (step 5a) and MPAI Store.
6. Implementers submit Implementations to the MPAI Store tested for Confor­mance and security.
7. Users download and use Implementations and submit experience scores.

*Figure 2 – The MPAI ecosystem operation*

# References

## Normative References

## Informative References