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

MPAI Technical Specification

MPAI Metaverse Model (MPAI-MMM) – Technologies (MMM-TEC)

V1.0

Technical Specification
MPAI Metaverse Model (MPAI-MMM) – Technologies (MMM-TEC) V1.0

Contents

1   Foreword

The international, unaffiliated, non-profit ***Moving Picture, Audio, and Data Coding by Artificial Intelligence (MPAI)*** organisation was established in September 2020 in the context of:
1. **Increasing** use of Artificial Intelligence (AI) technologies applied to a broad range of domains affecting millions of people
2. **Marginal** reliance on standards in the development of those AI applications
3. **Unprecedented** impact exerted by standards on the digital media industry affecting billions of people

believing that AI-based data coding standards will have a similar positive impact on the Information and Communication Technology industry.

The design principles of the MPAI organisation as established by the MPAI Statutes are the development of AI-based Data Coding standards in pursuit of the following policies:
1. <u>Publish</u> upfront clear Intellectual Property Rights licensing frameworks.
2. <u>Adhere</u> to a rigorous standard development process.
3. <u>Be friendly</u> to the AI context but, to the extent possible, remain agnostic to the technology thus allowing developers freedom in the selection of the more appropriate – AI or Data Processing – technologies for their needs.
4. <u>Be attractive</u> to different industries, end users, and regulators.
5. <u>Address</u> five standardisation areas:
    1. *Data Type*, a particular type of Data, e.g., Audio, Visual, Object, Scenes, and Descriptors with as clear semantics as possible.
    2. *Qualifier*, specialised Metadata conveying information on Sub-Types, Formats, and Attributes of a Data Type.
    3. *AI Module* (AIM), processing elements with identified functions and input/output Data Types.
    4. *AI Workflow* (AIW), MPAI-specified configurations of AIMs with identified functions and input/output Data Types.
    5. *AI Framework* (AIF), an environment enabling dynamic configuration, initialisation, execution, and control of AIWs.
6. <u>Provide</u> appropriate Governance of the ecosystem created by MPAI Technical Specifications enabling users to:
    1. *Operate* Reference Software Implementations of MPAI Technical Specifications provided together with Reference Software Specifications
    2. *Test* the conformance of an implementation with a Technical Specification using the Conformance Testing Specification.

3. *Assess* the performance of an implementation of a Technical Specification using the Performance Assessment Specification.
4. *Obtain* conforming implementations possibly with a performance assessment report from a trusted source through the MPAI Store.

Today, the MPAI organisation rests on four solid pillars:

1. The MPAI Patent Policy specifies the MPAI standard development process and the Framework Licence development guidelines.
2. *Technical Specification: Artificial Intelligence Framework (MPAI-AIF)* specifies an environment enabling initialisation, dynamic configuration, and control of AIWs in the standard AI Framework environment depicted in Figure 1. An AI Framework can execute AI applications called AI Workflows (AIW). An AIW includes interconnected AI Modules (AIM). MPAI-AIF supports small- and large-scale high-performance components and promotes solutions with improved explainability.
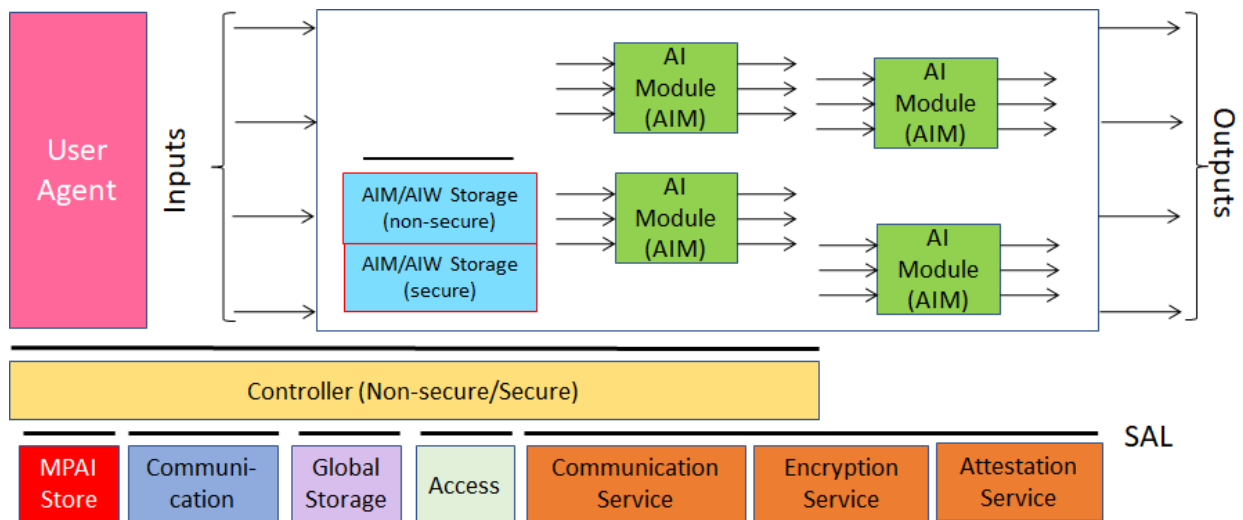
Figure 1 – The AI Framework (MPAI-AIF) V2 Reference Model

3. *Technical Specification: Data Types, Formats, and Attributes (MPAI-TFA) V1.0* specifies Qualifiers, a type of metadata supporting the operation of AIMs receiving data from other AIMs. Qualifiers convey information on Sub-Types (e.g., the type of colour), Formats (e.g., the type of compression and transport), and Attributes (e.g., semantic information in the Content). Although Qualifiers are human-readable, they are only intended to be used by AIMs. Therefore, Text, Speech, Audio, and Visual Data exchanged by AIWs and AIMs should be interpreted as being composed of Content (Text, Speech, Audio, and Visual as appropriate) and associated Qualifiers. The specifications of most MPAI Data Types reflect this point.
4. *Technical Specification: Governance of the MPAI Ecosystem (MPAI-GME) V1.1* defines the following elements:
    1. Standards, i.e., the ensemble of Technical Specifications, Reference Software, Conformance Testing, and Performance Assessment.
    2. Developers of MPAI-specified AIMs and Integrators of MPAI-specified AIWS (Implementers).
    3. MPAI Store in charge of making AIMs and AIWs submitted by Implementers available to Integrators and End Users.
    4. Performance Assessors, independent entities assessing the performance of implementations in terms of Reliability, Replicability, Robustness, and Fairness.
    5. End Users.

The interaction between and among actors of the MPAI Ecosystem are depicted in Figure 2.
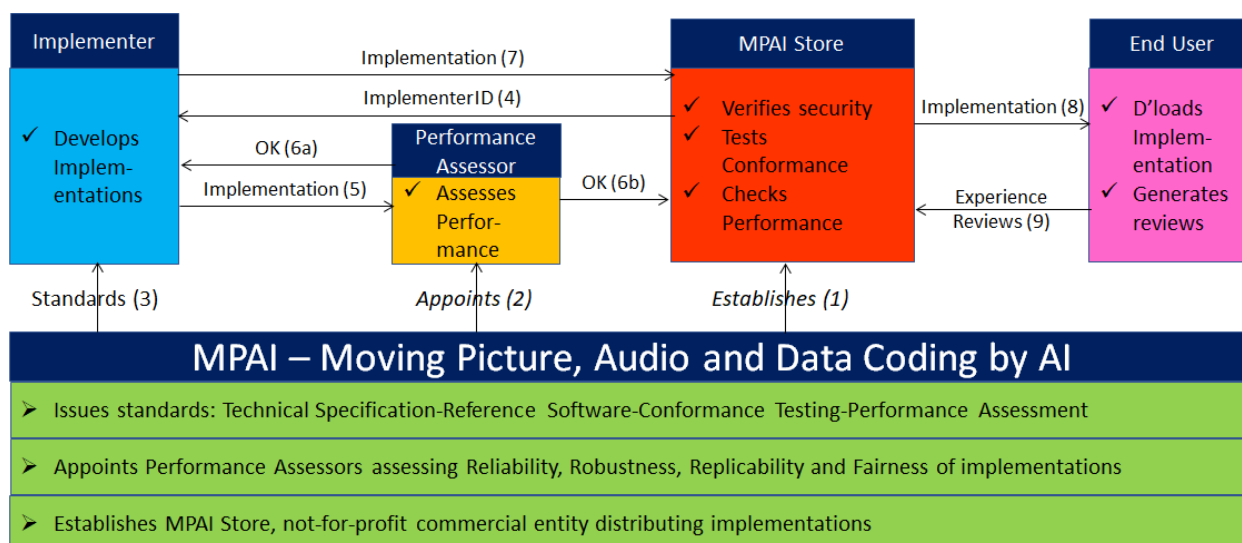
Figure 2 – The MPAI Ecosystem

2 Introduction (informative)

Metaverse is a loose concept considered by many as one of the most promising evolutionary steps of Information and Communication Technology and there are many implementations that can be classified as metaverse instances. So far, however, the metaverse developers made technology decisions that best responded to their needs, often without considering the choices that other developers might have made for similar purposes.

As there have been mounting concerns that such metaverse "walled gardens" do not fully exploit the opportunities offered by current and expected technologies and calls have been made to make metaverse instances "Interoperable", MPAI has developed two Technical Reports and two Technical Specification that provide solutions to the M-Instance Interoperability issues. They are:

1. **Technical Report: MPAI Metaverse Model (MPAI-MMM) – Functionalities** introduces definitions, assumptions for the work, a collection of high-level use cases, a collection of exemplary service providers, a set of ~150 Functionalities, review of the main metaverse-enabling technologies, an analysis of metaverse governance needs, and a standardisation roadmap.

2. **Technical Report: MPAI Metaverse Model (MPAI-MMM) – Functionality Profiles** introduces a revised and extended list of definitions; an operation model of the metaverse based on the notion of Processes performing or requesting other Processes to perform Actions on Items (Items are Data, Metadata, and Qualifiers supported by an M-Instance); an initial identification of Actions, Items, and Basic Data with Use Cases and Functionality Profiles; a collection of representative use cases tested against the Operation Model; and dour initial Functionality Profiles.

3. **Technical Specification – MPAI Metaverse Model (MPAI-MMM) – Architecture (MMM-ARC) V1.2** provides means to achieve M-Instance Interoperability by specifying the Functional Requirements of Processes and Actions. These allow Interoperation of two or more M-Instances that execute Processes, and producing Data that comply with the MMM-ARC Functional Requirements, if necessary via a Conversion Service.

4. **Technical Specification – MPAI Metaverse Model (MPAI-MMM) – Technologies (MMM-TEC) V1.0** specifies or references Items including Qualifiers to enable interoperability between M-Instances supporting the technologies referenced in the Qualifiers.

M-Instance indicates the type of metaverse specified by the two integrated specifications MMM-ARC V1.2 and MMM-TEC V1.0. The Table of Contents of MMM-ARC merges the references to two specifications into one.

In all Chapters and Sections, Terms beginning with a capital letter are defined in *Table 1* if they are specific to this Technical Specification and in *Table 2* if they are common to all MPAI Technical Specifications. All Chapters, Sections, and Annexes are Normative unless they are labelled as Informative.

3 Scope

Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Technologies (MMM-TEC) – in this document also called MMM-TEC V1.0 or MMM-TEC specifies

1. The types of Processes operating in an M-Instance.
2. The Actions that Processes can perform.
3. The Data Types and their Qualifiers that Processes can Act on

to achieve interoperability of clients and M-Instances in combination with ***Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Architecture (MMM-ARC)***.

All MPAI Qualifiers are specified in ***Technical Specification: Data Types, Formats, and Attributes (MPAI-TFA)*** referencing specifications of additional Data Types.

MMM-TEC has been developed by the MMM Group of the Requirements Standing Committee. MPAI may develop MMM-TEC extensions of new Technical Specifications in the area defined by MPAI Metaverse Model.

In all Chapters and Sections, Terms beginning with a capital letter are defined in *Table 1* if they are specific to this Technical Specification and in *Table 2* if they are common to all MPAI Technical Specifications. All Chapters, Sections, and Annexes are Normative unless they are labelled as Informative.

4 Definitions

Capitalised Terms used in MMM-ARC and MMM-TEC have the meaning defined in *Table 1*. Terms applicable to all MPAI Technical Specifications are defined in *Table 2*. Non-capitalised terms letter have the meaning commonly defined for the context in which they are used or represent an entity in the real world. For instance,

1. Table 1 defines *Object, Scene,* and *User* but does not define *object, scene,* and *human*.
2. Object indicates an Item but object indicates an entity in the Universe commonly classified as object.

A dash "-" preceding a Term in Table 1 means the following:

1. If the font is normal, the Term in the table without a dash and preceding the one with a dash should be placed <u>before</u> that Term. The notation is used to concentrate in one place all the Terms that are composed of, e.g., the word Decentralised <u>followed</u> by one of the words Application, Autonomous Organisation, Finance, System, and User Identifier, or definitions belonging to the same class, e.g., Action and Items.
2. If the font is *italic,* the Term in the table without a dash and preceding the one with a dash should be placed <u>after</u> that Term. The notation is used to concentrate in one place all the Terms that are composed of, e.g., the word Interface <u>preceded</u> by one of the words Brain-Computer, Haptic, Speech, and Visual.
3. If the term is underlined, it is a definition of the components of Actions, Items and Processes.

Table 1 – General Terms and Definitions

Terms	Definitions
Account	An Item that uniquely references a human Registered on the M-Instance managing the Account.
Action	A Functionality provided by a Process.
– Authenticate	The Action of requesting that a Service confirm that an Item is what it claims to be.
– Author	The Action of Calling a Service to obtain an Item with associated OutRights to Act on the Item.
– Change	The Action of requesting that a Service modify the Rights of a User and provide OutRights, e.g., to further Change the Rights.
– Convert	The Action of requesting that a Service Modify an Item according to a provided Data Qualifier.
– Discover	The Action of requesting that a Service provide information about Items or Processes satisfying the conditions expressed in the request.
– Execute	The Action of requesting that a Process execute the conditions of a non-executable Contract.
– Hide	The Action of requesting that a Service make the ID of an Item unavailable and provide OutRights, e.g., to make the ID available again.
– Identify	The Action of requesting that a Service produce an Item from Data & Metadata.
– Inform	The Action of requesting that a Service provide information about an Item or Process, such as the Metadata of an Item.
– Interpret	The Action of requesting that a Service provide interpretations of an InItem, such as translation or extraction of Personal Status.
– MM-Add	The Action of requesting that a Service add an Item at an M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Added Item.
– MM-Animate	The Action of requesting that a Service change the features of a Model MM-Embedded at an M-Location with a Stream and provide the OutRights to Act on the MM-Animated Item.
– MM-Disable	The Action of requesting that a Service stop MM-Enabling selected Items Embedded at an M-Location and provide OutRights to Act on the MM-Disabled Entities.
– MM-Embed	The Composite Action of requesting that a Service MM-Add and MM-Enable an Item either located at a Service or at an M-Location at a destination M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Embedded Item.
– MM-Enable	The Action of requesting that a Service accept requests to MM-Send selected Entities MM-Added at an M-Location or to MM-Embed those selected Entities at a destination M-Location and provide OutRights to act on the M-Entities.
– MM-Send	The Action of requesting that a Process forward an Item or Data/Metadata to a Process with appropriate Rights to act on Item or Data/Metadata.
– Modify	The Action of requesting that a Service produce a new Item from an existing Item by providing new Data and Metadata with the OutRights to further Act on the new Item.
– MU-Actuate	The Action of requesting that a Device present an Item available at a Device to a U-Location as Media with a Spatial Attitude.
– MU-Embed	The Composite Action of requesting that:

	1. A Service MM-Send selected Entities Embedded at an M-Location to a Device. 2. The Device MU-Actuate the Item received at a U-Location with a Spatial Attitude.
– MU-Send	The Action of requesting that a Process transmit an Item to a Device or store an Item at an Address.
– Post	The Action of requesting that a Marketplace include an Asset to its repertory of Assets.
– Register	The Action of requesting that a Service grant selected Processes of a human the Rights to perform Actions in the M-Instance.
– Resolve	The Action of requesting that a Service forward a Request-Action or a Response-Action to a Resolution Service in another M-Instance.
– Track	The Composite Action of requesting that a Service: 1. MM-Embed a Model at an M-Location with a Spatial Attitude. 2. MU-Animate the Model MM-Embedded at an M-Location. 3. MU-Embed specified Entities at the M-Location to a U-Location.
– Transact	The Action of a User$_1$ ("sender") requesting that a Service: 1. Assign Rights on an Asset to User2 ("receiver"). 2. Cause: 2.1.Wallet1 of User1 to be increased by Value1. 2.2.Wallet2 of User2 to be decreased by Value2. 2.3.Wallet3 of the Service enabling/facilitating the Transaction to be increased by Value3 (optionally).
– UM-Animate	The Composite Action of a User requesting: 1. A Device to1.1.UM-Capture an animation stream extracted from a scene at a U-Location. 1.2.UM-Send the animation stream and Metadata to a User. 2. A Service to Identify the Animation Stream. A Service to MM-Animate the Model MM-Embedded at the M-Location using the Animation Stream.
– UM-Capture	The Action of requesting that a Device capture Media from a scene at a U-Location.
– UM-Embed	The Composite Action of a User requesting: 1. A Device to:1.1.UM-Capture a scene at U-Location. 1.2.MM-Send Data and Device-provided Metadata to a User. 2. A Service to: 2.1.Identify an Item from UM-Sent Data and Metadata. 2.2.MM-Embed the Item at an M-Location with a Spatial Attitude.
– UM-Send	The Action of a Device acquiring Data & Metadata from an Address.
– Validate	The Action of requesting that a Service verify that a Process has the Rights to perform or request a Process to perform an Action on an Item.
Avatar	A digital representation of a real or fictitious human.
Blockchain	A shared immutable ledger stored on a peer-to-peer network of computers.
Certification	The attestation that a Process or Item has specified characteristics.
Connected Autonomous Vehicle	(CAV) A vehicle able to autonomously reach a U-Location by using its own sensing and processing capabilities to generate an M-Instance, sharing its M-Instance with other CAVs and issuing actuation commands to its Motion Actuation Subsystem.
Coordinates	A set of numbers used to represent a Position in an M-Instance using a coordinate system.

Conversion	The process of Modifying the Data of an Item according to a provided Data Qualifier.
Data	Information represented in digital form.
– Format	The syntax and semantics of Data.
– Qualifier	Data about Data designed for use by a Machine.
DataMdata	The combination of Data and Metadata that is not (yet) an Item.
Decentralised	
– Application	(dApp) A Process that runs on a decentralised computing system.
– Autonomous Organisation	(DAO) An organisation without centralised leadership, where the main governing rules are typically encoded by means of a Smart Contract.
– Finance	(DeFi) A financial technology based on a secure infrastructure of distributed ledgers like those used by crypto currencies.
– System	A set of dApps enabling a group of Users to make decisions without a centralised entity.
Device	Equipment enabling: – A U-Environment to interact with an M-Instance and/or- An M-Instance to interact with a U-Environment.
Duty	A moral or legal obligation to act or behave.
Entitlement	The state of a User having certain Rights in an M-Instance.
Functional Requirement	A Functionality that is expected to be provided by an entity.
Human	
– *Digital*	Either a Digitised or a Virtual Human.
– *Digitised*	The digital representation of a human.
– *Virtual*	A computer-created Object that has a human appearance when rendered but is not a Digitised Human.
Governance	The action or manner of directing and controlling actors of the Metaverse Ecosystem.
Information and Communication Technologies	(ICT) Technologies that enable the processing and distribution of information via the network.
Interface	A communication pathway enabling systems to interact.
– *Brain-Computer*	(BCI) A communication pathway that allows a human to interact with an M-Instance by sensing and processing the electrical activity of the brain.
– *Haptic*	A communication pathway that allows a human to interact with an M-Instance through bodily movements and sensations.
– *Speech*	A communication pathway that allows a human to interact with an M-Instance using spoken language.
– *Visual*	A communication pathway that allows a human to interact with an M-Instance through bodily movements and visual messages.
Interoperability	The ability of an M-Instance to exchange and make use of the data of another M-Instance as intended by the latter M-Instance.
Item	Data and Metadata supported and identified by an M-Instance.
– Account	An Item that uniquely references a human who has Registered. A User may have more than one Account with one or more Services.
– Activity Data	An Item containing the record of all the Process Actions made by a Process.
– Address	The URL of a storage facility.
– Amount	A number expressing a Value in a Currency.

– Asset	An Item that may be the object of a Transaction. It may be MM-Embedded at an M-Location or Posted to a Service.
– Contract	An Item expressing terms and conditions or a Program that is activated when terms and conditions are met.
– Smart	A Program stored on a Blockchain that runs when activated by an external entity, e.g., a User or another Smart Contract.
– Currency	A medium of exchange enabling Transactions.
– Emotion	The representation of a User's Personal Status that results from its interaction with an environment, such as "Angry", "Sad", "Determined".
– Event	An Item that includes selected Entities at an M-Location and their Animations during a period.
– Identifier	An Item that uniquely references an Item or a Process in an M-Instance.
– M-Environment	An administratively identified subset of an M-Instance.
– Capabilities	(E-Capabilities) An Item expressing the capabilities of an M-Environment.
– Message	An Item containing application-specific Data MM-Sent by a Source Process to a Destination Process.
– M-Instance	An implementation of the MMM-ARC and MMM-TEC Technical Specification.
– M-Location	A region of an M-Instance with Space-Time attributes that is exposed as further subdivided.
– Model	An Object that can be used to spawn other Objects, e.g., by animating them.
– Object	An Item with at least one of Audio, Visual, or Haptic perceptibility attributes.
– *Audio*	An Object perceptible by a hearing device or audible to a human when rendered.
– *Audio-Visual*	An Object whose rendering has both Audio and Visual perceptibility attributes.
– *Visual*	An Object perceptible by a visual device or visible to a human when rendered.
– Orientation	An Item representing an Object's orientation, velocity, and acceleration.
– Persona	A Model representing a human.
– Personal Data	An Item containing a human's Personal Profile, Activity Data of their Users, and Personae.
– Personal Profile	An Item containing a human's Personal Data submitted when Registering with an M-Instance.
– Personal Status	An Item representing the information internal to a User that characterises their behaviour.
– Point of View	The Spatial Attitude of a Persona watching an Environment.
– Position	The Coordinates of a point in a Metaverse Environment using a Coordinate system.
– Program	An Item containing executable code, e.g., application program.
– Provenance	A Data Type containing the list of all Transactions executed on an Asset, first and last included.
– Request-Action	An Item of the request to a Process to perform an Action.
– Response-Action	An Item containing the response of a Process to a Request-Action.
– Rights	An Item expressing the authorisation of a Process to perform Actions on Items at M-Locations during a Time and the Rights Level.
– Level	A type of Right, currently Internal (granted at Registration Time), Acquired (by Process Activity), Granted (by another Process).
– Rules	An Item expressing the terms and conditions under which a Process can perform Action in an M-Instance or M-Environment.

– Scene	A hierarchical Composition of Objects and Scenes having Spatial Attitudes.
– *Basic*	A hierarchical Composition of Objects having Spatial Attitudes.
– Social Attitude	A Personal Status Factor representing the internal state of an Entity related to the way it intends to position itself vis-à-vis the Context, e.g., "Respectful", "Confrontational", "Soothing"..
– Space-Time	An Item representing the combined digital representation of space and time.
– Spatial Attitude	An Item representing the Position and Orientation of an Object, and their velocities and accelerations.
– Stream	An Item made by a continuous temporal flow of Data.
– Time	An Item representing the measure of time.
– Transaction	An Item representing: – The Amount, the WalletID and the Rights on an Asset of a User transferring Rights to another User (Sender). – The Amount, the WalletID and the Rights on the Asset of another User receiving the Rights (Receiver). – Optionally the Amount and the WalletID of the Service Provider facilitating/enabling the Transaction.
– U-Location	An Item representing a region of the Universe with Space-Time attributes.
– Universe-Metaverse Map	An Item containing a structure establishing a correspondence between U-Locations with M-Locations.
– Value	An Amount and the Currency with which the Amount is expressed.
– Wallet	A container of Values.
– *Crypto*	Software or hardware holding the Public and Private Keys of a User to enable them to make Transactions by accessing their Account on a Blockchain.
Ledger	An Item containing a list of Transactions involving Assets.
Media	Data that is: 1. acquired by a Device sensor whose rendering can be perceived by a human. 2. Can be presented and perceived by a human.
Metadata	Data about Data, e.g., of a human, a Process, or an Item.
Metaverse	
– Actuator	A component of a Device able to MU-Embed an Item to a U-Environment.
– Ecosystem	The ensemble of entities and rules ensuring that Metaverse Instances operate in the interest of Metaverse Stakeholders.
– Enabling Service Layer	The set of Services such as payment, security, identity, privacy, etc. that enable operation of an M-Instance.
– Experience Layer	The set of functions, such as Devices, that generate Experiences.
– Industry	The collection of players that support the design, development, deployment, operation, and content and service provisioning to Metaverse Instances.
– Instance	(M-Instance) A set of Processes providing some or all the following functions: 1. To sense data from U-Locations.2. To process the sensed data and produce Data. 3. To produce one or more M-Environments populated by Objects that can be either digitised or virtual, the latter with or without autonomy. 4. To process Objects from the M-Instance or potentially from other M-Instances to affect U- and/or M-Environments using Objects in ways that are: 4.1.Consistent with the goals set for the M-Instance. 4.2.Effected within the capabilities of the M-Instance. 4.3.Complying with the Rules set for the M-Instance and applicable laws.

Term	Definition
– Interoperability	The ability of M-Instance$_A$ to use data from and as intended by M-Instance$_B$. Interoperability can be Direct or Mediated by a Conversion Service.
– Infrastructure Layer	The set of functions such as network, transport, storage, and (cloud, edge) processing that enable an M-Instance to operate.
– Manager	The entity overseeing the operation of an M-Instance.
– Operation Model	The components and sequence of steps involved in an M-Instance providing Functionalities.
– Operator	The entity overseeing the operation of an M-Environment.
– Partner	A User participating in activities of a Metaverse Operator (i.e., a business customer of an Operator)
– Platform Layer	The set of Services, such as content creation, content discovery, and content access functions that enable an M-Instance to operate.
– Process	The instance of a program being executed.
– Profile	A recognised subset of Technologies specified by MMM-ARC and MMM-TEC.
– Stakeholder	An entity performing a function aimed at achieving a goal in an M-Instance.
– Tool	A Technology or group of Technologies enabling an M-Instance to provide a Functionality.
– Technology	A structured application of scientific and/or technical methods that supports a Functionality.
Object	
– *Audio*	The digital representation of an object or a computer-generated Object that can be rendered to and perceived by a human ear.
– *Autonomous*	A Virtual Object animated by a Process giving it the ability to act (e.g., move, speak, respond, execute) with a degree of autonomy.
– *Composite*	An Object that includes more than one Object Type.
– *Digital*	A Digitised or a Virtual Object.
– *Digitised*	The digital representation of an object.
– *Haptic*	An Object with the haptic features of an object able to be rendered to provide haptic sensations in a human.
– *Human*	An Object representing a human.
– *Speech*	The digital representation of a sound emitted by the vocal tract of a human or generated by a computer with similar audio characteristics.
– Type	One of Audio, Visual, Haptic, Olfaction, and Gustation.
– *Virtual*	A computer-generated Object that is not a Digitised Object.
– *Visual*	The digital representation of an object captured by an electromagnetic or high-frequency audio signal or computer-generated that can be rendered to and perceived by a human eye.
Oracle	A Process providing information from a U-Environment to a Blockchain.
Privacy	The Rights of a User to keep their Personal Profile secret.
Process	An instance of a Program running in a Device or in the computing platform underpinning an M-Instance.
– App	An application-specific Program executed on a Device.
– Capabilities	(P-Capabilities) An Items containing a description of the capabilities of a Process.
– Device	A Process able to: 1. UM-Capture Data from a U-Location2. UM-Send Data and Metadata to a User. 2. and/or

	1. MM-Send an Item from an M-Location to the Device. 2. MU-Embed an Item at a U-Location.
– Actuator	The component of a Device able to convert Data into information for the Universe
..- Sensor	The component of a Device able to capture information from the Universe and convert it into Data and Metadata.
– Service	A Process that can be called to provide specific Functionalities.
– *Authoring*	A Service enabling the creation of Items.
– *Conversion*	A Service converting the Data produced by an M-Instance$_A$ into Data understood and acted upon by M-Instance$_B$ as intended by M-Instance$_A$.
– User	A Process representing a Registered human.
Profile	A set of base standards and/or their subsets.
– *Functional*	The set of Functionalities offered by a Metaverse Profile.
– Level	A subdivision of a Profile indicating the completeness of the user experience provided by the Profile.
– *Technology*	The set of Technologies offered by a Metaverse Profile.
Registration	The process whereby a human provides a subset of Personal Data to an M-Instance/Environment to obtain an Account and be authorised to deploy their Processes and Personae.
Rendering	The process of making an Item perceptible by human senses.
Representation	Data in an M-Instance representing an entity of a U-Environment.
Sense of	
– Agency	The subjective awareness of being able to decide, execute, and control one's own actions in an M-Environment.
– Embodiment	The engagement of senses to form a complete M-Instance Experience.
– Presence	The feeling of being in an M-Instance with other Digital Humans for real.
Social Graph	A representation of a User's network of connections with Items, M-Locations, and Processes.
Token	
– *Fungible*	A representation of an Asset that is interchangeable with other Assets of the same type.
– *Non-Fungible*	(NFT) A unique digital identifier of an Asset that: – Cannot be copied (i.e., a copy is known to be a copy), substituted, or subdivided. – Is recorded in a digital ledger. – Is used to certify Object authenticity and ownership.
Trust-less system	A system allowing a User to make reliable Transactions without trusting or knowing the parties the User makes Transactions with.
Universe	The physical world.
– Location	(U-Location) A region of the Universe with Space-Time attributes.
Use Case	An example of how an application domain can be supported by an MMM-ARC and MMM-TEC.
User Keys	The pair of public and private keys where the public key is used to encrypt, and the private key is used to both encrypt and decrypt Data.
User Identifier	
– *Decentralised*	An Identifier that enables the verifiable association with a human without requiring a centralised registry.
– *Self-Sovereign*	A Decentralised Identifier derived from the human's Public Key owned and managed directly by the human based on the knowledge of their own Private

	Key, e.g., stored in the Crypto Wallet enabled by the Blockchain underpinning the M-Instance.

Table 1 is shared between MMM-ARC V1.2 and MMM-TEC V1.0.
Table 2 includes Terms generally used across MPAI Technical Specifications.

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 Model (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 AIW-specific inputs and producing AIW-specific outputs according to the AIW 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, Store, and User Agent
Composite AIM	An AIM aggregating more than one AIM.
Component	One of the 7 AIF elements: Access, Communication, Controller, Internal Storage, Global Storage, Store, and User Agent
Conformance	The attribute of an Implementation of being a correct technical Implementation of a Technical Specification.
– Testing	The normative document specifying the Means to Test the Conformance of an Implementation.
– 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.
– Format	The standard digital representation of Data.
– Type	An instance of Data with a specific Data Format.
– Semantics	The meaning of Data.
Descriptor	Coded representation of a text, audio, speech, or visual feature.
Digital Representation	Data corresponding to and representing a physical entity.

Ecosystem	The ensemble of actors making it possible for a User to execute an application composed of an AIF, one or more AIWs, each with one or more AIMs potentially sourced from independent implementers.
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.
AIM/AIW 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.
Implementer	A legal entity implementing MPAI Technical Specifications.
ImplementerID (IID)	A unique name assigned by the ImplementerID Registration Authority to an Implementer.
ImplementerID Registration Authority (IIDRA)	The entity appointed by MPAI to assign ImplementerID's to Implementers.
Instance ID	Instance of a class of Objects and the Group of Objects the Instance belongs to.
Interoperability	The ability to functionally replace an AIM with another AIW having the same Interoperability Level
– 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.
– Assessment	The normative document specifying the Means to Assess the Grade of Performance of an Implementation.
– Assessment Means	Procedures, tools, data sets and/or data set characteristics to Assess the Performance of an Implementation.
– Assessor	An entity Assessing the Performance of an Implementation.
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	A set of Technical Specification, Reference Software, Conformance Testing, Performance Assessment, and Technical Report 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 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.

5 References

5.1 Normative reference

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2. MPAI; Technical Specification: [MPAI Metaverse Model](#) (MPAI-MMM) – [Architecture](#) (MMM-ARC) V1.2.
3. MPAI; Technical Specification: [Object and Scene Description](#) (MPAI-OSD) V1.1.
4. MPAI; Technical Specification: [Portable Avatar Format](#) (MPAI-PAF) V1.2.
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6. MPAI; Technical Specification: [Data Types, Formats, and Attributes](#) (MPAI-TFA) V1.1.
7. ECMA; [ECMA-404 The JSON Data Interchange Standard](#).

5.2 Informative references

8. MPAI; [The MPAI Statutes](#).
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10. MPAI; Technical Report – [MPAI Metaverse Model](#) (MPAI-MMM) – [Functionalities](#) (MMM-FNC).
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12. MPAI; Technical Specification: [Governance of the MPAI Ecosystem](#) (MPAI-GME) V1.1.
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16. MPAI; MPAI; Framework Licence: [MPAI Metaverse Model](#) (MPAI-MMM) – [Architecture](#).
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6 Items

Item is the third constitutive element of MMM. An Item is:
1. Produced by
    1. Autonomous decision of a Process.
    2. Human request
    3. Sensing Data from the Universe.
2. Acted on by Processes.

MMM-TEC utilises 65 types of Items defined by:
1. The JSON Syntax and Semantics of Data Type specified by MMM-TEC or other MPAI Technical Specifications, and, when required,.
2. [Qualifier](#) signaling the relevant characteristics or technologies of a Data Type.

General	**Contract**	**Identifier**	**M-Capabilities**	**M-Environment**
	M-Instance	**Program**	**Rights**	**Rules**
	U-Environment			
Human&User	**Account**	**Activity Data**	**Personal Profile**	**Personal Data**
Process Interaction	**Message**	**P-Capabilities**	**Process Action**	**Request-Action**
	Response-Action			
Service Access	**Authentication**	**Basic Discovery**	**Basic Information**	**Basic Interpretation**

	Discovery	Information	Interpretation	
Finance	**Asset**	**Currency**	**Provenance**	**Transaction**
	Value	**Wallet**		
Perception	**Audio Basic Scene Descriptors**	**Audio Object**	**Audio Scene Descriptors**	**Audio-Visual Basic Scene Descriptors**
	Audio-Visual Event Descriptors	**Audio-Visual Object**	**Audio-Visual Scene Descriptors**	**3D Model**
	Speech Basic Scene Descriptors	**Speech Object**	**Speech Scene Descriptors**	**Visual Basic Scene Descriptors**
	Visual Object	**Visual Scene Descriptors**	**Summary**	**Text Object**
Internal State	**Cognitive State**	**Emotion**	**Personal Status**	**Social Attitude**
Space&Time	**Basic M-Location**	**Basic U-Location**	**M-Location**	**Orientation**
	Point of View	**Position**	**Space-Time**	**Spatial Attitude**
	Time	**U-Location**	**Universe-Metaverse Map**	

7 Profiles

7.1 Introduction

Profiles define groups of Items and Actions that serve specific application areas while providing a programmed level of Interoperability with Profiles defined for other application areas.

Table 1 lists the currently identified Actions, Items and Data Types supported by a Profile. Cells with text in italic indicate a classification of Items, Action, and Data Types.

Table 1 – Classified Actions

General Actions	**Authenticate**	**Change**	**Execute**	**Hide**
	Identify	**Modify**	**Register**	**Validate**
Call a Service	**Author**	**Discover**	**Inform**	**Interpret**
	Post	**Transact**	**Convert**	**Resolve**
Metaverse to Metaverse	**MM-Add**	**MM-Animate**	**MM-Disable**	**MM-Embed**
	MM-Enable	**MM-Send**		
Metaverse to Universe	**MU-Actuate**	**MU-Embed**	**MU-Send**	**Track**
Universe to Metaverse	**UM-Animate**	**UM-Capture**	**UM-Embed**	**UM-Send**

Table 2 – Classified Items

General	**Contract**	**Identifier**	**M-Capabilities**	**M-Environment**
	M-Instance	**Program**	**Rights**	**Rules**
	U-Environment			
Human&User	**Account**	**Activity Data**	**Personal Profile**	**Personal Data**
Process Interaction	**Message**	**P-Capabilities**	**Process Action**	**Request-Action**
	Response-Action			
Service Access	**Authentication**	**Basic Discovery**	**Basic Information**	**Basic Interpretation**
	Discovery	**Information**	**Interpretation**	
Finance	**Asset**	**Currency**	**Provenance**	**Transaction**

	Value	Wallet		
Perception	**Audio Basic Scene Descriptors**	**Audio Object**	**Audio Scene Descriptors**	**Audio-Visual Basic Scene Descriptors**
	Audio-Visual Event Descriptors	**Audio-Visual Object**	**Audio-Visual Scene Descriptors**	**3D Model**
	Speech Basic Scene Descriptors	**Speech Object**	**Speech Scene Descriptors**	**Visual Basic Scene Descriptors**
	Visual Object	**Visual Scene Descriptors**	**Summary**	**Text Object**
Internal State	**Cognitive State**	**Emotion**	**Personal Status**	**Social Attitude**
Space&Time	**Basic M-Location**	**Basic U-Location**	**M-Location**	**Orientation**
	Point of View	**Position**	**Space-Time**	**Spatial Attitude**
	Time	**U-Location**	**Universe-Metaverse Map**	

7.2   Profile structure

The current MMM features are:

1. Identified Profiles are Baseline, Management, Finance, and High.
2. The High Profile includes the Management Profile that includes the Baseline and Finance Profiles.
3. The Baseline, Management, and High Profiles have Levels, currently identified as: Audio only, Audio-Visual, and Audio-Visual-Haptic.
4. The Finance Profile does not have Levels.

This is depicted in Figure 1. The next Sections provide additional details.
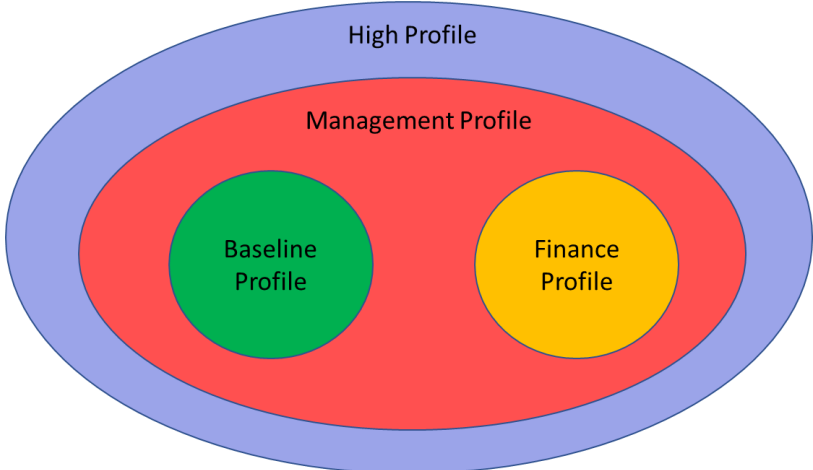
Figure 1 – The Profiles of MPAI-MMM – Architecture

Each Profile allocates the supported Actions and Items. While the identified four Profiles serve well the needs conveyed by the identified Functionalities, the consideration of more Functionalities in the future may lead to an increased number of Profiles and potentially Levels.

7.3　Baseline Profile

The Baseline Profile is designed to enable a human equipped with a Device supporting the Baseline Profile to allow their Users to perform the functions of Table 3. Currently, this Profile has the following Levels: Audio only; Audio-Visual; and Audio-Visual-Haptic.

Table 3 – Functions, Actions, and Items of the Baseline Profile

Functions	Action	Item/Process
Read Items and Data	UM-Send	Item
Identify Item	Identify	Item, Identifier
Author Item	Author	Item
Place Item at an MLoc without perception	MM-Add	Entity, MLoc
Make a placed Item perceptible	MM-Enable	Entity
Place an Item at MLoc, with perception	MM-Embed	Entity, MLoc
Stop perception of Item	MM-Disable	Entity, MLoc
Make available an Item or DataMdata to a Process	MM-Send	Entity
Render at ULoc an Item placed at MLoc	MU-Render	Entity, MLoc, ULoc
Make scene at ULoc available to a Device	UM-Capture	ULoc
Make Data of a Device available to a Process	UM-Send	Device, Process
Transfer Item or DataMdata between Processes	MM-Send	Message
Animate Model @MLoc w/ Data from ULoc	UM-Animate	Model, ULoc
Place Entity @ MLoc	UM-Embed	Item, MLoc, ULoc
Send an Item at an MLoc to a Device	MM-Send	Item, Device, MLoc
Place, Animate, and Render Model at MLoc	Track	Model, Item (stream)
Store Item	MU-Send	Item

This Profile generally supports applications in a basic form for e.g., lecture, meeting, hang-out. Table 4 lists the Actions and Item of the Baseline Profile.

Table 4 – Actions of the Baseline Profile

General Actions	Identify			
Call a Service	Author			
Metaverse to Metaverse	MM-Add	MM-Disable	MM-Embed	MM-Enable
	MM-Send			
Metaverse to Universe	MU-Actuate	MU-Embed	MU-Send	Track
Universe to Metaverse	UM-Animate	UM-Capture	UM-Embed	UM-Send

Table 5 – Items of the Baseline Profile

General	**M-Instance**			
Process Interaction	**Request-Action**	**Response-Action**		
Perception	**Audio Basic Scene Descriptors**	**Audio Object**	**Audio-Visual Basic Scene Descriptors**	**Audio-Visual Event Descriptors**
	Audio-Visual Object	**Audio-Visual Scene Descriptors**	**3D Model**	**Speech Basic Scene Descriptors**
	Speech Object	**Speech Scene Descriptors**	**Visual Basic Scene Descriptors**	**Visual Object**
	Visual Scene Descriptors	**Text Object**		
Space&Time	**Basic M-Location**	**Basic U-Location**	**M-Location**	**Orientation**
	Point of View	**Position**	**Space-Time**	**Spatial Attitude**
	Time	**U-Location**		

7.4 Finance Profile

The Finance Profile is designed to enable a human equipped with a Device supporting the Baseline Profile to allow their Users to perform the functions of Table 5. The Finance Profile enables a User to Post Assets and make Transactions. As depicted in *Figure 1*, this Profile is independent of the Basic Profile, although it shares some basic Actions and Items with it. Currently, this Profile does not have Levels.

Table 6 – Functions, Actions, and Items of the Finance Profile

Functions	Action	Items
Register	Register	M-Environment, Account, Activity Data, Personal Profile, Rules, Social Graph
Check that an Item is what it says it is	Authenticate	Item
Make Item inaccessible	Hide	Item
Modify Item into Asset	Modify	Item
Submit Asset to marketplace	Post	Asset
Make a Transaction of an Asset	Transact	Asset, Provenance, Rights, Transactions, Value, Wallet
Discover Assets	Discover	Discovery
Get information on Asset, User	Inform	Information
Change User Rights	Change	Rights

Table 7 lists the Actions, Items, and Data Types of the Finance Profile.

Table 7 – Actions of Finance Profile

General Actions	**Authenticate**	**Change**	**Execute**	**Hide**
	Identify	**Modify**	**Register**	**Validate**
Call a Service	**Author**	**Discover**	**Inform**	**Interpret**
	Post	**Transact**	**Convert**	

Metaverse to Metaverse	MM-Add	MM-Disable	MM-Embed	MM-Enable
	MM-Send			
Metaverse to Universe	MU-Actuate	MU-Embed	MU-Send	UM-Capture
Universe to Metaverse	UM-Embed	UM-Send		

Table 8 – Items of Finance Profile

General	Contract	Identifier		M-Environment
	M-Instance	Program	Rights	Rules
	U-Environment			
Human&User	Account	Activity Data	Personal Profile	Personal Data
Process Interaction	Message	Process Action		
Service Access	Authentication	Basic Discovery	Basic Information	Basic Interpretation
	Discovery	Information	Interpretation	
Finance	Asset	Currency	Provenance	Transaction
	Value	Wallet		
Perception	3D Model	Audio Object	Audio-Visual Object	Speech Object
	Visual Object	Text Object		
Space&Time	Basic M-Location	Basic U-Location	Orientation	Point of View
	Position	Space-Time	Time	

7.5 Management Profile

The Management Profile enables a human equipped with a Device supporting the Management Profile to allow their Users to perform the functions of Table 6 in a controlled ecosystem that supports all Actions, Items, and Data Types of the Baseline and the Finance Profiles in addition to some others of its own. As depicted in *Figure 1* the Management Profile is a superset of the Baseline and Finance Profiles. Currently, this Profile has the following Levels: Audio; Audio-Visual; and Audio-Visual-Haptic.

Table 9 – Functions, Actions, and Items of the Management Profile

Functions	Actions	Items
Register with an M-Environment	(Register)	M-Environment
Make Item inaccessible	Hide	Item
Animate Model with an autonomous Process	MM-Animate	Model
App triggers perception of Entities	UM-Send	Map, Message
Request interpretation of Item	Interpret	InterpretIn, InterpretOut
Save an Experience of an Event	MU-Export	Interaction, Experience, Event
Convert formats	Convert	

Table 7 lists the Actions, Entities, and Data Types required by the Management Profile.

Table 10 –Actions of Management Profile

General Actions	Authenticate	Change	Execute	Hide
	Identify	Modify	Register	
Call a Service	Author	Discover	Inform	Interpret
	Post	Transact		
Metaverse to Metaverse	MM-Add	MM-Animate	MM-Disable	MM-Embed
	MM-Enable	MM-Send		
Metaverse to Universe	MU-Actuate	MU-Embed	MU-Send	Track
Universe to Metaverse	UM-Animate	UM-Capture	UM-Embed	UM-Send

Table 11 –Items of Management Profile

General	Contract	Identifier	M-Capabilities	M-Environment
	M-Instance	Program	Rights	Rules
	U-Environment			
Human&User	Account	Activity Data	Personal Profile	Personal Data
Process Interaction	Message	P-Capabilities	Process Action	Request-Action
	Response-Action			
Service Access	Authentication	Basic Discovery	Basic Information	Basic Interpretation
	Discovery	Information	Interpretation	
Finance	Asset	Currency	Provenance	Transaction
	Value	Wallet		
Perception	Audio Basic Scene Descriptors	Audio Object	Audio Scene Descriptors	Audio-Visual Basic Scene Descriptors
	Audio-Visual Event Descriptors	Audio-Visual Object	Audio-Visual Scene Descriptors	3D Model
	Speech Basic Scene Descriptors	Speech Object	Speech Scene Descriptors	Visual Basic Scene Descriptors
	Visual Object	Visual Scene Descriptors	Summary	Text Object
Space&Time	Basic M-Location	Basic U-Location	M-Location	Orientation
	Point of View	Position	Space-Time	Spatial Attitude
	Time	U-Location	Universe-Metaverse Map	

7.6   High Profile

This Profile includes all other Profiles. Table 8 gives the list of Actions, Items and Data Types not included in the Management Profile. Currently, this Profile has the following Levels: Audio; Audio-Visual; and Audio-Visual-Haptic.

Table 12 – Actions and Items not in Management Profile

Actions	Convert	Resolve	Validate	

Item	Cognitive State	Emotion	Personal Status	Social Attitude

8 Verification Use Cases (informative)

8.1 Introduction

This Informative Chapter collects diverse Metaverse Use Cases where Users request to perform Actions on different types of Items. The goal is to verify that the Metaverse elements of this Technical Specification do indeed support a range of representative Use Cases thus confirming validity of the Technical Specification.

Note that, unless disclaimed otherwise, a sentence like "*A student attends a lecture held by a teacher in a classroom created by a school manager*" s to be read as "*A User representing a student attends a virtual lecture in a virtual classroom Authored by a User representing a school manager and MM-Embedded at an M-Location*".

8.2 Use Case Description Language

Metaverse Use Cases involve a plurality of Processes – Users, Devices, Services, Apps – performing or requested by other Processes to perform Actions on a variety of Items. In a Use Case:

1. *Processes* (e.g., Users) are sequentially identified by one subscript.
2. *Items* Acted on by a Process are identified by the subscript of the Process performing the Action on the Item followed by a sequential number.
3. Objects, Scenes, Events, and Personae are prefixed by S, A, V, AV, or AVH to indicate their Speech, Audio, Visual, Audio-Visual, or Audio-Visual-Haptic nature, respectively.
4. The *Locations* where the Actions take place are similarly identified by the subscript of the Process performing an Action at the Location followed by a sequential number.
5. If the *Actions* are performed at different M-Instances, all Processes, Items, and Locations are prefixed by a sequential capital letter.

For instance:

1. $User_i$ MM-Embeds $Persona_j$ at $M\text{-}Location_{i.k}$.
2. $User_i$ MU-Embeds $Item_j$ at $U\text{-}Location_{i.k}$.
3. $User_{A,i}$ MM-Sends $Message_{i.j}$ to $User_{B.k}$.

All Use Cases assume that Actions are performed in an M-Instance. Action specified in the Universe are specifically noted.

The following conventions are used throughout:

MLoc	M-Location
SA	Spatial Attitude
ULoc	U-Location
Persona(AV)	Persona whose rendering activates audio-visual perceotion.
Object(AVH)	Object whose rendering activates audio-visual-haptic perception

8.3 Virtual Lecture

8.3.1 Description

1. School Manager
   - Authors and embeds a virtual classroom in an M-Instance.
   - Pays teacher.
2. Teacher

- Is at home.
- Embeds a persona of theirs from home close to the classroom's desk.
- Embeds and animates a 3D Object in the lecture.
- Eventually the classroom and returns home.

3. Student
   - Is at home.
   - Pays lecture fees with the right to make a copy of the Audio-Visual Event.
   - Embeds a persona of theirs in the classroom.
   - Approaches the teacher's desk to feel the 3D Object with haptic gloves.
   - Stores the lecture's Audio-Visual Event.
   - Leaves the classroom and returns home.

8.3.2 MMM-Script representation

Declarations

Declare	User$_1$	// School manager //
	AVHObject$_1$	//Classroom //
	MLoc$_{1.1}$	// Metaverse Location //
	Value$_{1.1}$	// Lecture consideration //
Declare	Service$_1$	// Author Service //
Declare	User$_2$	// Teacher's User //
	human$_2$	// Teacher //
	AVHPersona$_{2.1}$	// Teacher's Persona //
	MLoc$_{2.1}$	// Place of classroom desk //
	MLoc$_{2.2}$	// Place close to object being experimented //
	AVHObject$_{2.1}$	// Object being experimented //
Declare	User$_3$	// Student //
	AVHPersona$_{3.1}$	// Student's Persona //
	MLoc$_{3.1}$	// Student's home //
	MLoc$_{3.2}$	// Classroom seat //
	MLoc$_{3.3}$	// Location close to Object being experimented //
	Value$_{3.1}$	// Lecture fees //
	AVHEvent$_{3.1}$	// Lecture //

Operation

ProcessA	Actions	Items	Indirect Item or Process	ProcessB
User$_1$	Authors	DataMdata	By Service$_1$ At Service$_1$	Item(AVH)$_1$
	MM-Embeds	AVHObject$_{1.1}$	From Service$_1$ At MLoc$_{1.1}$	
User$_2$	Tracks	human$_2$	At MLoc$_{2.1}$ With SA	
	MM-Embeds	AVHPersona$_{2.1}$	At MLoc$_{2.2}$ With SA	
	MM-Disables	AVHPersona$_{2.1}$	At MLoc$_{2.1}$	
	MM-Embeds	AVHObject$_{2.1}$	At MLoc$_{2.2}$ With SA	
User$_3$	Tracks	AVHPersona$_{3.1}$	At MLoc$_{3.1}$ With SA	
	Transacts	Value$_{3.1}$	To User$_1$	
	MM-Embeds	AVHPersona$_{3.1}$	At MLoc$_{3.2}$ With SA	
	MM-Embeds	AVHPersona$_{3.1}$	At MLoc$_{3.3}$ With SA	
	MM-Sends	AVHEvent	To URI	
	MM-Disables	AVHPersona$_{3.1}$	At MLoc$_{3.3}$	
	MM-Embeds	AVHPersona$_{3.1}$	At MLoc$_{3.1}$ With SA	

8.3.3 Actions and Items

Table 6 gives the list of Actions, Items, and Data Types used by the Virtual Lecture Use Case. The Table also gives the Actions implied by the Track Composite Action (MM-Embed, MM-Animate, MM-Send, MU-Render, UM-Capture, MU-Send, and Identify). The list of these Actions will not be repeated in the next tables.

Table 6 – Virtual Lecture Actions, Items, and Data Types

Actions	Items
Author	Coordinates
Identify	Currency
MM-Disable	Experience
MM-Embed	AVHObject
MM-Send	M-Location
MU-Render	Orientation
MU-Send	Persona(AVH)
UM-Animate	Position
UM-Capture	Spatial Attitude
UM-Send	U-Location
Track	Value
Transact	Value

8.4 Virtual Meeting

8.4.1 Description

A meeting manager
1. Authors a meeting room.
2. Deploys a Process acting as a Virtual Meeting Secretary tasked to produce a summary of the conversations, enriched by information about participants' Personal Statuses.
3. The Summary is displayed in the meeting room for participant to comment.

A participant
1. Attends a meeting held in the room.
2. Pays to get a translation of the sentences uttered in languages other than their own.
3. Stores the Event.

8.4.2 MMM-Script representation

Declarations

Declare	User$_1$	// Meeting manager //
	AVObject$_{1.1}$	// Meeting room //
	MLoc$_{1.1}$	// Meeting location //
	Persona(AV)$_{1.1}$	// Virtual Meeting Secretary //
	Stream$_{1.2}$	// Virtual Meeting Secretary 's animating Persona(AV)$_{1.1}$ //
	MLoc$_{1.2}$	// Place assigned to Virtual Meeting Secretary //
	Summary$_{1.3}$	// Meeting Summary //
	MLoc$_{1.3}$	// Place for Summary display
Declare	Service$_1$	// Authoring Service //
Declare	User$_2$	// Meeting participant #1 //
	human$_2$	// human participant #1 //

	AVPersona$_{2.1}$	// Participant #1's Persona //
	MLoc$_{2.1}$	// Participant#1's home //
	MLoc$_{2.2}$	// Place assigned to Participant#1 //
	AVHObject$_{2.1}$	// Presentation //
	MLoc$_{2.3}$	// Place assigned for presentation display //
	Event$_{2.1}$	// Meeting/s recording //
	Address$_1$	// Storage (for recording)
Declare	User$_3$	// Meeting participant #2 //
	AVPersona$_1$	// Participant #2's Persona //
	MLoc$_1$	// Place assigned to Participant#2 //
	SObject$_{1.1}$	// Speech Object to be Interpreted //
Declare	Service$_2$	// Interpretation Service //

Operation

ProcessA	Actions	Items	Indirect Item or Process	ProcessB
User$_1$	Authors	DataMdata	By Service$_1$ At Service$_1$	Item(AV)$_1$
	MM-Embeds	AVObject$_{1.1}$	From Service$_1$ At MLoc$_{1.1}$	
Process$_1$	MM-Animates	AVPersona$_{1.1}$	At MLoc$_{1.2}$ With Stream$_{1.1}$ With SA	
	MM-Embeds	Summary$_{1.1}$	At MLoc$_{1.3}$	
User$_2$	Tracks	human$_2$	At MLoc$_{2.1}$ With SA	
	MM-Embeds	AVPersona$_{2.1}$	At MLoc$_{2.2}$ With SA	
	MM-Disables	AVPersona$_{2.1}$	At MLoc$_{2.1}$	
User$_3$	Tracks	AVPersona$_{3.1}$	At MLoc$_{3.1}$ With SA	
	Transacts	Value$_{3.1}$	To User$_1$	
	MM-Embeds	AVPersona$_{3.1}$	At MLoc$_{3.2}$ With SA	
	Interprets	AudioObject$_{1.1}$	By Service$_1$ At User$_3$	
	MM-Sends	Event$_{3.1}$	To URI	
	MM-Disables	AVPersona$_{3.1}$	At MLoc$_{3.3}$	
	MM-Embeds	AVPersona$_{3.1}$	At MLoc$_{3.1}$ With SA	

8.4.3 Actions and Items

Table 7 gives the list of Actions and Items used by the Virtual Meeting Use Case. For simplicity, the Actions implied by the Track Action have not been added to the Table.

Table 7 – Virtual Meeting Actions, Items, and Data Types.

Actions	Items
Author	Coordinates
Interpret	AVPersona
MM-Animate	AVObject
MM-Disable	Event

MM-Embed	Orientation
MM-Send	Position
Track	Spatial Attitude
	Summary

8.5 Hybrid working

8.5.1 Description

A company applies a mixed in-presence and remote working policy.
1. Some Workers (R-Workers) attend Company physically.
2. Some Workers (V-Workers) attend Company virtually.
3. All Workers
   - Are Authenticated.
   - Are also present in the Virtual office if physically present.
   - Communicate by sharing AV messages (Communication of R-Workers' Personae is also mapped to the M-Environment).
   - Participate in Virtual meetings where a whiteboard is placed.

8.5.2 MMM-Script representation

Declarations

Declare	$User_1$	// Company manager //
	$AVObject_{1.1}$	// Office //
	$MLoc_{1.1}$	// Office Location //
	$AVPersona_{1.1}$	// Office Gatekeeper //
	$MLoc_{1.2}$	// Place for Gatekeeper //
Declare	$Process_1$	//Animates Office Gatekeeper //
Declare	$User_2$	// R-Worker //
	$AVPersona_{2.1}$	// R-Worker's Persona (R-Persona) //
	$MLoc_{2.1}$	// Home (R-Worker) //
	$MLoc_{2.2}$	// Place of R-Worker's Office desk //
	$MLoc_{2.3}$	// Place in meeting room
	$AVObject_{2.1}$	// Whiteboard //
	$MLoc_{2.4}$	// Place for Whiteboard //
Declare	$Process_2$	// Animates Whiteboard //
Declare	$User_3$	// V-Worker #1 //
	$AVPersona_{3.1}$	// V-Worker's Persona (V-Persona) //
	$MLoc_{3.1}$	// V-Worker's home //
	$MLoc_{3.2}$	// Place for V-Worker's desk //
	$SObject_{3.1}$	// Speech Object//
	$MLoc_{3.3}$	// Place close to R-Worker's virtual desk //
	$MLoc_{3.4}$	// Place#7 in meeting room //

Operation

$Process_A$	Action	Item	Indirect Item or Process
Manager	MM-Embeds	Office	*At* $MLoc_{1.1}$ *With* SA
	MM-Embeds	$AVPersona_{1.1}$	*At* $MLoc_{1.2}$ *With* SA
	MM-Animates	$AVPersona_{1.1}$	
$User_2$	Tracks	$AVPersona_{2.1}$	*At* $MLoc_{2.1}$ *With* SA

User$_1$	Authenticates	human$_2$	*At* User$_1$
User$_3$	Tracks	AVPersona$_{3.1}$	*At* MLoc$_{3.1}$ *With* SA
	MM-Embeds	V-Persona	*At* MLoc$_{3.2}$ *With* SA
	MM-Sends	SObject$_{3.1}$	*To* User$_2$
	MM-Embeds	AVPersona$_{3.1}$	*At* MLoc$_{3.3}$ *With* SA
	MM-Disables	AVPersona$_{3.1}$	*From* MLoc$_{3.2}$
	MM-Embeds	AVPersona$_{3.1}$	*At* MLoc$_{3.4}$ *With* SA
	MM-Disables	AVPersona$_{3.1}$	*From* MLoc$_{3.3}$
User$_2$	MM-Embeds	AVPersona$_{2.1}$	*At* MLoc$_{2.2}$ *With* SA
	MM-Disables	AVPersona$_{2.1}$	*From* MLoc$_{2.1}$
	MM-Embeds	AVObject$_{2.1}$	*At* MLoc$_{2.2}$ *With* SA
	MM-Disables	AVPersona$_{2.1}$	*From* MLoc$_{2.2}$
V-Worker	MM-Embeds	V-Persona	*At* MLoc$_{3.1}$ *With* SA
	MM-Disables	V-Persona	*From* MLoc$_{3.4}$

8.5.3 Actions, Items, and Data Types

Table 8 – Hybrid Working Actions and Items

Actions	Items
MM-Animate	AObject
MM-Disable	AVHObject
MM-Embed	AVPersona
MM-Send	Coordinates
Track	M-Location
	Orientation
	Position
	Spatial Attitude

8.6 eSports Tournament

8.6.1 Description

1. Site manager
   - Develops a game landscape.
   - Makes it available to a game manager.
2. Game manager
   - Deploys autonomous characters.
   - Places virtual cameras and microphones in the landscape.
3. Captured AV from game landscape is displayed onto a dome screen and streamed online. MMM-Script representation

8.6.2 MMM-Script representation

Declarations

Declare	User$_1$	// Site Manager //
	AVHObject$_1$	// Game landscape
	MLoc$_{1.1}$	// Game Location //
Declare	Service$_1$	// Author Service //
Declare	User$_2$	// Game manager //
	Value$_1$	// Game Location Renting Fees //
	Personae$_{2.i}$	//Autonomous characters //
	M-Loc$_{2.i}$	// Places in Game landscape //

	Scene$_{2.1}$	//Game's Scene //
Declare	User$_j$	// Players //
	Personae$_{j.1}$	// Players' characters //
	M-Loc$_{j.1}$	// Location in Game landscape //
Declare	Process$_i$	// Animates i-th Autonomous character //
	Device$_1$	// Microphone/Camera control
Declare	Service$_2$	// Operates Microphone/Camera control //
Declare	Device$_2$	//Dome screen //
Declare	Device$_k$	// Online Device of human //

Operation

Process$_A$	Action	Item	Secondary Item – Process
User$_1$	Authors	AVHObject$_1$	*By* Service$_1$ *With* Data *At* Service$_1$
	MM-Embeds	AVHObject$_1$	*From* Service$_1$ *At* MLoc$_{1.1}$ *With* SA
User$_2$	Transacts	Value$_1$	*To* User$_1$
	MM-Embeds	Personae$_{2.i}$	*At* M-Loc$_{2.i}$ *With* SA
	MM-Animates	Personae$_{2.i}$	
User$_j$	Tracks	Personae$_{j.1}$	*At* M-Loc$_{2.i}$ *With* SA
User$_2$	Calls	Service$_2$	*To* Device$_1$
User$_2$	MU-Renders	Scene$_{2.1}$	*At* Device$_2$
			At Device$_k$

8.6.3 Actions, Items, and Data Types

Table 9 – eSports Tournament Actions, Items, and Data Types.

Actions	Items
Author	AVHObject
MM-Animate	AVHPersona
MM-Embed	AVHScene
MU-Render	Coordinates
Track	Currency
Transact	M-Location
	Orientation
	Position
	Spatial Attitude
	U-Location
	Value

8.7 Virtual performance

8.7.1 Description

1. Impresario:
   - Acquires Rights to parcel.
   - Authors Auditorium
   - Embeds Auditorium on Parcel.

2. Participant
   - Buys a ticket for an event with the right to stay close to the performance stage for 5 minutes.
   - Utters a private speech to another participant.
3. Impresario:
   - Collects participants' preferences.
   - Interprets participants' mood (Participants Status).
   - Generates special effects based on preferences and Participants Status.

8.7.2   MMM-Script representation

Declarations

Declare:	$User_1$	// Impresario //
	$Value_{1.1}$	// Payment for Land Parcel //
	$AVObject_1$	// Auditorium //
	$Value_{1.2}$	// Payment for Auditorium authoring //
	$M\text{-}Loc_{1.1}$	// Parcel//
	$AObject_{1.i}$	// SFX //
	$M\text{-}Loc_{1.i}$	// SFX Places on Auditorium //
	$Value_{1.3}$	// Consideration for Performance //
	$PersonalStatus_{1.i}$	// Status of i-th event participants //
Declare:	$Service_1$	// Content Authoring //
Declare:	$Service_2$	// Preference Collection //
Declare	$Service_3$	// Parcel Service //
Declare:	$User_2$	// Performer //
	$AVPersona_{2.1}$	// Performer's Persona
	$M\text{-}Loc_{2.1}$	// Performer's home //
	$M\text{-}Loc_{2.2}$	// Stage in Auditorium //
Declare:	$User_3$	// Participant #1//
	$AVPersona_{3.1}$	// Participant#1's Persona //
	$M\text{-}Loc_{3.1}$	// Home //
	$M\text{-}Loc_{3.2}$	// Seat#1 in Auditorium //
	$Scene_{3.1}$	// Scene of Stage //
	$SObject_{3.1}$	// Speech Object ///
	$Value_{3.1}$	// Ticket#1 to event //
Declare	$User_4$	// Participant#2//
	$AVPersona_1$	//Participant#2's Persona //
	$M\text{-}Loc_1$	// Participant#2's Home //
	$M\text{-}Loc_2$	// Seat#2 in Auditorium //
	$Value_1$	// Ticket#2 to event //
Declare:	$User_5$	// Land Parcel owner //

Operation

Service_A	*Action*	*Item*	*Secondary Item – Process*
$User_1$	Transacts	$Value_{1.1}$	*To* $Service_3$
	Authors	Auditorium	*By* $Service_1$ *With* Data *At* $Service_1$
	Transacts	$Value_{1.2}$	*To* $Service_1$
	MM-Embeds	$AVObject_{1.1}$	*From* $Service_1$ *At* $M\text{-}Loc_{1.1}$ *With* SA
	Calls	$Service_2$	*At* $Service_2$
$User_2$	Tracks	$AVPersona_{2.1}$	*At* $M\text{-}Loc_{2.1}$ *With* SA

	MM-Embeds	AVPersona$_{2.1}$	*At* M-Loc$_{2.2}$ *With* SA
	MM-Disables	AVPersona$_{2.1}$	*From* M-Loc$_{2.1}$
User$_3$	Tracks	AVPersona$_{3.1}$	*At* M-Loc$_{3.1}$ *With* SA
	Transacts	Value$_{3.1}$	*At* User$_1$
	MM-Embeds	Persona$_{3.1}$	*At* M-Loc$_{3.2}$ *With* SA
	MM-Disables	AVPersona$_{3.1}$	*From* M-Loc$_{3.1}$
User$_4$	Tracks	AVPersona$_{4.1}$	*At* M-Loc$_{4.1}$ *With* SA
	Transacts	Value$_{3.1}$	*At* User$_1$
	Embeds	AVPersona$_{4.1}$	*At* M-Loc$_{4.2}$ *With* SA
	MM-Disables	AVPersona$_{4.1}$	*From* M-Loc$_{4.1}$
User$_3$	MM-Sends	SObject$_{3.1}$	*To* User$_4$
	Calls	Service$_2$	At Service$_2$
	MM-Sends	Scene$_{3.1}$	*To* User$_3$
User$_1$	Calls	Service$_2$	*At* User$_1$
	Interprets	PersonalStatus$_{1.i}$	*At* User$_1$
	MM-Embeds	AObject$_{1.i}$	*At* M-Loc$_{1.i}$ *With* SA
	Transacts	Value$_{1.3}$	*To* User$_2$
User$_2$	MM-Embeds	AVPersona$_{2.1}$	*At* M-Loc$_{2.1}$ *With* SA
	MM-Disables	AVPersona$_{2.1}$	*From* M-Loc$_{2.2}$
User$_3$	MM-Embeds	AVPersona$_{3.1}$	*At* M-Loc$_{3.1}$ *With* SA
	MM-Disables	AVPersona$_{3.1}$	*From* M-Loc$_{3.2}$
User$_4$	MM-Embeds	AVPersona$_{4.1}$	*At* M-Loc$_{4.1}$ *With* SA
	MM-Disables	AVPersona$_{4.1}$	*From* M-Loc$_{4.2}$

12.7.3 Actions and Items

Table 10 – Virtual Event Actions and Items.

Actions	Items
Author	AObject
Interpret	AVObject
MM-Disable	AVPersona
MM-Embed	Coordinates
MM-Send	Currency
Track	M-Location
Transact	Orientation
	Participants Status
	Position
	Spatial Attitude
	Value

8.8 AR Tourist Guide

8.8.1 Description

In this Use Case human$_3$ (AR Tourist Guide Service Provider) engages the following humans:
1. human$_1$ to cause their User$_1$ to buy a virtual parcel and develop a virtual landscape suitable for a tourist application.
2. human$_2$ to cause their User$_2$ to develop scenes and autonomous agents for the different places of the landscape.
3. human$_4$ to create an app that alerts the holder of a smart phone running the app.

4. human$_5$ holding a smart phone with the app to perceive Entities and interact with Personae MM-Embedded at M-Locations and MM-Animated.

8.8.2 MMM-Script representation

Declarations

Declare	User$_1$	// Virtual Land developer//
	MLoc$_{1.1}$	// Land Parcel //
	AVObject$_{1.1}$	// Landscape //
	Value$_{1.1}$	// Payment for Land Parcel //
Declare	Service$_1$	// Authoring Service //
Declare	User$_2$	// Object developer //
	AVObject$_{2.i}$	// Objects for landscape //
	MLoc$_{2.i}$	// Where Objects are placed //
	Value$_{2.1}$	// Payment for AVObjects$_{2.i}$ //
Declare	User$_3$	// Tourist application developer //
	Value$_{3.1}$	// Payment for populated landscape //
	Persona$_{3.k}$	// Persona to be MM-Animated //
	MLoc$_{3.k}$	// correspondent to ULoc$_{3.k}$ //
	ULoc$_{3.k}$	// ULoc where App reacts //
Declare	human$_4$	// Software developer //
	Map$_{4.1}$	// Universe Metaverse Map for mobile app //
	Value$_{4.1}$	// Payment for Map and App //
Declare	human$_5$	// holds Device running human$_4$'s App //
	User$_5$	// User of human$_5$ //
Declare	App$_1$	// Installed on Device$_1$ //
	Message$_{1.1}$	// From App$_1$ to User$_4$ //
Declare	User$_6$	// Land Parcel Rights holder //

Operation

Process$_A$	Action	Item	Secondary Item or Process
User$_1$	Transacts	Value$_{1.1}$	To User$_6$
	Authors	AVObject$_{1.i}$	At Service$_1$
	Embeds	Object(V)$_{1.1}$	At MLoc$_{1.1}$ With SA
User$_2$	Transacts	Value$_{2.1}$	To User$_1$
	Authors	AVObject$_{2.1}$	At Service$_1$
	MM-Embeds	AVObject$_{2.1}$	From Service$_1$ At MLoc$_{2.i}$ With SA
User$_3$	Transacts	Value$_{3.1}$	To User$_2$
	Authors	AVPersonae$_{3.i}$	At Service$_1$
	MM-Embeds	AVPersonae$_{3.i}$	From Service$_1$ At MLoc$_{2.i}$ With SA
	MM-Animates	MLoc Personae$_{3.i}$	
human$_4$	develops	Uni-Metaverse Map	
	develops	App	
	sells	Map and App	To human$_3$
human$_5$	arrives		At U-Loc$_{3.i}$
App$_1$	MM-Sends	Message$_{1.1}$	To Device
User$_4$	MM-Animates	Persona$_{3.i}$	At MLoc$_{3.i}$
User$_5$	MU-Renders	Animated Persona	At U-Loc$_{3.i}$

8.8.3 Actions and Items

Table 11 – AR Tourist Guide Actions and Items.

Actions	Items
Author	Coordinates
Author	Currency
MM-Animate	Map
MM-Animate	Message
MM-Embed	M-Location
MM-Send	Object(AV)
MU-Render	Object(V)
MM-Send	Orientation
Transact	Persona
	Position
	Service
	Spatial Attitude
	U-Location
	Value

8.9 Virtual Dance

8.9.1 Description

This Use Cases envisages that:
1. Dance teacher places their virtual secretary Persona animated by an autonomous agent in the dance school.
2. Student #1:
   - Shows up at school.
   - Greets the secretary.
3. Virtual secretary reciprocates greetings.
4. Dance teacher:
   - Places a haptic Persona of theirs in the dance school.
   - Dances with student #1.
5. Student #2:
   - Is at home.
   - Shows up at school.
6. Teacher:
   - Places their haptic Persona close to student #2.
   - Places (replaces) another haptic Persona of theirs close to student #1.
   - Animates the new haptic Persona with autonomous agent dancing with student #1.
   - Dances with student #2.

8.9.2 MMM-Script representation

Declarations

Declare	$User_1$	// Dance teacher //
	$AVHPersona_{1.1}$	// Dancing persona#1 //
	$MLoc_{1.1}$	// Place#1 (Teacher's Office) //
	$AVHPersona_{1.2}$	// School Secretary //
	$MLoc_{1.2}$	// Place#2 (Dancing School //
	$AVH\ Persona_{1.3}$	// Dancing persona#2 //
	$MLoc_{1.3}$	// Place#3 (dancing area) //

	SObject$_1$	// Speech Object#2 (Greetings) //
	MLoc$_{1.4}$	// Place#4 (dancing area) //
Declare	User$_2$	// Dance student #1 //
	AVHPersona$_{2.1}$	// Student's Persona/
	MLoc$_{2.1}$	// Student#1's home //
	MLoc$_{2.2}$	// Place#5 in dancing area //
Declare	User$_3$	// Dance Student #2 //
	AVHPersona$_{3.1}$	// Student's Persona //
	MLoc$_{3.1}$	// Dance Student#2's home //
	MLoc$_{3.2}$	// Place#6 in dancing area //

Operation

Process$_A$	Action	Item	Secondary Item or Process
User$_1$	Tracks	AVHPersona$_{1.1}$	*At* MLoc$_{1.1}$ *With* SA
	MM-Embeds	AVHPersona$_{1.1}$	*At* MLoc$_{1.2}$ *With* SA
	MM-Embeds	AVHPersona$_{1.2}$	*At* MLoc$_{1.3}$ *With* SA
	MM-Animates	AVHPersona$_{1.2}$	
User$_2$	Tracks	AVHPersona$_{2.1}$	*At* User$_2$'s MLoc$_{2.1}$ *With* SA
	MM-Embeds	AVHPersona$_{2.1}$	*At* MLoc$_{2.2}$ *With* SA
	MM-Disables	AVHPersona$_{2.1}$	*From* MLoc$_{2.1}$
User$_1$	MM-Embeds	AVHPersona$_{1.3}$	*At* MLoc$_{1.3}$ *With* SA
User$_3$	Tracks	AVHPersona$_{3.1}$	*At* MLoc$_{3.1}$ *With* SA
	MM-Embeds	AVHPersona$_{3.1}$	*At* MLoc$_{3.2}$ *With* SA
	MM-Disables	AVHPersona$_{3.1}$	*From* MLoc$_{3.1}$
User$_1$	Tracks	AVHPersona$_{1.1}$	*At* MLoc$_{1.4}$ *With* SA
	MM-Disables	AVHPersona$_{1.1}$	*From* MLoc$_{1.3}$
	Tracks	AVHPersona$_{1.3}$	*At* MLoc$_{1.3}$ *With* SA

8.9.3 Actions and Items

Table 12 – Virtual Dance Actions and Items.

Actions	Items
MM-Animate	AObject
MM-Disable	AVHPersona
MM-Embed	AVPersona
MM-Send	M-Location
Track	Orientation
	Position
	Spatial Attitude

8.10 Virtual Car Showroom

8.10.1 Description

This Use Cases envisages that:
1. A car dealer MM-Embeds an MM-Animated Persona in the car showroom (as attendant).
2. A customer:
   - MM-Embeds its Persona in the car showroom.
   - Greets the showroom attendant.
3. The Showroom attendant reciprocates the greeting.
4. The dealer:

- UM-Animates the attendant.
- Converses with the customer.
- Embeds a 3D AVH model of a car.

5. The customer
- Has a virtual test drive.
- Buys the car.
- Returns home.

8.10.2 MMM-Script representation

Declarations

Declare	$User_1$	// Car dealer //
	$AVPersona_{1.1}$	// Car dealer //
	$MLoc_{1.1}$	// Place#1 (Car dealer's Office) //
	$AVPersona_{1.2}$	//Showroom attendant //
	$MLoc_{1.2}$	// Place#2 (in Showroom) //
	$AObject_{1.1}$	//Greetings //
	$M\text{-}Loc_{1.2}$	// Place#3 (in Showroom) //
	$AVHModel_{1.1}$	// 3D Model of car //
Declare	$User_2$	// Customer //
	$AV\ Persona_{2.1}$	// Customer's Persona //
	$M\text{-}Loc_{2.1}$	// Customer's home //
	$M\text{-}Loc_{2.2}$	// Place#4 in showroom //
	$AVH\ Persona_{2.1}$	// $User_2$'s Persona for test driving //
	$M\text{-}Loc_{2.3}$	// Place#5 (in virtual car)
	$Value_{2.1}$	// Payment for car //
	$U\text{-}Loc_{2.1}$	// U-Place#1 (U-Location of Customer) //

Operation

$Process_A$	Action	Item	Secondary Item or Process
$User_1$	Tracks	$AVPersona_{1.1}$	*At* $MLoc_{1.1}$ *With* SA
	MM-Embeds	$AVPersona_{1.2}$	*At* $MLoc_{1.2}$ *With* SA
	MM-Animates	$AVPersona_{1.2}$	
$User_2$	Tracks	$AVPersona_{2.1}$	*At* $MLoc_{2.1}$ *With* SA
	MMEmbeds	$AVPersona_{2.1}$	*At* $MLoc_{2.2}$ *With* SA
	MMDisables	$AVPersona_{2.1}$	*From* $MLoc_{2.1}$
$User_1$	MMSends	Speech Object	*To* $User_2$
	MMEmbeds	$AVPersona_{1.1}$	*At* $MLoc_{1.2}$ *With* SA
	MMDisables	$AVPersona_{1.1}$	*From* $MLoc_{2.1}$
	MMEmbeds	$AVHModel_{1.1}$	*At* $MLoc_{2.3}$ *With* SA
	MMAnimates	$AVHModel_{1.1}$	
$User_2$	MMEmbeds	$AVPersona_{2.1}$	*At* $MLoc_{2.3}$ *With* SA
	MMDisables	$AVPersona_{2.1}$	*From* $MLoc_{2.2}$
	Transacts	$Value_{2.1}$	*To* $User_1$
	MMEmbeds	$AVPersona_{2.1}$	*At* $MLoc_{2.1}$ *With* SA
	MMDisables	$AVPersona_{2.1}$	*From* $MLoc_{2.3}$

8.10.3 Actions and Items

Table 13 – Virtual Car Showroom Actions and Items

Actions	Items

MM-Animate	Currency
MM-Disable	AObject
MM-Embed	Orientation
MM-Send	AVPersona
Track	AVHPersona
Transacts	Position
	AVHScene
	Spatial Attitude
	Value

8.11 Drive a Connected Autonomous Vehicle

8.11.1 Description

This Use Case considers some of the steps made by a human having rights to an implementation of Technical Specification: Connected Autonomous Vehicle (MPAI-CAV)
– Architecture and Technologies. The Use Case assumes that there are two CAVs: CAV_A and CAV_B and that the CAV_A rights holder ($User_{A.1}$) wants to see the CAV_B Environment in the CAV_B M-Instance and have their Persona joining CAV_B's cabin:
The human CAV_A rights holder *Registers* with the CAV to access the CAV-created M-Instance by providing:
1. The requested subset of their Personal Profile.
2. Two User Processes required to operate a CAV:
   - $User_{A.1}$ to operate the Human-CAV Interaction Subsystem.
   - $User_{A.2}$ to operate the Autonomous Motion Subsystem.
3. $User_{A.1}$'s $Persona_{A.1.1}$ (representing the human CAV rights-holder).

The workflow then progresses as follows:
1. $User_{A.1}$
   - Authenticates the human's voice.
   - Interprets driving instructions from human.
   - Communicates driving instructions to $User_2$.
2. $User_{A.2}$
   - Gets information about CAV_A
   - Gets travel options from Route Planner.
   - Communicates travel options to $User_{A.1}$.
3. $User_{A.1}$
   - Produces Speech Object with travel options.
4. human
   - utters selected option to $User_{A.1}$.
5. $User_{A.1}$
   - Interprets driving instructions from human.
   - Communicates driving instructions to $User_{A.2}$.
6. $User_2$
   - Gets the Basic Environment Representation from its ESS.
   - Authenticates its peer $User_{B.2}$ in CAV_B.
   - Gets elements of CAV_B's Full Environment Representation from $User_{B.2}$ in CAV_B.
   - Produces Full Environment Representation.
   - Sends a command to the Ego CAV's Motion Actuation Subsystem.
7. $User_{A.1}$
   - Authenticates its peer $User_{B.1}$ in CAV_B.
   - Watches CAV_B's Environment.

- MM-Animates Persona$_{A.1.1}$ in CAV$_B$'s cabin.

8.11.2 MMM-Script representation

Declarations

Declare	human$_{A.1}$ // CAV$_A$'s rights holder //
Declare	Device$_{A.1}$ // Audiovisual sensor and actuator //
Declare	User$_{A.1}$ // CAV$_A$'s HCI //
	1. scene$_{A.1.1}$ // Scene at ULoc $_{A.1.1}$ //
	2. DataMdata$_{A.1.1}$ // Data and Metadata of scene captured by Device$_1$ //
	3. Object(AV)$_{A.1.1}$ //AV Object used to Authenticate human$_{A.1}$ //
	4. Object(A)$_{A.1.1}$ // Speech Object #1 requesting Routes //
	5. AMS-HCIMessage$_{A.1.1}$ // Travel request to User $_{A.2}$ //
	6. ULoc $_{A.2.1}$ // Place where CAV$_A$ is located //
	7. MLoc$_{A.2.1}$ // M-Location corresponding to ULoc$_{A.1.1}$ //
	8. Scene$_{A.2.1}$ // Scene at MLoc $_{A.1.1}$ //
	9. AMS-HCIMessage$_{A.1.2}$ // Travel response to User $_{A.1}$ //
	10. Object(A)$_{A.1.2}$ //Speech Object #2 selecting Route//
	11. HCI-AMSMessage$_{A.1.3}$/Travel selection to User $_{A.2}$ //
	12. EgoRemoteHCIMessage$_{A.1.1}$ //Request to MM-Embed Avatar //
Declare	Route Planner$_{A.1}$ // CAV Process //
Declare	Path Planner$_{A.1}$ // CAV Process //
Declare	Motion Planner$_{A.1}$ // CAV Process //
Declare	Obstacle Avoider$_{A.1}$ // CAV Process //
Declare	Command Issuer$_{A.1}$ // CAV Process //
Declare	User$_{A.2}$ // CAV$_A$'s AMS //
	1. Scene$_{A.2.1}$ // CAV$_A$'s Environment //
	2. EgoRemoteAMSMessage$_{A.1.1}$ // Request Environment Descriptors //
Declare	User$_{B.2}$ // CAV$_B$'s AMS //
	1. EgoRemoteAMSMessage$_{A.1.2}$ // Environment Descriptors //
	2. Scene$_{B.2.1}$ // CAV$_B$'s scene in ULoc$_{B.1.1}$ – CAV$_B$'s Environment//
Declare	User$_{B.1}$ // CAV$_B$'s HCI //
	1. Scene$_{B.1.1}$ // CAV$_B$'s scene in ULoc$_{B.1.2}$ – cabin//
	2. MLoc$_{B.1.1}$ // M-Location corresponding to ULoc$_{B.1.1}$ //

Operation

Process$_A$	Action	Item	Secondary Item or Process
human$_A$	Registers		*With* CAV$_A$
User$_{A.1}$	UM-Captures	scene	*At* Device
	UM-Sends	DataMdata	*From* Device *To* User$_{A.1}$
	Identifies	Scene$_{A.1}$	*At* User$_{A.1}$
	Authenticates	Object(AV)$_{A.1.1}$	*At* User$_{A.1}$
	Interprets	Object$_{A.1.1}$(A)	*At* User$_{A.1}$
	MM-Sends	HCI-AMSCmd$_{A.1.1}$	*To* User$_{A.2}$
User$_{A.2}$	MM-Sends	ESS $_A$'s Scene$_{A.2.1}$	*To* Route Planner
	MM-Sends	AMS-HCIResp$_{A.2.1}$	*To* User$_{A.1}$
User$_{A.1}$	Interprets	Object(A)$_{A.1.3}$	*At* User$_{A.1}$
	MM-Sends	HCI-AMSCmd$_{A.1.2}$	*To* User$_{A.2}$
User$_{A.2}$	Authenticates	User$_{B.2}$	*At* User$_{A.2}$
	MM-Sends	EgoRemoteAMSMessage$_{A.1.1}$	*To* User$_{A.2}$

User$_{B.2}$	MM-Sends	EgoRemoteAMSMessage$_{A.1.2}$	*To* User$_{B.2}$
	MM-Sends	ESS's Scene$_{A.2.2}$	*To* User$_{B.2}$
	MM-Sends	Path$_{A2.1}$	*To* Motion Planner$_A$
Motion Planner$_A$	MM-Sends	Trajectory$_{A.2.1}$	*To* Obstacle Avoider$_A$
Obstacle Avoider$_A$	MM-Sends	Trajectory$_{A.2.1}$	*To* Command Issuer$_A$
Command Issuer$_A$	MM-Sends	AMS-MASMessage$_{A.2.1}$	*To* MAS$_A$
MAS$_A$	MM-Sends	AMS-MASMessage$_{A.2.2}$	*To* Command Issuer$_A$
User$_{A.1}$	Authenticates	User$_{B.1}$	*At* User$_{A.1}$
	MM-Sends	EgoRemoteHCIMessage$_{A.1.1}$	*To* User$_{A.2}$
User$_{A.2}$	MM-Sends	EgoRemoteHCIMessage$_{A.1.2}$	*To* User$_{A.1}$

8.11.3 Actions, Items, and Data Types

Note: The MPAI-CAV specific Items are included. New application-dependent Items and Processes are needed.

Table 14 – Drive a Connected Autonomous Vehicle Actions, Items, and Data Types.

Action	Item	Data Types
Authenticate	AMS-HCIR Message	Spatial Attitude
Interpret	AMS-MAS Message	Coordinates
MM-Embed	Environment Representation	Orientation
MM-Send	Ego-Remote HCI Message	Position
MU-Render	Ego-Remote AMS Message	
Register	M-Location	
Request	Audio Object	
Track	Audio-Visual Object	
UM-Render	Path	
	Persona	
	Route	
	Scene	
	Trajectory	