Moving Picture, Audio and Data Coding
by Artificial Intelligence
www.mpai.community

MPAI Reference Software

Compression and Understanding of Industrial Data MPAI-CUI

V1

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Readers are invited to review Annex 2 – Notices and Disclaimers.

Compression and Understanding of Industrial Data

1   Introduction

Moving Picture, Audio and Data Coding by Artificial Intelligence (MPAI) is an international Standards Developing Organisation with the mission to develop *AI-enabled data coding standards*. Research has shown that data coding with AI-based technologies is generally *more efficient* than with existing technologies. Compression and feature-based description are notable examples of coding. MPAI Application Standards enable the development of AI-based products, applications and services.

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.

Figure 1 depicts the Reference Model of the MPAI AI Framework (AIF) Standard (MPAI-AIF) [2]. MPAI-AIF provides the foundation on which Implementations of MPAI Application Standards operate.

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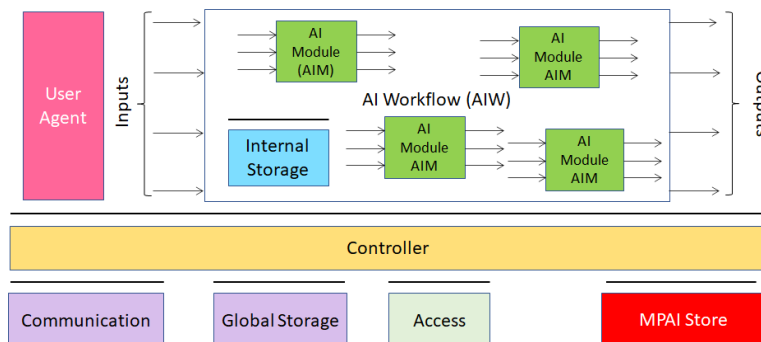

Figure 1 – The AI Framework (AIF) Reference Model and its Components

MPAI Application Standards normatively specify Semantics and Format 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 AIF, an AIW or an AIM Implementation with a functionally equivalent Implementation. MPAI also defines 3 Interoperability Levels of an AIF that executes an AIW. The AIW may be:

1. Proprietary and composed of AIMs with proprietary functions using any proprietary data Format (*Level 1*).
2. Composed of AIMs having all their Functions, Formats and Connections specified by an MPAI Application Standard (*Level 2*).
3. Composed of AIMs that have the characteristics of point 2. above and certified by an MPAI-appointed Assessor to possess the attributes of Reliability, Robustness, Replicability and Fairness – collectively called Performance (*Level 3*).

MPAI is the root of trust of the MPAI Ecosystem [1] offering 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 iformation is provided by Annex 3.

2 Scope of the MPAI-CUI Reference Software

This document describes the Reference Software Implementation of the AIW and the AIMs defined in the *AI-based Company Performance Prediction* Use Case of the *Compression and Understanding of Industrial Data* (*MPAI-CUI)* Technical Specification [4]. The software can be downloaded from https://mpai.community/wp-content/uploads/2021/10/CUI-CPP-Reference-Software.zip.

The current version of MPAI-CUI Reference Software has been developed by the MPAI *Compression and Understanding of Industrial Data* Development Committee (CUI-DC).

MPAI may decide to produce new Versions of the MPAI-CUI Reference Software specification.

3 Terms and definitions

The Terms used in this Reference Software specification that are specific of MPAI-CUI and whose first letter is capital have the meaning defined in *Table 1*. The general MPAI Terms are defined *Table 2*.

Table 1 – MPAI-CUI Terms

Term	Definition
Business Discontinuity	An interruption of the operations of a company for a period of time less than 2% of the Prediction Horizon.
Company Default	The status of a company who has failed to make full and timely payments on its obligations.
Cyber Risk	Risk of financial loss, disruption, or damage, caused by the failure of the digital technologies due to unauthorised access, use, disclosure, disruption, modification, or destruction of the systems.
Financial Features	A set of indexes and ratios computed using financial statement data.

Financial Statement	Data produced based on a set of accounting principles driving maintenance and reporting of company accounts so that financial statements can be consistent, transparent, and comparable across companies.
Governance Features	A set of indexes/parameters that are used to assess the adequacy of the organisational model.
Risk Assessment	Attributes indicating the internal company assessment to identify and measure potential or existing Vertical Risks, and their impact on Business Continuity.
Risk Matrix	Table composed of two rows for the risks (cyber and seismic) and four columns for the characteristics (occurrence, business impact, gravity and risk retention) as evaluated by the company.
Seismic Risk	The measure of the possible losses associated with the behavior of a building or structure in likely earthquakes [10].
Vertical Risk	A risk that must be understood in a specific context/domain of the business.

4 Normative references

The following documents are normatively referenced by this Standard.
1. MPAI Standard: Governance of the MPAI Ecosystem V.1
2. MPAI Technical Specification: AI Framework (MPAI-AIF), currently MPAI document N359, https://mpai.community/standards/mpai-aif/
3. MPAI Technical Specification: Compression and Understanding of Financial Data V1
4. MPAI Reference Software: Compression and Understanding of Financial Data V1
5. MPAI Conformance Testing: Compression and Understanding of Financial Data V1
6. MPAI Performance Testing: Compression and Understanding of Financial Data V1
7. International Financial Reporting Standard. List of IFRS Standards. Available online: https://www.ifrs.org/issued-standards/list-of-standards/
8. International Organization for Standardization. ISO 31000 – Risk Management. Available online: https://www.iso.org/files/live/sites/isoorg/files/store/en/PUB100426.pdf
9. International Organization for Standardization. ISO 27005 Information technology -- Security techniques -- Information security risk management
10. Federal Emergency Management Agency (FEMA). Earthquake-Resistant Design Concepts. An Introduction to the NEHRP Recommended Seismic Provisions for New Buildings and Other Structures. FEMA P-749/December 2010.

4.1 Informative references

11. An introduction to MPAI-CUI, MPAI N371, https://mpai.community/standards/mpai-cui/
12. Perboli G., Arabnezhad E., A Machine Learning-based DSS for Mid and Long-Term Company Crisis Prediction. Expert systems with applications. Volume 174. 15 July 2021, 114758

5 Definition of MPAI-CUI Reference Software

The Reference Software provides a specific Implementation that behaves in a manner that is Conformant with the MPAI-CUI Technical Specification [3].

Reference Software is Normative in the sense that the expression of the computer code is equivalent to the expression of the natural language in the MPAI-CUI Technical Specification [3].

This document does not aim to provide a ready-to-use product, rather to provide an Implementation exposing the correct input/output interfaces of the MPAI-CUI AIMs and AIW.

MPAI makes no claim that the MPAI-CUI Reference Software passes and MPAI-CUI Performance Assessment.

6   Reference software architecture

The normative Architecture of the AI-based Company Performance Prediction Use Case is given by *Figure 2*.
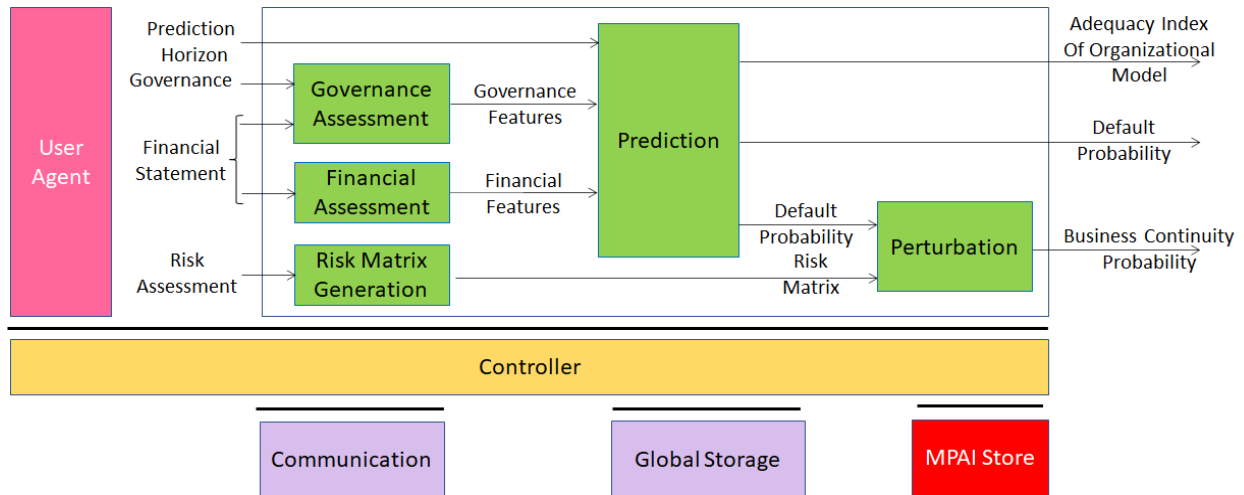

Figure 2 – AI-based Company Performance Prediction architecture

The data formats are specified in [3].

6.1   Governance Assessment

This AIM computes the Governance Features defined in the MPAI-CUI Technical Specification [3].

Input: Governance data and Financial Statement data in JSON.
Output: Governance Features.

6.2   Financial Assessment

This AIM computes the Financial Features defined in MPAI-CUI Technical Specification [3].

Input: Financial Statement data in JSON.
Output: Financial Features.

6.3   Risk Matrix Generation

This AIM builds the Risk Matrix defined in the MPAI-CUI Technical Specification [3].

Input: Risk Assessment data in JSON.
Output: Risk Matrix.

6.4   Prediction

This AIM computes the Default Probability in a Predition Horizon of *n*-months and the Organisational Model Index.

Input: Financial Features, Governance Features, and Prediction Horizon.
Output: Default Probability and Organisational Model Index.

6.5 Perturbation

This AIM computes the Business Discontinuity Probability assessing how the Default Probability is influenced by the Risk Matrix.

Input: Default Probability, Risk Matrix, and Prediction Horizon.
Output: Business Discontinuity Probability.

7 How to use the Reference Software

7.1.1 Sotware licence and location

The Reference Software is released with the [MPAI Software Licence](#) and is available from https://www.mpai.community/resources/.

7.1.2 Software installation

The Reference Software code is written in Pyhton 3.7. and must be run in a Python console (command line or Jupiter Notebook) in interactive mode.
The Prediction AIM uses the Random Forest algorithm implemented by the *SKLearn* libraries [12].

Annex 1 – MPAI-wide terms and definitions (Normative)

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

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 data 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.
Application Standard	An MPAI Standard designed to enable a particular application domain.
Channel	A connection between an output port of an AIM and an input port of an AIM. The term "connection" is also used as synonymous.
Communication	The infrastructure that implements message passing between AIMs
Component	One of the 7 AIF elements: Access, 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 Format	The standard digital representation of data.
Data Semantics	The meaning of data.
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.
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.
Internal Storage	A Component to store data of the individual 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) conforming with a Use Case of an MPAI Application Standard.
Interoperability	The ability to functionally replace an AIM with another AIM having the same Interoperability Level
Interoperability Level	The attribute of an AIW and its AIMs to be executable in an AIF Implementation and to: 1. Be proprietary (Level 1) 2. Pass the Conformance Testing (Level 2) of an Application Standard 3. `Pass the Performance Testing (Level 3) of an Application Standard.
Knowledge Base	Structured and/or unstructured information made accessible to AIMs via MPAI-specified interfaces
Message	A sequence of Records transported by Communication through Channels.
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
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	A data structure 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.
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.

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

The notices and legal disclaimers given below shall be borne in mind when downloading and using approved MPAI Standards.

In the following, "Standard" means the collection of four MPAI-approved and published documents: "Technical Specification", "Reference Software" and "Conformance Testing" and, where applicable, "Performance Testing".

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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 inter-connected 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.

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.

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.

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 | - | Verifies the Implementations' security |
| role | - | Indicates unambiguously that Implementations are Level 3. |

The MPAI ecosystem

The following *Figure 3* 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 (step 1).
2. MPAI appoints Performance Assessors (step 2).
3. MPAI publishes Standards (step 3).
4. Implementers submit Implementations to Performance Assessors (step 4).
5. If the Implementation Performance is acceptable, Performance Assessors inform Implementers (step 5a) and MPAI Store (step 5b).
6. Implementers submit Implementations to the MPAI Store (step 6); The Store Tests Conformance and security of the Implementation.
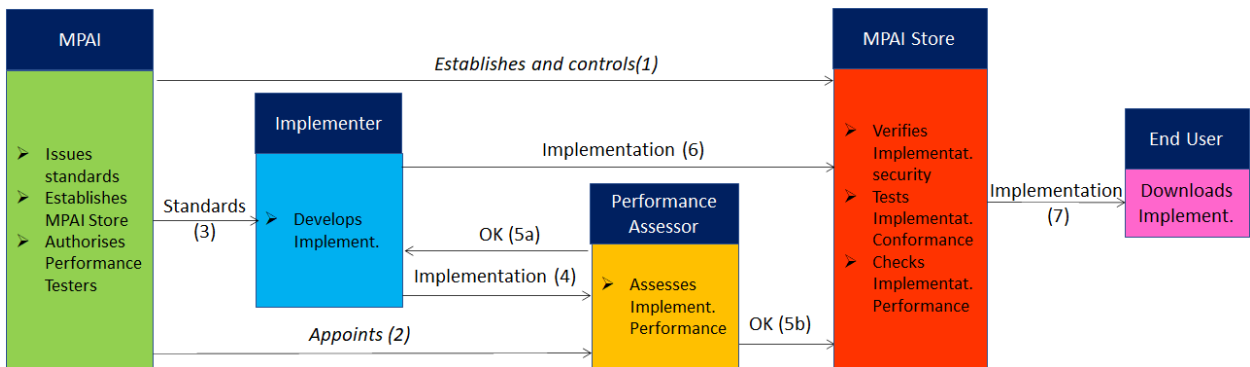7. Users download Implementations (step 7).

Figure 3 – The MPAI ecosystem operation