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

N1128 2023/03/27

Source Requirements (MMM)
Title Technical Report - MPAI Metaverse Model - Functionality Profiles WD0.3
Target MPAI-30

This document is an MPAI working draft published to elicit Community Comments. Anybody can send an email to the MPAI Secretariat by 2023/04/17 proposing changes, additions, and removals. Comments will be considered by Requirements (MMM), and the final text finally approved by the 31st General Assembly (MPAI-31) on 2023/04/19.

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

MPAI Technical Report

MPAI Metaverse Model (MPAI-MMM) Functionality Profiles

WD0.3

WARNING

Use of the technologies described in this Technical Report may infringe patents, copyrights or intellectual property rights of MPAI Members or non-members.

MPAI and its Members accept no responsibility whatsoever for damages or liability, direct or consequential, which may result from the use of this Technical Report.

Readers are invited to review Annex 4 - Notices and Disclaimers.

Technical Report
MPAI Metaverse Model – Functionality Profiles
V1 (Under development)

1 Introduction

Metaverse is a widely used term that conveys a still nebulous notion encompassing new forms of communication expected to create new jobs, opportunities, and experiences with transformational impacts on virtually all sectors of human interaction. This document considers the metaverse as a **communication and interaction system centred around digital environments containing digital objects.** A simple example is an audioconference system where human participants are represented by audio objects mixed and distributed to all participants.

In general, a metaverse instance is viewed as a more complex communication environment with several additional features, such as synchronous and persistent experiences and virtual reality features such as avatars that may or may not be controlled by humans and objects of the real world.

The MPAI Metaverse Model (MPAI-MMM) is a project aiming to provide Technical Reports and Technical Specifications that apply to as many kinds of metaverse instances as possible and enable varied metaverse implementations to interoperate.

At present, achieving this interoperability target is difficult because:

1. There is no common understanding of what a metaverse is or should be, in detail.
2. There is an abundance of existing and potential metaverse use cases.
3. Some independently designed metaverse implementations are very successful.
4. Some important technologies enabling more advanced and even unforeseen forms of the metaverse may be uncovered in the next several years.

MPAI has developed a roadmap to deal with this unusually challenging situation. The **first milestone** is based on the idea of collecting the *functionalities* that potential metaverse users expect the metaverse to provide, instead of trying to define what the metaverse is. The first Technical Report of this roadmap [1] includes definitions, assumptions guiding the MPAI-MMM project, sources that can generate functionalities, an organised list of commented functionalities, and an analysis of some of the main technology areas underpinning the development of the metaverse.

Potential metaverse users with different needs might require different technologies to support these needs. Therefore, an approach that tried to achieve the goal of making every M-Instance be able to interoperate with every other M-Instance would force implementers to take technologies on board that are potentially costly and useless for their needs.

Reference [1] posits that metaverse standardisation should be based on the notion of Profiles[1] and Levels[2] successfully adopted by digital media standardisation. A Metaverse Standard that includes Profiles and Levels would enable metaverse developers to use only the technologies they need that are offered by whatever profile is most suitable to them.

The notion of profile can mitigate the impact of having many disparate metaverse users with diverse requirements. Unfortunately, that notion cannot be currently implemented because some key technologies are not yet available and at this time it is unclear which technologies, existing or otherwise, will eventually be adopted [2]. To cope with this situation, this Technical Report documenting **the second milestone** only targets **Functionality Profiles**, i.e., profiles that are defined

[1] A Profile is sets of one or more base standards and, if applicable, chosen classes, subsets, options, and parameters of those standards that are necessary for accomplishing a particular function.
[2] A Level is a subdivision of a Profile indicating the completeness of the user experience.

by the functionalities they offer, not by technologies implementing them. Functionality Profiles are not meant to fully address the interoperability problem, but rather to allow a technology-independent definition of profiles based on the functional value they provide rather than on the "influence" of specific technologies.

The structure of this Technical Report is the following:

Chapter 2 Collects all relevant definitions.
Chapter 3 Develops an operational functional model of an M-Instance based on Sources requesting Destinations to perform Actions on Items both containing Data Types.
Chapter 4 Specifies the payloads of the **Actions** that Sources request Destinations to perform and of the responses provided by Destinations to such requests.
Chapter 5 Specifies the Metadata of the **Items** without specifying the Formats of the Data.
Chapter 6 Specifies the **Data Types** used by requests and responses.
Chapter 7 Analyses some relevant **Use Cases** applying to verify the methodology.
Chapter 8 Provides a first set of **Functionality Profiles and Levels**.

Continuing the convention adopted in [1], in this Technical Report terms beginning with a capital letter have the meaning defined in Table 1, Table 2, Table 3, and Table 4. Terms beginning with a small letter have the meaning commonly defined for the context in which they are used. E.g., *User* and *Object* are defined in Table 3, *human* and *object* are not defined.

This *Technical Report – MPAI Metaverse Model (MPAI-MMM) – Functionality Profiles* has been developed by the Requirements Standing Committee. MPAI may decide to develop new versions of this document.

MPAI plans on releasing more documents of the MPAI-MMM project as follows:

1. **Architecture**: Functional blocks and which Items are exchanged between the blocks.
2. **Data Formats**: Functional requirements of Items exchanged between functional blocks.
3. **Technology landscape**: Table of Contents of the Common Metaverse Specifications as envisaged in [2].
4. **MPAI Technologies**: Mapping of MPAI Technologies to the Common Metaverse Specifications.

MPAI believes that, by completing the 4 steps above, it will be possible to design and implement metaverse instances that can be made interoperable using the options identified in Annex 1 - Interoperability of Metaverse Instances and in any case facilitate the subsequent task of specifying Technology Profiles.

2 Definitions

This document adopts and extends the definitions used by V1 [1].

Table 1 – General Terms and Definitions

Terms	Definitions
Account	An Item that uniquely references a human who has Registered.
Avatar	A rendered Digital Human.
Blockchain	A shared immutable ledger stored on a peer-to-peer network of computers.

Common Metaverse Specifications	(CMS) The collection of standards specifying the technologies enabling Metaverse Interoperability including recognised Profiles.
Connected Autonomous Vehicle	(CAV) A vehicle able to autonomously reach a geographical position by using its own sensing, processing, and actuation capabilities and by exchanging information with other CAVs.
Data	Information represented in digital form.
- Format	The syntax and semantics of Data.
- Type	Data characterised by its Format.
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 used to Sense and/or Actuate a Universe Environment allowing: - A Universe Environment to interact with an M-Instance and/or - An M-Instance to interact with a Universe Environment.
Duty	A moral or legal obligation to act or behave.
Entitlement	The state of a User having certain Rights in an M-Instance.
Functionality	An attribute of an M-Instance expected to be enabled by a Common Metaverse Specifications Tool.
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 with and make use of Data from another Metaverse Instance.
Metadata	An attribute of Data, e.g., of a User, an Environment, an Object, or a Service.
Metaverse	A collection of digital environments that are implementations of Common Metaverse Specification Profiles; it is populated by Digital Objects that are

	representations of either real Objects – called Digitised – or computer-generated Objects – called Virtual – or both.
- Action	An operation affecting an Item.
- Actuator	A component of a Device able to present an Entity in a Universe Environment.
- Asset	An Item Embedded at an M-Location or Posted to a Service that may be the object of a Transaction.
- 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.
- Entity	Any of the following Item that can be MU-Rendered: Object, Model, Scene, Event, and Experience.
- Environment	(M-Environment) A portion of an M-Instance covered by an Account.
- Experience	An Entity comprising an Event as MM-Captured by a User and the User Interactions with the Entities of the Event.
- Experience Layer	The set of functions, such as Devices, that generate Experiences.
- Functionality	The ability of an M-Instance to perform actions that further the goals set by the Metaverse Manager for the Metaverse Instance.
- Industry	The collection of players that support the design, development, deployment, operation, and content and service provisioning to Metaverse Instances.
- Instance	(M-Instance) An implementation providing all or a subset of Metaverse Functionalities.
- Item	Data recognised by an M-Instance.
- Infrastructure Layer	The set of functions such as network, transport, storage, and (cloud, edge) processing that enable an M-Instance to operate.
- Level	A subdivision of a Profile that indicates the degree of completeness of the Experience provided by that Level.
- Location	(M-Location) An identifiable delimited portion of the Metaverse.
- Manager	The human overseeing the operation of an M-Instance.
- Operator	The human overseeing the operation of an M-Environment.
- Partner	A User participating in activities of a Metaverse Operator (i.e., the 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 the Functionalities (Functionality Profile) or Technologies (Technology Profile) specified by the Common Metaverse Specifications.
- Sensor	A Device able to Capture Data.
- Service	A Functionality that enables a User to perform a particular Action in an M-Instance or Environment.
- Specifications	(CMS) A collection of standards specifying the technologies enabling Metaverse Interoperability.
- Stakeholder	An entity or a human performing a function aimed at achieving a goal in an M-Instance.
- State	The set of values and stored data of an M-Instance at a given time.

- 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.
- User	Either a Digitised Human driven by a human, or else a Virtual Human driven by a Process.
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 with 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 or that can be rendered to and perceived by a human eye.
Oracle	A Service providing information from a Universe Environment to a Blockchain.
Privacy	The Rights of a User to keep their personal data secret.
Profile	
- *Functionality*	The grouping of Functionalities offered by a Metaverse Profile.
- *Technology*	The grouping of Technologies offered by a Metaverse Profile.
Representation	Data that represent an entity of a Universe Environment in an M-Instance.
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 Environment Experience.
- Presence	The feeling of being in an M-Environment with other Digital Humans for real.
Smart Contract	A Program stored on a Blockchain that runs when activated by an external entity, e.g., a User or another Smart Contract.
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.
- Environment	A delimited portion of the Universe.
- Location	(U-Location) An identifiable delimited portion of the Universe.
Use Case	An example of how an application domain may use an M-Instance/Environment.
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 User without requiring a centralised registry.
- *Self-Sovereign*	A Decentralised Identifier derived from the User's Public Key owned and managed directly by the User based on the knowledge of their own Private Key, e.g., stored in the Crypto Wallet enabled by the Blockchain underpinning the Metaverse Instance.
Wallet	
- *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.

To facilitate access to terms, Table 2, Table 3, and Table 4 provide the definitions of **Actions**, **Items**, and **Data Types**, respectively. Chapter 4, Chapter 5, and Chapter 6, respectively will provide the corresponding specifications, to the extent possible in a Technical Report.

Table 2 – Definitions of Actions

Note: Composite Action, i.e., composed of more than one basic Actions.

Action	Definition
Action	An operation affecting an Item.
Authenticate	The Action of requesting confirmation that an Entity MM-Embedded at an M-Location is what it claims to be.
Author	The Action of Calling a Service to obtain an Entity including the Rights to Act on the Entity.
Call	The Action of requesting a Process to start.
Change	The Action of requesting that a Service modify the Rights of a User at an M-Location.
Create	The Action of requesting that a Service produce or update an Item from MM-Sent Data and Metadata.
Destroy	The Action of a User requesting that a Service make the ID of an Item unavailable.
Discover	The Action of requesting that a Service provide a Response-Discover Item containing the IDs of the Items relevant to a Request-Discover and the Rights to Act on the Response-Discover Item.
Inform	The Action of requesting that a Service provide a Response-Inform Item containing the IDs of the Items relevant to a Request-Inform and the Rights to Act on the Response-Inform Item.

Interpret	The Action of requesting that a Service provide a Response-Interpret Item containing the IDs of the Items relevant to a Request-Interpret and the Rights to Act on the Response-Interpret Item.
MM-Add	The Action of requesting that a Service add an Entity with a Spatial Attitude to an M-Location without MM-Rendering it.
MM-Animate	The Action of requesting that a Service change the features of an Entity MM-Embedded at an M-Location.
MM-Capture	The Action of requesting that a Service Send selected Entities MM-Embedded at an M-Location to a User.
MM-Embed	The Composite Action of requesting that a Service MM-Add, MM-Enable and MM-Render an Entity at an M-Location.
MM-Enable	The Action of enabling a User to MM-Capture an Entity MM-Added at an M-Location.
MM-Disable	The Action of requesting that a Service stop MM-Enabling an Entity Embedded at an M-Location.
MU-Render	The Composite Action of requesting that: 1. A Service MU-Send selected Entities Embedded at an M-Location to a Device. 2. The Device present the Entities to a U-Location.
MU-Send	The Action of requesting that a Service stream selected Entities that are MM-Embedded at an M-Location to a Device.
Post	The Action of requesting that a Marketplace include an Asset.
Read	The Action of reading Data & Metadata or an Item stored at an Address.
Register	The Action of a human requesting that an M-Instance/Environment grant their Users the Rights to perform Actions in the M-Instance/Environment.
Track	The Composite Action of requesting: 1. A Service to MM-Add a Persona at an M-Location with a Spatial Attitude. 2. A Service to UM-Animate the Persona MM-Added at an M-Location. 3. A Service to MU-Render specified Entities at the M-Location to a U-Location.
Transact	The Action of a User1 requesting that a Service: 1. Assign Rights on an Asset to User2. 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 Action of requesting 1. Embed an Entity at an M-Location with a Spatial Attitude. 2. UM-Transfer a scene at a U-Location. 3. Call Process to change the features of the Entity MM-Embedded at the M-Location using the Stream obtained at step 2.
UM-Capture	The Action of requesting that a Device acquire a scene at a U-Location as Media.
UM-Render	The Composite Action of: 1. UM-Capturing a scene at U-Location. 2. UM-Sending Data and Metadata. 3. Creating an Entity from Sent Data and Metadata. 4. MM-Embedding the Entity at an M-Location with a Spatial Attitude. 5. MM-Rendering the Entities at the M-Location.

UM-Send	The Composite Action of: 1. UM-Sending Data and Metadata. 2. Creating an Entity from Sent Data and Metadata. 3. MM-Embedding the Entity at an M-Location with a Spatial Attitude.
Write	The Action of storing an Item at an Address.

Table 3 – Definitions of Items

Item	Definition
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 the Actions of a User.
App	An application-specific Program executed on a Device.
Asset	An Item Embedded at an M-Location or Posted to a Service that may be the object of a Transaction.
Device	A Process able to: 1. UM-Capture Data from a U-Location 2. UM-Send Data and Metadata to a User. and/or 1. MU-Send an Entity from an M-Location to the Device. 2. MU-Render an Entity at a U-Location.
Entity	Any of the following Item that can be MM-Rendered: Object, Model, Scene, Event, and Experience.
Event	An Entity corresponding to an M-Location, its Entities and their Animations starting from Start Time until End Time.
Experience	An Entity comprising an Event as MM-Captured by a User and the User Interactions with the Entities of the Event.
Identifier	An Item that uniquely references an Item. The Item can have more than one Identifier.
Interaction	An Item containing the list of Actions made by a User on the Entities at an M-Locations and the corresponding Times.
Item	Metaverse-specific Data that may include Metadata that may include Rights.
Ledger	An Item containing a list of Transactions involving Assets.
Map	An Item containing a structure establishing a correspondence between U-Locations with M-Locations.
M-Environment	An identifiable portion of an M-Instance covered by an Account.
Message	An Item containing application-specific Data MM-Sent by a Source to a Destination.
M-Instance	A Metaverse implementation.
M-Location	An identifiable delimited portion of an M-Environment.
Model	An Object representing an object with its features ready to be UM-Animated by a Stream or MM-Animated.
Object	An Entity representing an object. Currently, the following types of Objects are supported: Audio, Visual, and Haptic.
Persona	An Object representing a human with its features ready to be UM-Animated by a Stream or MM-Animated.
Personal Profile	An Item containing the Data about the human represented by User.

Process	An Item able to: 1. Receive Items and/or Data and the Right to Call the Process 2. Produce Items or Data.
Provenance	The Ledger associated with a specific Asset.
Request-Authenticate	An Item containing the request to a Service to "Authenticate Item".
Request-Discover	An Item containing the request to a Service to "Discover Item".
Request-Inform	An Item that contains the request to a Service to "Inform Entity".
Request-Interpret	An Item containing a description of the request to "Interpret Item".
Response-Authenticate	An Item that contains the response of a Service to an "Authenticate Item" request.
Response-Discover	An Item that contains the response of a Service to an "Discover Item" request.
Response-Inform	An Item that contains the response of a Service to an "Inform Item" request.
Response-Interpret	An Item containing the response to the request to Interpret an Item.
Rights	An Item expressing the ability of a User to perform an Action on an Item until a Time.
Rules	An Item expressing the terms and conditions under which a User operates in an M-Instance/Environment.
Scene	A possibly hierarchical Composition of Objects each having a Spatial Attitude.
Service	A Process that can be Called to provide Functionalities.
Social Graph	A representation of a User's network of connections with Items, Processes, and Services.
Stream	An Item made by a continuous flow of Data.
Transaction	Item representing the changed state of the Accounts and the Rights of a seller User and a buyer User on an Asset and optionally of the Service facilitating/enabling the Transaction: 1. The Value moving into the Wallet of User 1 (seller). 2. The Value moved from the Wallet of User2 (buyer). 3. The Value moved into the Wallet of User 3 (service) - optional. 4. The Time the Values were moved. 5. The Rights to Act owned by User1 before Time. The Rights to Act owned by User2 after Time.
U-Environment	A portion of the Universe.
U-Location	An identifiable delimited portion of a U-Environment.
User	A Process representing an MM-Captured human as a Persona that is either UM-Animated by a Stream or MM-Animated by an autonomous agent.
User Data	An Item containing Activity Data, Personae, Social Graph, and User Profile of a User.
Value	An Amount and the Currency with which the Amount is expressed.
Wallet	A container of Currency units. In general, a Wallet is implemented outside of the Environment.

Table 4 - Definitions of Data Types

Data Type	**Definition**

Address	A URL.
Amount	A number expressing a Value in a Currency.
Cognitive State	The representation of a User's Personal Status that reflects the way they understand the Environment, such as "Confused", "Dubious", "Convinced".
Coordinates	A set of numbers representing a Position in a Metaverse Environment using a coordinate system.
Currency	A medium of exchange enabling Transactions in a Metaverse Instance.
Emotion	The representation of a User's Personal Status that results from their interaction with an Environment, such as "Angry", "Sad", "Determined".
Orientation	The set of the 3 roll, pitch, yaw angles indicating the rotation around the principal axis (x) of an Object, its y axis having an angle of 90° counter clockwise (right-to-left) with the x axis and its z axis (pointing up toward the viewer viewing from above).
Personal Status	The representation of the information internal to a User characterising their behaviour.
Point	A point in an M-Environment identified by the set of local Coordinates.
Point of View	The Spatial Attitude of a Digital Human watching the Environment.
Position	The x,y,z coordinates of an Object with respect to a set of coordinates in a Metaverse Environment.
Social Attitude	The representation of a User's Personal Status related to the way the User intends to position vis-à-vis a Metaverse Environment, e.g., "Respectful", "Confrontational", "Soothing".
Spatial Attitude	The Position and Orientation of an Entity, and their velocities and accelerations.
Time	A measure of time.

3 A functional operation model

3.1 Introduction

This chapter illustrates the operation of Metaverse Instances or Environments by means of a walkthrough. Please note the following:

1. The walkthrough defines and illustrates all the terms used in this Technical Report as they are introduced.
2. To the extent possible, the definition of a term (indicated in bold with a capital first letter) is provided when it is introduced.
3. If a definition is slow in coming up because of the complexity of the walkthrough, the reader may rely on the common meaning of the term or access the definition in one of Table 1, Table 2, Table 3, or Table 4.
4. If a noun is defined, the corresponding verb may be introduced without engaging in a definition and vice-versa.
5. The walkthrough uses verbs called **Actions** to indicate functions performed on **Item**, i.e., Data recognised by an M-Instance, belonging to a Metaverse Instance (**M-Instance**) or a **U-Environment** of the **Universe** (the real world). An Item that can be perceived is called an **Entity**.
6. An Action may start from a location called **M-Location** of an **M-Environment**, i.e., a delimited portion of an M-Instance, and 1) have an effect on the same or a different M-Location or 2) may start from an M-Location and have an effect on a location of a **U-Environment** called

U-Location, or 3) may start from a U-Location and have an effect on an M-Location. Accordingly, Action verbs will be prefixed by **MM-**, **MU-**, and **UM-**.

3.2 M-Instances

Figure 1 depicts some elements at the basis of this Technical Report.

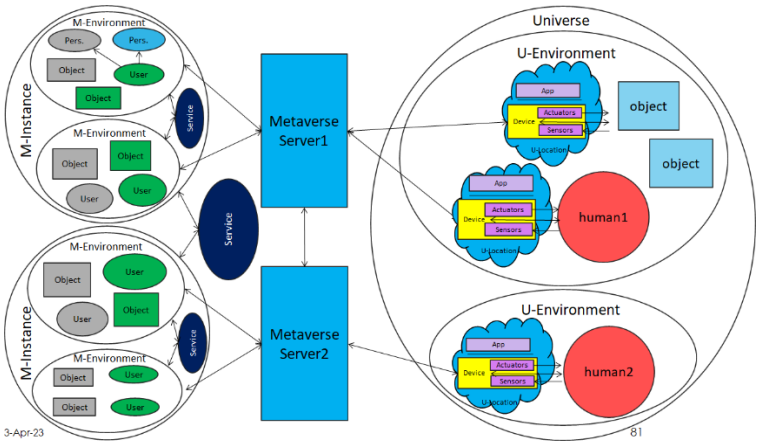

Figure 1 – A Metaverse Scenario of this Technical Report

The humans and objects in the U-Instances on the right-hand side of Figure 1 are potentially connected to one or more Metaverse Servers though Devices that UM-Capture scenes with their Sensors and MU-Render Entities though their Actuators. Metaverse Servers, implemented using centralised or decentralised architectures, are designed to generate the M-Instances on the left-hand side of Figure 1 where green indicates that a User or an Object is a digital twin of a human or an object. The two colours of the M-Environment at top-left indicating Personae signal the fact that a User can be rendered either as a Persona that reflects the movements of the human or as an autonomous Persona.

An M-Instance is populated by Users and Objects potentially having a Device-enabled relationship with one or more U-Environments or else synthetically generated by an M-Instance. The Functionalities provided by an M-Instance enable its Users 1) to achieve their goals, 2) within the constraints of the Metaverse Server capabilities, and 3) respecting the Rules under which Users operate in the M-Instance.

M-Instances are digital spaces where Processes are executed. A **Process**:

1. Receives Items and/or Data with the Right to Call the Process and produces Items or Data.
2. May request another Process to perform Actions on Items.
3. Processes communicate and interact with other Processes by **MM-Sending** one another Items, and Data and Metadata.
   Processes and Items can be in the same or a different M-Instance/Environment. The ability to execute will depend on the Rights of the requesting Process.

This Technical Report identifies three types of Process:

1. **Service** is a Process offering functionalities necessary for the proper functioning on an M-Instance/Environment, e.g., content Authoring.
2. **Device** is a Process having either or both the capabilities to **UM-Capture**, i.e., to acquire a scene at a U-Location as Media, and **UM-Send** Data and Metadata from the Device to a User who then Creates and Embeds an Entity at an M-Location with a Spatial Attitude.

3. **User** is a Process representing a human who has an Account in an M-Instance/Environment. A User can be:
   3.1. UM-Rendered as an Object representing a human.
   3.2. **MM-Render**ed as a **Persona**, i.e., a Model of a human that is UM-Animated (i.e., having the features and position of the Model modified) by Streams provided by a Device.
   3.3. **MM-Animate**d by an autonomous agent.

It should be noted that an M-Instance can be implemented so that it executes only a subset of the Actions on a subset of the Items defined by this Technical Report. It can also implement more Functionalities, either proprietary or belonging to future versions of this Technical Report.

3.3 Registration

A human wishing to have its User(s) join an M-Instance/M-Environment may be asked to **Register**:

1. The human may be requested to provide a subset of their **User Data** that may include:
   1.1. **Activity Data**, i.e., the record of the Actions of a User.
   1.2. Persona(e).
   1.3. **Social Graph**, i.e., the network of connections of a User with Items, M-Locations, U-Locations, and Services.
   1.4. **Personal Profile**, i.e., Data about the human represented by the User.
   The human may also be requested to provide the ID of a **Wallet**, i.e., a container of Currency units.
2. **Account** is an Item that unequivocally associates a Registered human with the subset of Items they provide.
   2.1. A human may have more than one Account in one or more M-Instances/M-Environments.
   2.2. A User has certain Rights to Act in the M-Instance/M-Environment which is associated with the Account.
   2.3. An M-Instance/M-Environment may allow a human to have more than one Account.
   2.4. A User exists after a human Registers with an M-Instance/Environment.
   2.5. An M-Instance/Environment may allow a human to have more than one User per Account.
   2.6. Different Users of an Account may have different Rights.

Note that some User Data may be kept private and that the laws of the jurisdiction under which the M-Instance/M-Environment operates may prescribe that it may not request certain User Data.

A human Registered with an M-Instance may be able to join another M-Instance if the Metaverse Servers generating both M-Instances are implemented with compatible technologies, or rely on a Data Format conversion service, or use a combination of the two (see Annex 1 - Interoperability of Metaverse Instances).

The **Rules** of an M-Instance/M-Environment express:

1. The terms and conditions under which a User exists in an M-Instance/M-Environment and operates either there or in another M-Instance/M-Environment.
2. The obligations undertaken by the Registering human represented by the User.

Rules may prevent a human Registered on an M-Instance/M-Environment from joining another M-Instance/M-Environment.

Data entering an M-Instance, e.g., by the Action of **Reading** (e.g., from an external device) may include Metadata and the Rights granted to a Process to perform Actions on the Data. Item is Metaverse-specific Data that includes Metadata, possibly including Rights.

Rights is an Item expressing the ability to perform an Action on an Item.

- Rights include the User, the Actions, and the Items the User can perform Actions on.
- The Rules of some M-Instances/M-Environments may forfeit Rights enforcement on some Actions performed on some Items.

Identifier is an Item uniquely associated to a particular Item. An Item may be Identified by more than one Identifier by virtue of the following hierarchical structure:

1. [M-InstanceID] [ItemID]
2. [M-InstanceID] [M-EnvironmentID] [ItemID]
3. [M-InstanceID] [M-EnvironmentID] [M-LocationID] [ItemID].

3.4 Actions

A Process performs Actions on Items, and Data and Metadata inside an M-Instance to the extent allowed by the Rights held by the Process in the M-Instance and/or in other M-Instances to the extent allowed by the Rights the Process has in those external M-Instances. Actions are defined in Table 2 and specified in Chapter 4.

A User can **Call**, i.e., start a Service to perform Actions on Items or Data & Metadata. The request and response payloads have the following naming convention: [Service name]-Request and [Service name]-Response. As a result, an Item can be affected as follows:

1 **Create**d by, e.g.:

1.1 A Device UM-Sending Data and Metadata to a Service.

1.2 A Service MM-Sending the ID of an Entity that includes the UM-Sent Data and Metadata.

1.3 Data can be an Animation Stream coming from a human via a Device. The Device adds Metadata, e.g., Device ID and Rights to Act on the Animation Stream, depending on the rights exercised by the Device in the process of MM-Capturing the human.

1.4 The Metadata provided by the Device can be UM-Sent to a Service to Create an Item or MM-Sent to the Service to modify the Metadata of an existing Item.

1.5 The **Destroy** Action makes an Item unavailable.

Note that the Create Action is required as Data and Metadata shall be converted to an Item before being Actionable in an M-Instance/Environment.

2 **Changed**, i.e., its Rights are modified.

3 **Discover**ed, i.e., by Calling a Service with a Request-Discover and obtaining a Response-Discover.

4 **Writte**n, i.e., stored as Data at an Address.

A User can Call a Service to perform Actions on **Assets**, i.e., Items that can be Transacted:

- **Post** an Asset to a Marketplace.
- **Transact** an Asset.

A User can Call a Process to perform Actions on Entities:

1. **Author**ed by a User Calling an Authoring Tool Service with an accompanying request to obtain Rights to Act on the Authored Entity.

2. **MM-Add**ed, i.e., the User requests that an Entity be added to an M-Location with a Spatial Attitude. The original [M-InstanceID] [M-EnvironmentID] [EntityID] Identifier is modified to [M-InstanceID] [M-EnvironmentID] [M-LocationID] [EntityID].
3. **MM-Enable**d, i.e., the User requests that a Process be allowed to MM-Capture an Entity that is MM-Added at an M-Location.
4. **MM-Embed**ded, i.e., MM-Added and MM-Enabled in one stroke.
5. **MM-Capture**d, i.e., the User requests that an Entity MM-Embedded at an M-Location be MM-Sent to a Process.
6. **UM-Animated**, i.e., the User requests that a Process change the features of an Entity using a **Stream** of Data obtained through the following process:
   6.1. UM-Capture an animation stream extracted from a scene at a U-Location.
   6.2. UM-Send the animation stream and Metadata to a User.
   6.3. Create the Stream to make the Stream Entity usable in the M-Instance.
7. **MM-Disable**d, i.e., the User requests that the MM-Enabling of the Entity be stopped.
8. **Authenticate**d, i.e., the User Calls a Service with Request-Authenticate and obtains Response-Authenticate giving evidence that an Entity is what it states it is.
9. **Interpret**ed, i.e., the User Calls a Service with Request-Interpret and obtains Response-Interpret containing, e.g., the response to the request to translate a Speech Object MM-Embedded at an M-Location into a specific language.
10. **Inform**ed, i.e., by Calling a Service with a Request-Inform and obtaining a Response-Inform containing, e.g., the Metadata of the Entity MM-Embedded at an M-Location.

A Device can be requested to:
1. **UM-Render** a scene at a U-Location to an M-Location, i.e.:
   1.1. UM-Capture, i.e., acquire a scene as Media from at a U-Location.
   1.2. UM-Send Data and Device-provided Metadata.
   1.3. Create an Entity from Data and Metadata.
   1.4. MM-Embed the Entity at an M-Location with a Spatial Attitude.
2. **MU-Render** an Entity Embedded at an M-Location to a U-Location, i.e.:
   2.1. MM-Send, i.e., stream to a Device an Entity that is MM-Embedded at an M-Location.
   2.2. **MU-Actuate**, i.e., present the Entity as Media to a U-Location with a Spatial Attitude.

The Composite Action **Track** enables a User to request:
1. A Service to MM-Add a Persona at an M-Location with a Spatial Attitude.
2. A Service to UM-Animate the Persona MM-Added at an M-Location.
3. A Service to MU-Render specified Entities at the M-Location to a U-Location.

The full list of Actions is provided below organised by the type of Item the Action is executed on.

1. Actions on Entities:
   1.1. Authenticate
   1.2. Author
   1.3. Create
   1.4. Inform
   1.5. Interpret
   1.6. MM-Add
   1.7. MM-Animate
   1.8. MM-Capture
   1.9. MM-Embed
2. Actions on Assets:
   2.1. Post
   2.2. Transact
3. Actions on imported data:
   3.1. UM-Animate
   3.2. UM-Capture
   3.3. UM-Render
   3.4. UM-Send
4. Action on Process:
   4.1. Call

1.10. MM-Disable
1.11. MM-Enable
1.12. MM-Send
1.13. MU-Actuate
1.14. MU-Render
1.15. Track

5. Generic Actions on Items:
   5.1. Change
   5.2. Destroy
   5.3. Discover
   5.4. Register
   5.5. Read
   5.6. Write

3.5 Items

An Item can belong to one of six categories:
1. Items characterised by the fact that they can be MM-Captured by a User.
2. Items that can cause an Entity to change its perceptible features.
3. Items that have space and time attributes.
4. Items that are finance related.
5. Items that are non-perceptible.
6. Items that are Process-related.

Items already defined above will not be defined again below.

Entity: is the first type of Item characterised by the fact that it can be MM-Captured by a User. This Technical Report identifies the following types of Entity:
1. **Event**: the set of Entities that are MM-Embedded at an M-Location from Start Time until End Time.
2. **Experience**: An Event as a User MM-Captured it and the User's Interactions with the Entities belonging to the Entity that spawned the Event.
3. **Object**: the representation of an object and its features. This Technical Report currently considers the following Object types: Audio, Visual, and Haptic.
4. **Model**: An Object that can be UM-Animated by a Stream or a Process.
   4.1. Speech Model: An Object Model whose Object type is Audio, specifically Speech.
   4.2. Avatar Model: An Object Model where the Object type is Visual.
   4.3. Haptic Model: An Object Model where the Object type is Haptic.
   4.4. Persona: An Object Model that may include an Avatar Model, a Speech Model, and a Haptic Model. The Persona can be perceived visually and/or audibly and/or haptically. Note that a User may appear simultaneously, for instance as:
      4.4.1. The same or a different Persona UM-Animated by the same Stream at different M-Locations.
      4.4.2. The same or a different Persona where one Persona is UM-Animated by a real-time Stream and the other is UM-Animated by a recorded Stream.
      4.4.3. The same or a different Persona, one UM-Animated by a Stream and the other UM-Animated by an autonomous Process.
5. **Scene**: a dynamic composition of Objects described by Time and Spatial Attitudes.

The second type of Item can cause an Entity to change its perceptible features, i.e.:
1. **Interaction**: The Action made by a User on an Entity at a specific Time.
2. Stream: A continuous flow of:
   2.1. Data from a Device to a User, or
   2.2. Data from an Entity at an M-Location to a Device.

The third type of Item has space and time attributes:

1. M-Instance: an implementation of metaverse specifications identified by [M-InstanceID].
2. M-Environment: A portion of an M-Instance identified by [M-InstanceID] [M-EnvironmentID].
3. M-Location: An identifiable delimited portion of an M-Environment identified by [M-InstanceID] [M-EnvironmentID] [M-LocationID].
4. U-Environment: An identifiable portion of the Universe.
5. U-Location: An identifiable delimited portion of a U-Environment.
6. **Map**: An Item containing information connecting U-Locations, M-Locations, and optionally Metadata.

The fourth type of Item is Finance-related:

1. Asset: An Item that may be the object of a Transaction and is Embedded at an M-Location or Posted to a Service.
2. **Ledger**: the list of Transactions executed on Assets.
3. **Provenance**: the list of Transactions executed on an Asset starting from the first and including the last.
4. **Transaction**: Item representing the changed state of the Accounts and the Rights of a seller User and a buyer User on an Asset and optionally of the Service facilitating/enabling the Transaction.
5. **Value**: An Amount expressed in a Currency.
6. **Wallet**: A container of Currency units.

The fifth type of Item is non-perceptible, i.e.:

1. Account: An Item issued by an M-Instance/M-Environment that uniquely identifies a human who is Registered with the M-Instance/M-Environment.
2. Activity Data.
3. **Request-Authenticate**: An Item that contains the request to a Service to "Authenticate Item".
4. **Request-Discover**: An Item containing the request to a Service to "Discover Item".
5. **Request-Inform**: An Item that contains the request to a Service to "Inform Item".
6. **Request-Interpret**: An Item containing a description of the request to Interpret an Item.
7. **Response-Authenticate**: An Item that contains the response of a Service to an "Authenticate Item" request.
8. **Response-Discover**: An Item that contains the response of a Service to an "Discover Item" request.
9. **Response-Inform**: An Item that contains the response of a Service to an "Inform Item" request.
10. **Message**: Application-specific Data or Item Sent by a Source to a Destination.
11. Personal Profile.
12. Social Graph.
13. Rights.
14. Rules.

The sixth type of Item includes:

1. **App**: A Program executed by a Device.
2. Device.
3. Process.
4. Service.
5. User

3.6 Data Types

Actions and Items may use several Data Types. Some Data Types may relate to a Metaverse Instance or the Universe; a U-/M- prefix may be added as needed. Data Types are currently defined as follow for the specific case on M-Instances/Environments/Locations:

1. **Address**: A URL.
2. **Amount**: A number expressing a Value in a Currency.
3. **Coordinates**: A set of numbers representing a Position in an M-Environment using a coordinate system.
4. **Currency**: A medium of exchange enabling Transactions in an M-Instance.
5. **Personal Status**: the representation of the information internal to a User characterising their behaviour.
   5.1. **Cognitive State**: the representation of a User's Personal Status that reflects the way it understands the environment, such as "Confused", "Dubious", "Convinced".
   5.2. **Emotion**: the representation of a User's Personal Status that results from its interaction with an environment, such as "Angry", "Sad", "Determined".
   5.3. **Social Attitude**: the representation of a User's Personal Status related to the way the User intends to position vis-à-vis an environment, e.g., "Respectful", "Confrontational", "Soothing".
6. **Point**: A point in an M-Environment identified by the set of local Coordinates.
7. **Spatial Attitude**: The Position and Orientation of an Entity, and their velocities and accelerations.
   7.1. **Position**: the coordinates of an Object with respect to a set of coordinates in an M-Environment.
   7.2. **Orientation**: The set of the 3 roll, pitch, yaw angles indicating the rotation around the principal axis (x) of an Object, its y axis having an angle of 90° counter clockwise (right-to-left) with the x axis and its z axis (pointing up toward the viewer viewing from above).
   7.3. **Point of View**: The Spatial Attitude of a Persona Perceiving the M-Environment.
8. **Time**: provides a measure of time.

4 Actions

4.1 General

The MPAI Metaverse Model assumes that a Source Process (User, Device, or Service) issue a request to a Destination Process (User, Device, or Service) to execute Actions on InItems placed at In-Locations. The Destination will execute the request if the Source has the necessary InRights, place the OutItems at M-Locations, and grant to the Source OutRights to Act on the OutItems.

This version of this Technical Report preserves the different names of User, Device, and Service, instead of using the generic name "Process" to facilitate understanding of the different requests. However, it should be borne in mind that Sources and Destinations will all be implemented as Processes with appropriate Metadata.

This Chapter specifies the Actions that are supported by at least one Functionality Profile. An Action is called *Basic* when the request involves only one Action and *Composite* when it involves a plurality of Actions and potentially Processes.

The payload of a Request is expressed by the set of Data of Table 5. Note that the logical ∨ symbol is used to indicate that each element of a list are possible.

Table 5 - Format of an Action request

Source	User (ID=UserID) ∨ Device (ID=DeviceID) ∨ Service (ID=ServiceID)
Destination	User (ID=UserID) ∨ Device (ID=DeviceID) ∨ Service (ID=ServiceID)
Action	*Act*
InItem	Item (ID=ItemID)
InLocations	M-LocationID ∨ U-LocationID ∨ Service (ID=ServiceID)
OutLocations	M-LocationID ∨ U-LocationID ∨ Device (ID=DeviceID) ∨ Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Table 6 provides the semantics of the components of a Request.

Table 6 - Semantics of the elements of an Action request

Source	The Process making the request.
Destination	The Process receiving the request.
Action	The Action that the Source requests that the Destination perform on the In-Items. The Destination performs the requested Action if the Source has the necessary Rights to make that request.
InItems	Items or Data&Metadata provided as input to the requested Action.
InLocations	The Locations of the InItems.
OutLocations	The requested Locations of the OutItems.
OutRights	The Rights requested by the Source on the OutItems.

Note1: The payload of a requested Action need not contain all the elements above.
Note2: TheOutRights are contained in the OutItem.

Table 7 provides the elements of all Actions considered in this document. Note that some Actions are Composite, i.e., made of Basic Actions.

Table 7 - Table of the elements of the Action requests

Legend: D=Device, Mdata=Metadata, MLoc=M-Location, P=Process, S=Service, SA=Spatial Attitude, U=User, ULoc=Universe Location, Unsp.= Unspecified, - = Absent.
The symbol & in a list means that all the elements of the list should be included. The symbol - in a list means that the elements of the list should be considered separately.

	Source	**Destination**	**Action**	**InItem**	**InLocation**	**OutItem**	**OutLocation**	**OutRights**
Change	U	S	Change	Entity	MLoc	Entity	MLoc, -	Rights
Create	U-D	S	Create	Data&Mdata	Address-D	Item	S	Rights
Destroy	U	S	Destroy	Item	S	-	-	-

Discover	U	S	Discover	DiscoverReq	U	DiscoverResp	U	Rights
Inform	U	S	Inform	InformReq	MLoc	InformResp	U	Rights
Interpret	U	S	Interpret	InterprReq	MLoc	InterpretResp	U	Rights
MM-Add	U	S	MM-Add	Entity & SA	S	Entity	MLoc	Rights
MM-Animate	U	S	MM-Animate	Entity & SA	MLoc	Entity	MLoc	Rights
MM-Capture	U	S	MM-Capture	Entity	MLoc	Entity	U	Rights
MM-Embed	U	S	MM-Add & MM-Enable	Entity & SA	S	Entity	MLoc	Rights
MM-Enable	U	S	MM-Enable	Entity	MLoc	Entity	MLoc	Rights
MM-Disable	U	S	MM-Disable	Entity	MLoc	-	-	-
MM-Send	P	P	Send	Item	P	Item	P	Rights Mdata
MU-Render	U	D	MU-Send	Entity	MLoc	Entity	D	Rights
	D	Act.	MU-Render	Data	D	media	ULoc	Mdata
MU-Actuate	U	D	MU-Actuate	Entity	D	Media	ULoc	Mdata
MU-Render	U	S	MM-Send	Entity	MLoc	Entity	D	Rights
	U	D	MU-Actuate	Entity	D	Media	ULoc	Mdata
Post	U	S	Post	Asset	S, Address	Asset	S	Rights
Read	U	D	Read	Data&Mdata	Address	Data&Mdata	D	Mdata
Register	human	S	Register	User Data	human-Address	Account	S	Rights
Track	U	S	MM-Embed	Persona & SA	MLoc	Persona	MLoc	Rights
	U	D	UM-Capture	scene	ULoc	animation stream	D	Mdata
	D	U	UM-Send	Data&Mdata	D	Data&Mdata	U	Mdata
	U	S	Create	Data&Mdata	S	Stream	S	Rights
	U	S	MM-Animate	Persona	MLoc	Entity	MLoc	Rights
	U	D	MU-Render	Persona	U	Media	ULoc	Mdata
Transact	U	S	Transact	Value	-	User	-	Rights
	U	S	Transact	Value	-	User	-	-
UM-Animate	U	S	UM-Animate	Entity & Stream & SA	MLoc	Entity	MLoc	Rights
UM-Capture	U-S	D	UM-Capture	scene	ULoc	Data	D	Rights
UM-Send	D	U	UM-Send	Data&Mdata	D	Data&Mdata	U	Mdata
	U	S	Create	Data&Mdata	U	Entity	S	Rights
	U	S	MM-Embed	Entity & SA	MLoc	Entity	MLoc	Rights
UM-Send	U	D	UM-Send	Data&Mdata	D	Data&Mdata	U	Mdata
Write	U	S	Write	Item	S	Item	Address	Rights

The response to a request is expressed by Table 8:

Table 8 - Format of an Action response

Success	OutItem	Item (ID=ItemID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Unsupported	Item not supported
	Mismatch	Item type mismatch
	User Data	Faulty
	Wallet	Insufficient Value
	Clash	Entity clashes with another Entity
	M-Location	Out of range
	U-Location	Out of range
	Address	Incorrect

The semantics of the terms of the response are expressed by Table 6:

Table 9 - Semantics of an Action response

Success	The execution of the requested Action was successful.	
	OutItem	Provides the Item of the demanded Action.
Error	The execution of the requested Action failed.	
	Request	The content of the request was Faulty.
	IDs	Some IDs in the request were found incorrect.
	Rights	Some Rights were missing or incomplete.
	Unsupported	An Item provided is not supported.
	Mismatch	There was a mismatch between Items.
	User Data	Faulty User Data.
	Wallet	The Wallet Value was not sufficient for the required Transaction.
	Clash	An Entity was found to clash with another Entity.
	M-Location	There is no such M-Location.
	U-Location	There is no such U-Location.
	Address	There is no such Address.

Table 10 - Table of the elements of the Action responses

	OutItem	Faulty Request	Wrong IDs	Missing Rights	Unsupported	Wallet error	Clash	M-Location	U-Location	Address	Mismatch	UserData
Authenticate	x	x	x	x				x				
Author	x					x						
Call	x	x	x	x		x						
Change	x	x	x	x				x				
Create	x	x	x	x		x						

Destroy	x	x	x	x								
Discover	x	x	x	x		x						
Inform	x	x	x	x				x				
Interpret	x	x	x	x		x		x				
MM-Add	x	x	x	x			x	x				
MM-Animate	x	x	x		x			x			x	
MM-Capture	x	x	x					x				
MM-Disable	x	x	x	x				x				
MM-Embed	x	x	x	x			x	x				
MM-Enable	x	x	x	x				x				
MM-Send	x	x	x	x								
MU-Actuate	x	x	x	x				x	x			
MU-Render	x	x	x	x				x	x			
Post	x	x	x	x								
Read	x	x	x	x						x		
Register	x					x						x
Track	x	x	x	x					x			
Transact	x					x						
UM-Animate	x	x	x		x			x	x		x	
UM-Capture	x	x	x	x				x	x			
UM-Render	x	x	x	x			x	x	x	x		
UM-Send	x	x		x			x	x	x			
Write	x									x		

Note1: This Technical Report does not specify the protocol to carry the requests and the responses.

4.2 Authenticate

Definition:
The Action of requesting confirmation that an Entity MM-Embedded at an M-Location is what it claims to be.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Authenticate*
InItem	Item (ID=ItemID)
InLocation	M-LocationID
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Response-Authenticate (ID=Response-AuthenticateID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

	M-Location	Out of range

4.3 Author

Definition:
The Action of Calling a Service to obtain an Entity with associated Rights to Act on the Entity.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Author*
InItem	Item (ID=ItemID) ∨ Data
InLocation	User (ID=UserID) ∨ Address
OutItem	Entity (ID= EntityID)
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Entity (ID=EntityID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Wallet error	Insufficient Value

4.4 Call

Definition:
The Action of requesting the start of a Service.

Payload:

Source	User (ID=UserID) ∨ Service (ID=ServiceID)
Destination	Service (ID=ServiceID) ∨ Process (ID=ProcessID)
Requested Action	*Call*
InItem	Item (ID=ItemID) ∨ Data
InLocation	User (ID=UserID) ∨ Service (ID=ServiceID) ∨ Address
OutLocation	Unspecified
OutRights	Rights (ID=RightsID)

Response:

Success		
Error	Request	Faulty
	Rights	Missing or incomplete

4.5 Change

Definition:

The Action of requesting that a Service modify the Rights of a User whose Persona is Embedded at an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Change*
InItem	User (ID=UserID)
InLocation	M-LocationID
OutLocation	User (ID=UserID)

Response:

Success	OutItem	Rights (ID=ItemID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	M-Location	Out of range

4.6 Create

Definition:
The Action of a requesting that a Service produce or update an Item from MM-Sent or UM-Sent Data and Metadata.

Payload:

Source	Process (ID= Process ID)
Destination	Service (ID=ServiceID)
Action	*Create*
InItems	Data & Metadata
InLocation	User (ID=UserID)
OutLocation	Service (ID=ServiceID)

Response:

Success	OutItem	Item (ID=ItemID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.7 Destroy

Definition:
The Action of a User requesting that a Service make the ID of an Item unavailable.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Requested Action	*Destroy*
InItem	(ID=ItemID)

Response:

Success		
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.8 Discover

Definition:
The Action of requesting that a Service provide a Response-Discover Item containing the IDs of the Items relevant to a Request-Discover and the Rights to Act on the Response-Discover Item.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Discover*
InItem	Request-Discover (ID=Request-DiscoverID)
InLocation	Service (ID=ServiceID)
OutLocation	User (ID=UserID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Response-Discover (ID=Response-DiscoverID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.9 Inform

Definition:
The Action of requesting that a Service provide a Response-Inform Item containing the IDs of the Items relevant to a Request-Inform and the Rights to Act on the Response-Inform Item.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Inform*
InItem	Request-Inform (ID=Request-InformID)
InLocation	M-LocationID
OutLocation	User (ID=UserID)

OutRights	Rights (ID=RightsID)

Response:

Success	Action result	Response-Inform (ID=Response-InformID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.10 Interpret

Definition:
The Action of requesting that a Service provide a Response-Inpret Item containing the IDs of the Items relevant to a Request-Interpret and the Rights to Act on the Response-Interpret Item.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Interpret*
InItem	Request-Interpret (ID=InterprRequestID)
OutLocation	User (ID=UserID)
OutRights	Rights (ID=RightsID)

Response:

Success	Action result	Response-Interpret (ID=Response-InterpretID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.11 MM-Add

Definition:
The Action of requesting that a Service add an Entity with a Spatial Attitude to an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Add*
InItem	Entity (ID=EntityID) & Spatial Attitude
InLocation	Service (ID=ServiceID)
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	Action result	Entity (ID=EntityID)

Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Clash	Entity clashes with another Entity
	M-Location	Out of range

4.12 MM-Animate

Definition:
The Action of requesting that a Service change the features of an Entity MM-Embedded at an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Animate*
InItem	Entity (ID=EntityID) & Spatial Attitude
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	Action result	Persona (ID=PersonaID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Item mismatch	Entity Data Type and Animation Stream Data Type.

4.13 MM-Capture

Definition:
The Action of requesting that a Service Send selected Entities MM-Embedded at an M-Location to a User.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Capture*
InItem	Entity (ID=EntityID), Spatial Attitude
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Entity (ID=EntityID)

Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.14 MM-Disable

Definition:
The Action of requesting that a Service stop MM-Enabling an Entity Embedded at an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Disable*
InItem	Item (ID=ItemID)
InLocation	Entity (ID=EntityID)

Response:

Success		
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	M-Location	Out of range

4.15 MM-Embed

Definition:
The Composite Action of requesting that a Service MM-Add and MM-Enable an Entity at an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Add*
InItem	Entity (ID=EntityID)
InLocation	Service (ID=ServiceID), Spatial Attitude
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)
Action	*MM-Enable*
InItem	Entity (ID=EntityID)
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Entity (ID=EntityID)

Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Clash	Entity clashes with another Entity
	M-Location	Out of range

4.16 MM-Enable

Definition:
The Action of enabling Rights-holding Users to MM-Capture an Entity MM-Added at an M-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Enable*
InItem	Entity (ID=EntityID)
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Entity (ID=EntityID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	M-Location	Out of range

4.17 MM-Send

Definition:
The Action of a Service forwarding an Item or Data/Metadata to a Process.

Payload:

Source	Process (ID=ProcessID)
Destination	Process (ID=ProcessID)
Action	*Send*
InItem	Item (ID=ItemID)
InLocation	Process (ID=ProcessID)
OutLocation	Process (ID=ProcessID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Item (ID=ItemID)
Error	Request	Faulty

	IDs	Incorrect
	Rights	Missing or incomplete

4.18 MU-Actuate

Definition:
The Action of a Device presenting a Scene as Media to a U-Location with a Spatial Attitude.

Payload:

Source	User (ID=UserID)
Destination	Device (ID=DeviceID)
Action	*MU-Actuate*
InItem	Data & Metadata
InLocation	Device (ID=DeviceID)
OutLocation	U-LocationID
OutRights	Metadata

Response:

Success	OutItem	Media
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	U-Location	Out of range

4.19 MU-Render

Definition:
The Composite Action of requesting that:
1. A Service MM-Send selected Entities Embedded at an M-Location to a Device.
2. The Device to MU-Actuate the Entities to a U-Location.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Send*
InItem	Entity (ID=EntityID)
InLocation	M-LocationID
OutLocation	Device
Source	User (ID=UserID)
Destination	Device (ID=DeviceID)
Action	*MU-Actuate*
InItem	Entity (ID=EntityID)
InLocation	Device (ID=DeviceID)
OutLocation	U-LocationID
OutRights	Metadata

Response:

Success	Action result	Media
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	M-Location	Out of range

4.20 Post

Definition:
The Action of requesting that a Marketplace include an Asset.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Post*
InItem	Asset (ID=AssetID)
InLocation	User (ID=UserID) ∨ Service (ID=ServiceID)
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Asset (ID=AssetID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete

4.21 Read

Definition:
The Action of a Process requesting that a Process read Data and Metadata stored at an Address.

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Requested Action	*Read*
InItem	Data and Metadata
InLocation	Address
OutLocation	User (ID=UserID)

Response:

Success	Action result	Data & Metadata
Error	Request	Faulty
	IDs	Incorrect

	Rights	Missing or incomplete

4.22 Register

Definition:
The Action of a human requesting that an M-Instance/Environment grant their Users the Rights to perform Actions in the M-Instance/Environment.

Payload:

Source	human
Destination	Service (ID=ServiceID)
Requested Action	*Register*
InItem	User Data
InLocation	Address
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Account (ID=AccountID)
Error	User Data	Faulty
	Wallet	Insufficient Value

4.23 Track

The Composite Action of requesting:
1. To MM-Embed a Persona at an M-Location with a Spatial Attitude.
2. To UM-Animate the Persona MM-Added at an M-Location.
3. To MU-Render specified Entities at the M-Location to a U-Location.

Request:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Embed*
InItem	Persona (ID=PersonaID) & Spatial Attitude
InLocation	Service (ID=ServiceID)
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)
Source	User (ID=UserID)
Destination	Device (ID=DeviceID)
Action	*UM-Animate*
InItem	Persona (ID=PersonaID)
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)
Source	User (ID=UserID)
Destination	Service (ID=ServiceID)

Action	*MU-Render*
InItem	Entity (ID=EntityID)
InLocation	M-LocationID
OutLocation	U-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Media
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	M-LocationID	Out of range
	U-LocationID	Out of range

4.24 Transact

Definition:
The Action of a User1 requesting that a Service:
1. Assign Rights on an Asset to User2.
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).

Payload:

Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Transact*
InItem	Asset (ID=AssetID)
InLocation	M-LocationID ∨ Service (ID=ServiceID)
OutLocation	User (ID=UserID)
OutRights	Rights (ID=RightsID1)

Response:

Success	OutItem	Wallet1 (ID=WalletID1, Wallet1 (ID=WalletID2, Wallet3 (ID=WalletID3
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Wallet	$User_2$ Wallet has insufficient Value

4.25 UM-Animate

Definition:
The Composite Action of requesting
1. To UM-Capture an animation stream extracted from a scene at a U-Location.

2. To UM-Send the animation stream and Metadata to a User.
3. To Create the Animation Stream.
4. To Call a Process to change the features of the Entity MM-Embedded at the M-Location using the Animation Stream.

Payload:

Source	User (ID=UserID)
Destination	Device (ID=DeviceID)
Action	*MM-Compose*
InItems	Persona (ID=PersonaID)
InLocation	Service (ID=ServiceID)
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)
Source	User (ID=UserID)
Destination	Device (ID=DeviceID)
Action	*UM-Capture*
InItem	scene
InLocation	U-LocationID
OutLocation	Device (ID=DeviceID)
OutRights	Metadata
Source	Device (ID=DeviceID)
Destination	User (ID=UserID)
Action	*MM-Send*
InItem	Data & Metadata
InLocation	Device (ID=DeviceID)
OutLocation	User (ID=UserID)
OutRights	Metadata
Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Create*
InItem	stream & Metadata
InLocation	User (ID=UserID)
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)
Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*Call*
InItem	Persona (ID=PersonaID), Stream (ID=StreamID), Spatial Attitude
InLocation	M-LocationID, User (ID=UserID)
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Persona (ID=PersonaID)
Error	Request	Faulty

	IDs	Incorrect
	Rights	Missing or incomplete

4.26 UM-Capture

Definition:
The Action of requesting that a Device acquire Media from a scene at a U-Location.

Payload:

Action	*UM-Capture*
InItem	scene
InLocation	U-LocationID
OutLocation	Device (ID=DeviceID)
OutRights	Metadata

Response:

Success	Action result	Data
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	U-Location	Out of range

4.27 UM-Render

Definition:
The Composite Action of:
1. UM-Capturing a scene at U-Location.
2. MM-Sending Data and Device-provided Metadata.
3. Creating an Entity from UM-Sent Data and Metadata.
4. MM-Embedding the Entity at an M-Location with a Spatial Attitude.

Request:

Action	*UM-Capture*
InItem	scene
InLocation	U-LocationID
OutLocation	Device (ID=DeviceID)
OutRights	Metadata
Source	Device (ID=DeviceID)
Destination	User (ID=UserID)
Action	*MM-Send*
InItem	Data
InLocation	Device (ID=DeviceID)
OutLocation	User (ID=UserID)
OutRights	Metadata
Source	User (ID=UserID)
Destination	Service (ID=ServiceID)

Action	*Create*
InItem	stream & Metadata
InLocation	User (ID=UserID)
OutLocation	Service (ID=ServiceID)
OutRights	Rights (ID=RightsID)
Source	User (ID=UserID)
Destination	Service (ID=ServiceID)
Action	*MM-Add*
InItem	Entity (ID=EntityID)
InLocation	Service (ID=ServiceID), Spatial Attitude
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)
Action	*MM-Enable*
InItem	Entity (ID=EntityID)
InLocation	M-LocationID
OutLocation	M-LocationID
OutRights	Rights (ID=RightsID)

Response:

Success	OutItem	Entity (ID=EntityID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Clash	Entity clashes with another Entity
	M-Location	Out of range
	U-Location	Out of range

4.28 UM-Send

Definition:
The Action of a Device streaming Data and Metadata.

Request:

Source	Device (ID=DeviceID)
Destination	User (ID=UserID)
Action	*UM-Send*
InItem	Data & Metadata
InLocation	Device (ID=DeviceID)
OutLocation	User (ID=UserID)
OutRights	Metadata

Response:

Success	Action result	Data & Metadata
Error	Request	Faulty
	IDs	Incorrect

	Rights	Missing or incomplete
	Clash	Entity clashes with another Entity
	M-Location	Out of range
	U-Location	Out of range

4.29 Write

Definition:
The Action of storing an Item at an Address.

Payload:

Source	Process (ID=ProcessID)
Destination	Service (ID=ServiceID)
Action	*Write*
InItem	Item (ID=ItemID)
InLocation	M-LocationID ∨ Process (ID=ProcessID)
OutLocation	Address

Response:

Success	OutItem	Item (ID=ItemID)
Error	Request	Faulty
	IDs	Incorrect
	Rights	Missing or incomplete
	Address	Incorrect

5 Items

5.1 General

This chapter specifies the Items that are Acted on in at least one Functionality Profile. Items are specified using the following format:

Table 11 - Item Format

Purpose	A functional description of the Item.	
Data	In general, the Item Data Format(s) is(are) not provided. List of Actions and Entities related to the Item are provided where available. Where possible, initial Functional Requirements are provided.	
Acted on Metadata	ItemID	ID of the Item.
	UserID	ID of the User who holds Rights on the Item with ItemID.
	WalletID	ID of the Wallet held by User with UserID
	InRightsID	ID of the Rights the User with UserID has on the Item with ItemID.
	OutRightsID	ID of the Rights a User may acquire on the Item with ItemID.
	AuthorID	ID of the User who Authored the Item with ItemID.

	AuthorToolID	ID of the Service who provided the AuthorTool.
	ParentItemID	ID of the Item that spawned the Item.
	ServiceID	ID of the Service that is Called.
	ServiceWalletID	ID of the Wallet of a Service.
	ActedOnItemID	ID of the Item that was Acted on.
	TargetUserID	ID of the User to be affected by the Action.
	TargetWalletID	ID of the Wallet of the User to be affected by the Action.
	UserDataID	ID of a User Data.
	PersonaID	ID of a User's Persona.
	PersonalDataID	ID of a User's Personal Data.
	ActivityDataID	ID of a User's Activity Data.
	DescrMdata	Any additional descriptive Metadata of the Item.

Table 12 provides a view of the Metadata Elements of each Items. For reason of space, ItemIDs and Descriptive Metadata are not reported.

Table 12 – Elements of Item Metadata

	User/human	InRights	OutRights	Service	ActedOnItem	ParentItem	Author	AuthoringTool	Target User	User Data	Persona	Personal Data	ActivityData	Social Graph	Wallet	Target Wallet	Service Wallet
Account	x	x		x													
Activity Data	x	x	x	x													
App	x	x	x														
Asset	x	x	x	x											x		
Device	x	x	x														
Event	x	x	x			x											
Experience	x	x	x			x											
Identifier	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Interaction	x	x	x														
Map	x	x	x				x	x									
M-Environment	x	x	x														
Message	x			x													
M-Instance	x	x	x														
M-Location	x	x	x														
Model	x	x	x				x	x									
Object	x	x	x				x	x									
Personal Profile	x	x	x														
Process	x	x	x		x												
Provenance	x	x	x		x												
Request-Authenti-cate	x	x	x	x	x												
Request-Discover	x	x	x	x	x												
Request-Interpret	x	x	x	x	x												
Request-Inform	x	x	x	x	x												
Response-Authen-ticate	x	x	x	x	x												
Response-Dis-cover	x	x	x	x	x												

Response-Inter-pret	x	x	x	x	x												
Response-Inform	x	x	x	x	x												
Rights	x	x	x														
Rules	x	x					x	x									
Scene	x	x	x				x	x									
Service	x	x	x														
Social Graph	x	x	x														
Stream	x	x	x														
Transaction	x	x	x	x					x						x	x	x
U-Location	x	x	x														
User	x	x								x	x	x	x	x	x		
User Data	x	x	x														
Value	x	x															
Wallet	x	x															

5.2 Account

Elements	Definitions	
Purpose	An Item issued by an M-Instance/M-Environment that uniquely identifies a human who is Registered with the M-Instance/M-Environment.	
Data	TBD	
Metadata	AccountID	The ID of the Account.
	humanID	The ID of the Account holder.
	InRightsID	The ID of the human's Rights in the M-Instance/M-Environment".
	ServiceID	The ID of the Service the Account refers to.
	DescrMdata	Any description of the Account.

5.3 Activity Data

Purpose	An Item containing the record of the Actions of a User.	
Data	TBD	
Metadata	ActivityDataID	The ID of the Activity Data.
	UserID	The ID of the User "having Rights to Act on the Activity Data".
	InRightsID	The ID of the User's Rights to Act on the Activity Data.
	OutRightsID	The ID of the Rights a User may acquire on the Activity Data.
	ServiceID	The ID of the Service the Account refers to.
	Descriptive Metadata	Any description of the Activity Data.

5.4 App

Purpose	An application-specific Program executed on a Device.	
Data	TBD	
Metadata	AppID	The ID of the App.
	UserID	The ID of the User "having Rights to Act on the App".
	InRightsID	The ID of the User's Rights to Act on the App.
	OutRightsID	The ID of the Rights a User may acquire on the App.
	DescrMdata	Any description of the App.

5.5 Asset

Purpose	An Item Embedded at an M-Location or Posted to a Service that may be the object of a Transaction.	
Data	The Data of an Asset conform to the Format of the Item that has spawned it	
Metadata	AssetID	The ID of the Asset.
	UserID	The ID of the User "having Rights to Act on the Asset".
	InRightsID	The ID of the User's Rights to Act on the Asset.
	OutRightsID	The ID of the Rights a User may acquire on the Asset.
	DescrMdata	Any description of the Asset.

5.6 Device

Purpose	A Process able to: 1. UM-Capture Data from a U-Location 2. UM-Send Data and Metadata to a User. and/or 3. MU-Send an Entity from an M-Location to the Device. 4. MU-Render an Entity at a U-Location.	
Data	TBD	
Metadata	DeviceID	The ID of the Device.
	UserID	The ID of the User "having Rights to Act on the Device".
	InRightsID	The ID of the User's Rights to Act on the Device.
	OutRightsID	The ID of the Rights a User may acquire on the Device.
	DescrMdata	Any description of Device.

5.7 Event

Purpose	The set of Entities that are MM-Embedded at an M-Location from Start Time until End Time.	
Data	M-Location	
	StartTime	The start Time of the Event.
	EndTime	The end Time of the Event.
Metadata	EventID	The ID of the Event.
	UserID	The ID of the User "having Rights to Act on the Event".
	InRightsID	The ID of the Rights "to Act on the Event".
	OutRightsID	The ID of the Rights a User may acquire on the Event.
	ParentItemID	The ID of the Entity "from which the Event is derived".
	DescrMdata	Any description of the Event.

5.8 Experience

Purpose	An Event as a User MM-Captured it and the User's Interactions with the Entities belonging to the Entity that spawned the Event.			
Data	$Time_1$	$Entity_1$	$Interaction_1$	$M\text{-}Location_1$
	$Time_2$	$Entity_2$	$Interaction_2$	$M\text{-}Location_2$
	$Time_n$	$Entity_n$	$Interaction_n$	$M\text{-}Location_n$
Metadata	ExperienceID	The ID of the Experience.		
	UserID	The ID of the User "having Rights to the Experience".		
	InRightsID	The ID of the Rights "to Act on the Experience".		

	OutRightsID	The ID of the Rights a User may acquire on the Experience.
	ParentEntityID	The ID of the Event spawning the Experience.
	DescrMdata	Any description of the Experience.

5.9 Identifier

Purpose	An Item that uniquely references an Item. The Item can have more than one Identifier.
Data	[M-InstanceID] [M-EnvironmentID] [M-Location] [ItemID]. Any of the [?] preceding [ItemID] can be absent. The Format of an Identifiers depends on the Technology it is based on, e.g.: 1. Multi-factor 2. Device Biometrics (iris, fingertips, voice, face, gestures, hand motions, body motions, etc.) 3. Behavioural Biometrics. 4. Cryptographic Security Keys. 5. Certificate-based authentication. 6. Hardware Security Keys. 7. Device Identity Technologies. 8. Decentralised Identifiers (DIDs) 9. Self-Sovereign Identifiers (SSIs)
Metadata	Any description of the Identifier.

5.10 Interaction

Purpose	An Item containing the list of Actions made by a User on the Entities MM-Embedded at an M-Locations and the corresponding Times.			
Data	$Action_1$	$Entity_1$	$M\text{-}Location_1$	$Time_1$
	$Action_2$	$Entity_2$	$M\text{-}Location_2$	$Time_2$
	$Action_n$	$Entity_n$	$M\text{-}Location_n$	$Time_n$
	Current Actions are MU-Send, UM-Animate, Authenticate, Author, MM-Add, Create, MM-Add, MM-Capture, Destroy, Discover, MM-Render, MU-Render, UM-Render, MM-Embed, Edit, MM-Add, UM-Send, Interpret, MU-Send, MM-Enable, Post, MM-Disable, MU-Sense, UM-Sense, Transact, and Write.			

Metadata	InteractionID	The ID of the Interaction.
	UserID	The ID of the User “having Rights to Act on the Interaction”.
	InRightsID	The ID of the Rights “to Act on the Interaction”.
	OutRights	The ID of the Rights a User may acquire on the Interaction.
	EntityID	The ID of Entity “User Interacted with”.
	DescrMdata	Any description of the Interaction.

5.11 Ledger

Purpose	An Item containing a list of Transactions involving Assets.	
Data	TBD	
Metadata	LedgerID	The ID of the Ledger.
	UserID	The ID of the User who “has Rights on the Ledger”.
	InRightsID	The ID of the Rights “to Act on the Ledger”.
	OutRightsID	The ID of the Rights “to Act on the Ledger” a User may acquire.
	DescrMdata	Any descriptive Metadata.

5.12 M-Environment

Purpose	A portion of an M-Instance covered by an Account	
Data	TBD	
Metadata	M-EnvironmentID	The ID of the M-Environment.
	UserID	The ID of the User "having Rights to Act on the M-Environment".
	InRightsID	The ID of the Rights "to Act on the M-Environment".
	OutRightsID	The ID of the Rights a User may acquire on the M-Location.
	DescrMdata	Any description of the M-Environment, e.g., about Persistence and Accessibility (Public/Private).

5.13 M-Instance

Purpose	A Metaverse implementation.	
Data	TBD	
Metadata	M-InstanceID	The ID of the M-Instance.
	UserID	The ID of the User "having Rights to Act on the M-Instance".
	InRightsID	The ID of the Rights "to Act on the M-Instance".
	OutRightsID	The ID of the Rights a User may acquire on the M-Instance.
	DescrMdata	Any description of the M-Instance.

5.14 M-Location

Purpose	An identifiable delimited portion of an M-Environment.	
Data	TBD	
Metadata	M-LocationID	The ID of the M-Location Item.
	UserID	The ID of the User "having Rights to Act on M-Location".
	InRightsID	The ID of the Rights "to Act on the M-Location.
	OutRightsID	The ID of the Rights of a User may acquire on the M-Location.
	DescrMdata	Any description of the M-Location.

5.15 Map

Purpose	An Item containing a structure establishing a correspondence between U-Locations with M-Locations.	
Data	TBD.	
Metadata	MapID	The ID of the Map.
	UserID	The ID of the User "having Rights to Act on the Map".
	InRightsID	The ID of the User Rights "to Act on the Map".
	OutRightsID	The ID of the Rights of a User may acquire on the Map.
	AuthorID	The ID of the User "who Authored the Map".
	AuthoringToolID	The ID of the Service "who provided the Authoring Tool".
	DescrMdata	Any description of the Map.

5.16 Message

Purpose	An Item containing application-specific Data MM-Sent by Source to Destination.
Data	Source Destination

	Message content		
Metadata	MessageID	The ID of the Map.	
	Descriptive Metadata	Any description of the Message.	

5.17 Model

Purpose	An Object representing an object with its features ready to be UM-Animated by a Stream or MM-Animated by an autonomous agent.	
Data	Objects represented are: 1. An inanimate Object (e.g., a table) 2. An autonomous Object (e.g., a robot) 3. An animal, possibly with high accuracy 4. A human, possibly with high accuracy	
Metadata	ModelID	The ID of the Object Model.
	UserID	The ID of the User "having Rights to Act on Object Model".
	InRightsID	The ID of the Rights "to Act on the Object Model".
	OutRightsID	The ID of the Rights a User may acquire on the Object Model.
	AuthorID	The ID of the User "who Authored the Object Model".
	Author-ingToolID	The ID of the Service "who provided the Authoring tool".
	DescrMdata	Any description of the Model.

5.18 Object

Purpose	An Entity representing an object. Currently, the following types of Objects are supported: Audio, Visual, and Haptic.	
Data	1. Audio Data representation 1.1. Mono (e.g., speech) 1.2. Stereo 1.3. Multichannel 1.4. Microphone array 1.5. Spatial Audio 2. Image Data representation 3. Visual Data representation 3.1. Mono 3.2. Camera array 3.3. Light field 3.4. Holography 4. Haptic Data representation	
Metadata	Object ID	The ID of the Object Identified by ObjectID.
	UserID	The ID of the User "having Rights to Act on the Object".
	InRightsID	The ID of the Rights "to Act on the Object".
	OutRightsID	The ID of the Rights a User may acquire on the Object.
	AuthorID	The ID of the User "who Authored the Object".
	AuthoringToolID	The ID of the Service "who provided the Authoring tool"
	DescrMdata	Any description of the Object.

5.19 Personal Profile

Purpose	An Item containing the Data about the human represented by User.	
Data	1. First Name 2. Last Name 3. Address 4. Country 5. Age 6. Interests 7. Biometric data 8. …	
Metadata	PersonalDataID	The ID of the Personal Data.
	UserID	The ID of the User "Having Rights on the Personal Data".
	InRightsID	The ID of the Rights "to Act on the Personal Data".
	OutRightsID	The ID of the Rights a User may acquire on the Personal Data.
	DescrMdata	Any description of the Personal Data.

5.20 Process

Purpose	An Item able to: 1. Receive Items and/or Data and the Right to Call the Process 2. Produce Items or Data.	
Data	TBD	
Metadata	ProcessID	The ID of the Process.
	UserID	The ID of the User "Having Rights on the Process".
	InRightsID	The ID of the Rights "to Act on the Process".
	OutRightsID	The ID of the Rights "to Act on the Process" a User may acquire.
	ActedOnItemID	The ID of the Item "input to Process".
	DescrMdata	Any description of Process.

5.21 Provenance

Purpose	The list of all Transactions executed on an Asset starting from the first and including the last.	
Data	$Transaction_1$	$Time_1$
	$Transaction_2$	$Time_2$
	$Transaction_n$	$Time_n$
Metadata	ProvenanceID	The ID of the Provenance.
	UserID	The ID of the User who "has Rights on the Provenance".
	InRightsID	The ID of the Rights "to Act on the Provenance".
	OutRightsID	The ID of the Rights "to Act on the Provenance" a User may acquire.
	AssetID	The ID of the Asset the Provenance refers to.
	DescrMdata	Any descriptive Metadata.

5.22 Request-Authenticate

Purpose	An Item containing the request to a Service to "Authenticate Item".

Data	TBD	
Metadata	Request-AuthenticateID	The ID of the Request-Authenticate Item.
	UserID	The ID of the User generating the Request-Authenticate Item.
	ServiceID	The ID of the Service providing Authentication Services.
	InRightsID	The ID of the Rights "to Act on the Request-Authenticate Item" granted to the Authenticate Service.
	OutRightsID	The ID of the Rights a User may acquire on the Request-Authenticate Item.
	DescrMdata	Any description of the Request-Authenticate Item.

5.23 Request-Discover

Purpose	An Item containing the request to a Service to "Discover Item".	
Data	TBD	
Metadata	Request-DiscoverID	The ID of the Request-Discover Item.
	UserID	The ID of the User generating the Request-Discover Item.
	ServiceID	The ID of the Service providing Discovery Services.
	InRightsID	The ID of the Rights "to Act on the Request-Discover Item" granted to the Discovery Service.
	OutRightsID	The ID of the Rights a User may acquire on the Request-Discover Item.
	DescrMdata	Any description of the Request-Discover Item.

5.24 Request-Inform

Purpose	An Item that contains the request to a Service to "Inform Item".	
Data	TBD	
Metadata	InterprRequestID	The ID of the Request-Inform Item.
	UserID	The ID of the User generating the Request-Inform Item.
	ServiceID	The ID of the Service providing Inform Services.
	InRightsID	The ID of the Rights "to Act on the Request-Inform Item" granted to the Interpretation Service.
	OutRightsID	The ID of the Rights a User may acquire on the Request-Inform Item.
	DescrMdata	Any description of the Request-Inform Item.

5.25 Request-Interpret

Purpose	An Item containing a description of the request to "Interpret Item".	
Data	TBD	
Metadata	InterprRequestID	The ID of the InterprRequest Item.
	UserID	The ID of the User generating the Request-Interpret Item.
	ServiceID	The ID of the Service providing Interpret Services.
	InRightsID	The ID of the Rights "to Act on the Request-Interpret Item" granted to the Interpretation Service.

	OutRightsID	The ID of the Rights a User may acquire on the Request-Interpret Item.
	DescrMdata	Any description of the Request-Interpret Item.

5.26 Response-Authenticate

Purpose	An Item that contains the response of a Service to an "Authenticate Item" request.	
Data	TBD	
Metadata	Response-AuthenticateID	The ID of the Response-Authenticate Item.
	ServiceID	The ID of the Service providing the Response-Authenticate Item.
	UserID	The ID of the User receiving the Response-Authenticate Item.
	InRightsID	The ID of the Rights "to Act on the Response-Authenticate Item" held by the Authentication Service.
	OutRightsID	The ID of the Rights to Act on the Response-Authenticate Item granted to the User.
	DescrMdata	Any description of the Response-Authenticate Item.

5.27 Response-Discover

Purpose	An Item that contains the response of a Service to an "Discover Item" request.	
Data	TBD	
Metadata	Response-DiscoverID	The ID of the Response-Discover Item.
	ServiceID	The ID of the Service providing the Response-Discover Item.
	UserID	The ID of the User receiving the Response-Discover Item.
	InRightsID	The ID of the Rights "to Act on the Response-Discover Item" held by the Discovery Service.
	OutRightsID	The ID of the Rights to Act on the Response-Discover Item granted to the User.
	DescrMdata	Any description of the Response-Discover Item.

5.28 Response-Inform

Purpose	An Item that contains the response of a Service to an "Inform Item" request.	
Data	TBD	
Metadata	Response-InformID	The ID of the Response-Inform Item.
	ServiceID	The ID of the Service providing the Response-Inform Item.
	UserID	The ID of the User receiving the Response-Inform Item.
	InRightsID	The ID of the Rights "to Act on the Response-Inform Item" held by the Inform Service.
	OutRightsID	The ID of the Rights to Act on the Response-Inform Item granted to the User.
	DescrMdata	Any description of the Response-Inform Item.

5.29 Response-Interpret

Purpose	An Item containing the response to the request to Interpret an Item.	
Data	TBD	
Metadata	Response-AuthenticateID	The ID of the Response-Interpret Item.
	ServiceID	The ID of the Service providing the Response-Interpret Item.
	UserID	The ID of the User receiving the Response-Interpret Item.
	InRightsID	The ID of the Rights "to Act on the Response-Interpret Item" held by the Interpret Service.
	OutRightsID	The ID of the Rights to Act on the Response-Interpret Item granted to the User.
	DescrMdata	Any description of the Response-Interpret Item.

5.30 Rights

Purpose	An Item expressing the ability of a User to perform an Action on an Item until a Time.	
Data	Expiration Time.	
Metadata	RightsID	The ID of the Rights.
	UserID	The IDs of the User "having Rights".
	ActionID	The ID of the Action "User may perform".
	ItemID	The ID of the Item "User can perform Actions on".
	OutRightsID	The ID of the Rights "to Act on the Item" a User may acquire.
	DescrMdata	Any description of the Rights.

5.31 Rules

Purpose	An Item expressing the terms and conditions under which a User operates in an M-Instance/Environment.	
Data	Rules establish the Rights of a User to the Items they Act on an M-Instance/M-Environment. The jurisdiction of the M-Instance/M-Environment may specify Rights that must be granted to a User.	
Metadata	RulesID	The ID of the Rules.
	UserID	The ID of the User having Rights on the Rules.
	InRightsID	The ID of the Rights "to Act on the Rules".
	M-InstanceID	The ID of the M-Instance "where the Rules hold (if an M-Instance)".
	M-EnvironmentID	The ID of the M-Environment "where the Rules hold (if an M-Environment)".
	DescrMdata	Any descriptive Metadata.

5.32 Scene

Purpose	A possibly hierarchical Composition of Objects each having a Spatial Attitude.	
Data	TBD	
Metadata	SceneID	The ID of the Scene Identified by SceneID
	UserID	The ID of the User "having Rights to Act on the Scene".
	InRightsID	The ID of the Rights "to Act on the Scene".

	OutRightsID	The ID of the Rights “to Act on the Scene” a User may acquire.
	AuthorID	The ID of the User “who created the Scene”.
	Auth.ToolID	The ID of the Service “who provided the Creation tool”.
	DescrMdata	Any description of the Scene.

5.33 Service

Purpose	A Process that can be Called to provide Functionalities.	
Data	TBD	
Metadata	ServiceID	The ID of the Service.
	UserID	The ID of the User having Rights to Call the Service.
	InRightsID	The ID of the Rights “to Call the Service”.
	OutRightsID	The ID of the Rights “to Call the Service” a User may acquire.
	DescrMdata	Any description of the Rights.

5.34 Social Graph

Purpose	A representation of a User’s network of connections with Items, Processes, and Services.	
Data	TBD	
Metadata	SocialGraphID	The ID of the Social Graph.
	UserID	The ID of the User “having Rights on the Social Graph”.
	inRightsID	The ID of the Rights “to Act on the Social Graph”.
	OutRightsID	The ID of the Rights “to Act on the Social Graph” a User may acquire.
	DescrMdata	Any description of the Social Graph.

5.35 Stream

Purpose	An Item made by a continuous flow of Data.	
Data	TBD	
Metadata	StreamID	The ID of the Stream.
	UserID	The ID of the User “having Rights to Act on the Stream”.
	InRightsID	The ID of Rights “to Act on the Stream”.
	OutRightsID	The ID of the Rights “to Act on the Stream” a User may acquire.
	DescrMdata	Any description of the Stream.

5.36 Transaction

Purpose	Item representing the changed state of the Account and the Rights of one or more Users and optionally of the Service facilitating/enabling the Transaction of an Asset: 1. The Value moving into the Wallet of User 1 (seller). 2. The Value moved from the Wallet of User2 (buyer). 3. The Value moved into the Wallet of User 3 (service) - optional. 4. The Time the Values were moved. 5. The Rights to Act owned by User1 before Time. 6. The Rights to Act owned by User2 after Time.	
Data	Value1	The Value moved into the seller’s Wallet.
	Value2	The Value moving from the buyer’s Wallet.

	Value3	The Value moved into the Marketplace's Wallet (optional).
	Time	The Time when the Transaction is carried out.
Metadata	TransactionID	The ID of the Transaction.
	AssetID	The ID of the Asset the Transaction refers to.
	UserID	The ID of User1 "who grants the Rights".
	InRightsID	The ID of the Rights of User1.
	WalletID1	The ID of the Wallet of UserID1.
	TargetUserID	The ID of the User2 "who is granted the Rights".
	OutRightsID	The ID of the Rights "granted to User2".
	TargetWalletID	The ID of the Wallet of UserID2.
	ServiceID	The ID of the Marketplace.
	ServiceWalletID	The ID of the Wallet of the Marketplace.
	DescrMdata	Any description of the Transaction.

5.37 U-Location

Purpose	An identifiable delimited portion of a Universe Environment.	
Data	TBD	
Metadata	U-LocationID	The ID of the U-Location.
	UserID	The ID of the User "having Rights to Act on the U-Location".
	RightsID	The ID of the Rights "to perform Actions on the U-Location".
	OutRightsID	The ID of the Rights "to perform Actions on the U-Location" a User may acquire.
	DescrMdata	Any description of the U-Location.

5.38 User

Purpose	A Process representing an MM-Captured human as a Persona that is either UM-Animated by a Stream or MM-Animated by an autonomous agent.	
Data	TBD	
Metadata	UserID	ID of User.
	RightsID	ID of Rights held by User
	AccountIDs	IDs of Accounts held by User.
	WalletIDs	IDs of Wallets held by User.
	UserDataID	ID of User Data.
	DescrMdata	Any description of the User.

5.39 User Data

Purpose	An Item containing Activity Data, Personae, Social Graph, and User Profile of a User.	
Data	TBD	
Metadata	UserDataID	ID of UserData.
	UserID	ID of User having Rights on UserData
	RightsID	ID of Rights held by User
	PersonaIDs	IDs of Personae held User.
	PersonalDataID	ID of Personal Data.
	ActivityDataID	ID of Activity Data
	SocialGraphID	ID of SocialGraph

	DescrMdata	Any description of the User.	

5.40 Value

Purpose	An Amount and the Currency with which the Amount is expressed.	
Data	TBD	
Metadata	ValueID	The ID of the Value.
	UserID	The ID of the User who has used the Value for a Transaction.
	DescrMdata	Any description of the User.

5.41 Wallet

Purpose	A container of Currency units. In general, a Wallet is implemented outside of the Environment.	
Data	A list of Values with the Time of the last Transaction.	
Metadata	WalletID	The ID of the Wallet.
	UserID	The ID of the User “having Rights to the Wallet”.
	InRightsID	The ID of the Rights “User has on the Wallet”.
	DescrMdata	Any description of the User.

6 Data Types

Actions and Items may use several Data Types. Some Data Types may relate to a Metaverse Instance or the Universe; a U-/M- prefix may be added as needed.

6.1 Address

Purpose	The URL of a storage facility.
Data	TBD
Metadata	No Metadata.

6.2 Amount

Purpose	A number expressing a Value in a Currency.
Data	A decimal number.
Metadata	No Metadata.

6.3 Cognitive State

Purpose	The representation of a User’s Personal Status that reflects the way they understand the Environment, such as “Confused”, “Dubious”, “Convinced”.	
Data	TBD	
Metadata	PersonaID	The ID of the Persona “the Cognitive State refers to”.
	CognitiveStateID	The ID of the Cognitive State.
	DescrMetadata	Any description of the Cognitive State.

6.4 Coordinates

Purpose	A set of numbers representing a Position in a Metaverse Environment using a coordinate system.	
Data	TBD	
Metadata	Coordinate System	The ID of the coordinate system.

	DescrMetadata	Any description of the Cognitive State.	

6.5 Currency

Purpose	A medium of exchange enabling Transactions in a Metaverse Environment.
Data	CurrencyID.
Metadata	No Metadata.

6.6 Emotion

Purpose	The representation of a User's Personal Status that results from their interaction with an Environment, such as "Angry", "Sad", "Determined".	
Data	TBD	
Metadata	PersonaID	The ID of the Persona "the Emotion refers to".
	EmotionID	The ID of the Emotion Identified by EmotionID.
	DescrMetadata	Any description of the Emotion.

6.7 Orientation

Purpose	The set of the 3 roll, pitch, yaw angles indicating the rotation around the principal axis (x) of an Object, its y axis having an angle of 90° counter clockwise (right-to-left) with the x axis and its z axis (pointing up toward the viewer viewing from above).
Data	TBD
Metadata	Any descriptive Metadata.

6.8 Personal Status

Purpose	The representation of the information internal to a User characterising their behaviour.	
Data	TBD	
Metadata	Personal-StatusID	The ID of the Personal Status Identified by PersonalStatusID.
	PersonaID	The ID of the Persona "with PersonalStatusID".
	DescrMetadata	Any descriptive Metadata.

6.9 Point of View

Purpose	The Spatial Attitude of a Persona watching an Environment.	
Data	As in Spatial Attitude.	
Metadata	PersonaID	The ID of the Persona "with PersonalStatusID".

6.10 Position

Purpose	The Coordinates of a point in a Metaverse Environment using a Coordinate system.	
Data	TBD	
Metadata	CoordinateSys-temID	ID of the Coordinate System used to express the Position.

6.11 Social Attitude

Purpose	The representation of a User's Personal Status representing the way User intends to position vis-à-vis other Users, e.g., "Respectful", "Confrontational", "Soothing".

Data	TBD		
Metadata	PersonaID	The ID of the Persona "the Social Attitude refers to".	
	SocialAttitudeID	The ID of the Social Attitude.	
	DescrMetadata	Any description of the Social Attitude.	

6.12 Spatial Attitude

Purpose	The Position and Orientation of an Entity, and their velocities and accelerations.
Data	TBD
Metadata	Any descriptive Metadata.

6.13 Time

Purpose	The representation of the measure of time.
Data	TBD
Metadata	Any descriptive Metadata

7 Use Cases

7.1 Introduction

This Chapter collects Metaverse Use Cases to facilitate the development of Functionality Profiles. The following notation will be used:

1. $User_i$ MM-Embeds $Persona_{i.1}$, $Persona_{i.2}$, etc.
2. $User_i$ Calls $Process_{i.1}$, $Process_{i.2}$, etc.
3. $User_i$ MM-Embeds $Persona_{i.j}$, at M-$Location_{i.1}$, M-$Location_{i.2}$, etc.
4. $User_i$ MU-Renders $Entity_{i.j}$ at U-$Location_{i.1}$, U-$Location_{i.2}$, etc.
5. $User_i$ MM-Sends $Object_{1.2}$ with $User_j$.

Note1 A = Audio, A-V = Audio-Visual, A-V-H = Audio-Visual-Haptic, SA=Spatial Attitude.
Note2 If a Composite Action is listed, its Basic Actions are not listed, unless they are independently used by the Use Case.

7.2 Virtual Lecture

7.2.1 Description

1. $User_1$ (Manager):
   1.1. Authors an $Entity_{1.1}$ (virtual classroom).
   1.2. MM-Embeds $Entity_{1.1}$ at M-$Location_{1.1}$.
2. $User_2$ (Student):
   2.1. Tracks $Persona_{2.1}$ (A-V) at $Location_{2.1}$ with SA.
   2.2. Pays to attend and make a copy of their Experiences at the lecture.
   2.3. MM-Embeds $Persona_{2.1}$ (A-V) at $Location_{2.2}$ (a seat in the classroom) with SA.
3. $User_3$ (Teacher):
   3.1. Tracks $Persona_{3.1}$ (A-V) at $Location_{3.1}$ with SA.
   3.2. MM-Embeds $Persona_{3.1}$ (A-V) at $Location_{3.1}$ with SA.
   3.3. MM-Embeds to M-$Location_{3.2}$ (desk in classroom).
   3.4. Holds a lecture at M-$Location_{3.2}$.
   3.5. Presents an animated 3D experiment model at M-$Location_{3.3}$ (close to M-$Location_{3.2}$).
4. Student

4.1. MM-Adds Persona$_{2.1}$ (A-V) at M-Location$_{2.3}$ (close to Teacher for better view).
4.2. Writes Experience$_{2.1}$ at Address.

5. Teacher is paid for giving the lecture.

7.2.2 Workflow and Actions

Table 13 – Virtual Lecture workflow and actions.

Who	Does	What	Where/comment
human$_1$ (Manager)	Registers		With M-Environment
User$_1$ (Manager)	Authors	Entity$_{1.1}$	Classroom model
	MM-Embeds	Entity$_{1.1}$	M-Location$_{1.1}$
human$_2$ (Student)	Registers		With M-Environment
User$_2$ (Student)	Authors	Persona$_{2.1}$	(Student's Avatar)
	Track	Persona$_{2.1}$ (A-V)	M-Location$_{2.1}$ w/ SA
	Transacts	Value	Lecture fee & Experience
	MM-Embeds	Persona$_{2.1}$ (A-V)	M-Location$_{2.2}$ (classroom)
User$_1$ (Manager)	Authenticates	Persona$_{2,1}$	
User$_2$ (Student)	MM-Disables	Persona$_{2.1}$ (A-V)	Location$_{2.1}$
	Writes	Experience	Address$_{2.1}$
User$_3$ (Teacher)	Registers		With M-Environment
	Authors	Persona$_{3.1}$	
	Track	Persona$_{3.1}$ (A-V)	M-Location$_{3.1}$ w/ SA
	MM-Embeds	Persona$_{3.1}$ (A-V)	M-Location$_{3.2}$ (desk in classroom)
User$_1$ (Manager)	Authenticates	User$_3$	
User$_3$ (Teacher)	MM-Disables	Persona$_{3.1}$ (A-V)	Location$_{3.1}$
	MM-Embeds	3D Model	M-Location$_{3.3}$
	Calls	Service$_{3.1}$	To MM-Animate 3D Model
User$_1$ (Manager)	Transacts	Value	To User$_2$ (Consideration)
User$_3$ (Teacher)	MM-Embeds	Persona$_{3.1}$ (A-V)	M-Location$_{3.1}$ (back home)
	MM-Disables	Persona$_{3.1}$ (A-V)	Location$_{3.2}$
User$_2$ (Student)	MM-Embeds	Persona$_{2.1}$ (A-V)	M-Location$_{2.1}$ (back home)
	MM-Disables	Persona$_{2.1}$ (A-V)	Location$_{2.2}$

7.2.3 Actions, Items, and Data Types

Actions	Items	Data Types
Authenticate	Service	Amount
Author	Entity	Coordinates
MM-Embed	M-Location	Currency
MM-Disable	U-Location	Spatial Attitude
MM-Animate	Value	Value
Register	User	
Track	Persona	
Transact	Experience	
Write		

7.3 Virtual Meeting

7.3.1 Description

1. $User_1$ (Meeting Manager)
   1.1. MM-Embeds virtual meeting room at $M\text{-}Location_{11}$.
   1.2. MM-Embeds $Persona_{1.1}$ (Virtual Secretary) at $M\text{-}Location_{1.2}$.
   1.3. MM-Animates $Persona_{1.1}$ (Virtual Secretary).
2. $User_2$ (Meeting participant):
   2.1. Tracks $Persona_{2.1}$ (A-V) at $Location_{2.1}$ (meeting room) with SA.
   2.2. MM-Embeds $Persona_{2.1}$ (A-V) to $M\text{-}Location_{2.2}$ with SA.
   2.3. MM-Disables $Persona_{2.1}$ (A-V) from $Location_{2.1}$.
   2.4. Interprets (requests translation of speech of) $User_3$'s $Persona_{3.1}$.
   2.5. MM-Embeds $Entity_{2.1}$ (3D presentation) at $M\text{-}Location_{2.3}$ (in the room).
   2.6. Calls $Service_{2.1}$ to MM-Animate 3D presentation.
3. Virtual Secretary ($Persona_{1.1}$ UM-Animated by $Service_{1.1}$):
   3.1. Interprets $Persona_{2.1}$'s Personal Status.
   3.2. Produces Summary of $Persona_{2.1}$'s speech adding graphical signs to express $Persona_{2.1}$'s Personal Status.
   3.3. MM-Embeds Summary at $M\text{-}Location_{1.3}$ for participants to read and comment.

7.3.2 Workflow and Actions

Table 14 – Virtual Meeting workflow and actions.

Who	Does	What	Where/comment
$User_1$ (Manager)	MM-Embeds	$Entity_{1.1}$	(Meeting room) $M\text{-}Location_{1.1}$
	MM-Embeds	$Persona_{1.1}$	(Virtual Secretary) $M\text{-}Location_{1.2}$
	MM-Animates	$Persona_{1.1}$	Operates Virtual Secretary.
$User_2$ (Participant)	Tracks	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$ w/ SA
	MM-Embeds	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.2}$ w/ SA
	MM-Disables	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$
$User_3$ (Participant)	Tracks	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.1}$ w/ SA
	MM-Embeds	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.2}$ w/ SA
	MM-Disables	$User_3$	$M\text{-}Location_{3.1}$
$User_2$ (Participant)	Interprets	$Persona_{3.1}$	(Requests translation)
	MM-Embeds	$Entity_{2.1}$	(3D presentation) $M\text{-}Location_{2.2}$
	Calls	$Process_{2.1}$	(MM-Animate 3D presentation)
Virtual Secretary	Interprets	$Persona_{2.1}$	(Personal Status)
	Produces	$Entity_{1.2}$	(Summary)
	MM-Embeds	$Entity_{1.2}$	$M\text{-}Location_{1.3}$ (in the room)
	MM-Disables	$Persona_{1.1}$	$M\text{-}Location_{1.2}$
$User_2$ (Participant)	Writes	Event	$Address_{2.1}$
	MM-Embeds	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$ (back home)
	MM-Disables	$Persona_{2.1}$ (A-V)	$Location_{2.2}$
$User_3$ (Participant)	MM-Embeds	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{2.1}$ (back home)
	MM-Disables	$Persona_{3.1}$ (A-V)	$Location_{3.2}$ (back home)

7.3.3 Actions, Items, and Data Types

Actions	Items	Data Types
Authenticate	Persona	Spatial Attitude
Call	User	Coordinates
Interpret	Entity	
MM-Animate	Service	
MM-Capture		
MM-Embed		
MM-Disable		
Register		
Track		
Write		

7.4 Hybrid working

7.4.1 Description

Company applies mixed in-presence and remote working policy.

1. Physical Workers attend Company physically.
2. All Workers
   2.1. Are Authenticated.
   2.2. Are present in the Virtual office.
   2.3. Communicate by Sharing AV messages (except R-worker to R-worker).
   2.4. Participate in Virtual meetings.

7.4.2 Workflow and Actions

Table 15 – Hybrid Working workflow and actions.

Who	Does	What	Where/comment
$User_1$ (Manager)	Authors	$Entity_{1.1}$ (A-V)	V-Office
	MM-Embeds	$Entity_{1.1}$	$M\text{-}Location_{1.1}$
	MM-Animates	$Persona_{1.1}$ (A-V)	$M\text{-}Location_{1.2}$ (V-Worker auth)
$User_2$ (R-Worker)	Tracks	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$ (V-Office)
$User_3$ (V-Worker)	Tracks	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.1}$ (home)
	MM-Embeds	$Persona_{3.1}$	$M\text{-}Location_{3.2}$ w/ SA (V-Desk)
$User_1$ (Manager)	Authenticates	$User_3$	
$User_3$ (V-Worker)	MM-Sends	$Objects_{3.1}$ (A)	$Persona_{2.1}$ (A-V)
	MM-Embeds	$Persona_{3.1}$	$M\text{-}Location_{3.3}$ (talk “in person”)
	MM-Disables	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.2}$
	MM-Embeds	$Persona_{3.1}$	$M\text{-}Location_{3.4}$ (V-Meeting)
	MM-Disables	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.3}$
$User_2$ (R-Worker)	MM-Embeds	$Persona_{2.1}$	$M\text{-}Location_{3.4}$ (V-Meeting)
	MM-Disables	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{2.2}$
	MM-Embeds	$Entity_{2.1}$	(Whiteboard) $M\text{-}Location_{3.4}$
	Calls	$Service_{2.1}$	To operate Whiteboard
	MM-Embeds	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$ (back home)

	MM-Disables	Persona$_{2.1}$	From M-Location$_{3.4}$
User$_3$ (V-Worker)	MM-Embeds	Persona$_{3.1}$ (A-V)	M-Location$_{3.1}$ (back home)
	MM-Disables	Persona$_{3.1}$ (A-V)	From M-Location$_{3.4}$

7.4.3 Actions, Items, and Data Types

Actions	**Items**	**Data Types**
Author	User	Spatial Attitude
MM-Embed	Persona (AV)	Position
Call	Entity	Orientation
Track	U-Location	Coordinates
MM-Embed	M-Location	
MM-Disable	Object (A)	
MM-Send	Service	

7.5 eSports Tournament

7.5.1 Description

1. User$_1$ (Site Manager)
   1.1. Authors Entity$_{1.1}$ (game landscape).
   1.2. MM-Embeds Entity$_{1.1}$ (game landscape) at M-Location$_{1.1}$.
2. User$_2$ (Game Manager)
   2.1. MM-Embeds Personae$_{2.i}$ with Spatial Attitude at M-Locations$_{2.i}$ (Autonomous characters).
   2.2. MM-Animates Personae$_{2.i}$.
   2.3. Calls Service$_{2.1}$ (virtual camera/microphone control).
   2.4. MU-Renders Entities at M-Location$_{1.1}$ to:
      2.4.1. U-Location$_{2.1}$ via Device$_{1.1}$ (screen).
      2.4.2. Various U-Locations (via streaming).
3. User$_2$ (Game Manager)
   3.1. MM-Embeds Entity$_{1.i}$ (autonomous characters, e.g., dragon, monsters) at M-Location$_{1.i+1}$ with Spatial Attitude.
   3.2. UM-Animates Entity$_{1.i}$.
4. User$_3$ (Player)
   4.1. Tracks Persona$_{3.1}$ (A-V) at Location$_{3.1}$ with Spatial Attitude.
      4.1.1. Wearing a costume with different roles (e.g., magician, warrior), forms and physical features, and abilities (e.g., cast spells, shoot, fly, jump).
      4.1.2. Calls Process$_{3.1}$ (specific of roles, abilities, etc.)

7.5.2 Workflow

Table 16 – eSports Tournament workflow and actions.

Who	**Does**	**What**	**Where/comment**
human$_1$ (Site Mgr)	Registers	User$_1$	M-Environment
User$_1$ (Site Mgr)	Authors	Entity$_{1.1}$	Game landscape
	MM-Embeds	Entity$_{1.1}$	M-Location$_{1.1}$ (Game landscape)
human$_2$ (Game Mgr)	Registers	User$_2$	M-Environment
User$_2$ (Game Mgr)	Calls	Service$_{2.1}$	(Vcamera/microphone control)

	MM-Embeds	$Persona_{2.i}$	M-Locations (auton. Characters)
	MM-Animates	$Persona_{2.i}$	(Autonomous characters)
$User_3$ (Player)	Registers	$User_3$	M-Environment
	Tracks	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.1}$ with SA

7.5.3 Actions, Items, and Data Types

Actions	**Items**	**Data Types**
Author	User	Spatial Attitude
Call	Persona (A-V)	Coordinates
MM-Animate	Entity	
MM-Embed	Service	
Track	U-Location	
	M-Location	

7.6 Virtual Event

7.6.1 Description

1. $User_1$ (Organiser)
   1.1. Transacts $M\text{-}Location_{1.1}$
   1.2. Authors $Entity_{1.1}$ (virtual auditorium).
   1.3. MM-Embeds $Entity_{1.1}$ at $M\text{-}Location_{1.1}$.
   1.4. Calls $Service_{1.1}$ (to collect Users' Preferences).
2. $User_2$ (Performer)
   2.1. Authors $Persona_{2.1}$ (AV).
   2.2. Tracks $Persona_{2.1}$ (AV) with Spatial Attitude at $MLocation_{2.2}$ (in virtual auditorium).
   2.3. MM-Disables $Persona_{2.1}$ from $Location_{2.1}$.
3. $User_3$ (Participant)
   3.1. Authors $Persona_{3.1}$ (AV).
   3.2. Transacts $Ticket_{3.1}$ (buys ticket).
   3.3. Tracks $Persona_{3.1}$ (AV) with Spatial Attitude at $Location_{3.2}$ (in virtual auditorium).
   3.4. MM-Disables $Persona_{3.1}$ (AV) from $Location_{3.1}$.
   3.5. MM-Sends $Object_{3.1}$(A) to $Persona_{4.1}$ (Participant).
   3.6. Calls $Service_{1.1}$ (expresses preferences).
   3.7. MM-Adds $Persona_{3.1}$ at $Location_{3.2}$ (close to stage for 5 minutes).
4. $User_1$ (Organiser)
   4.1. MM-Disables $Persona_{3.1}$ from $Location_{3.2}$ (5 minutes passed).
   4.2. Calls $Service_{1.1}$ (Collects preferences).
   4.3. Interprets Participants Status (of all participants).
   4.4. MM-Embeds $Entities_{1.i}$ (SFX).
   4.5. Transacts $Pay_{1.1}$ to $User_2$.
5. $User_2$ (Performer)
   5.1. MM-Embeds $Persona_{2.1}$ (A-V) to $M\text{-}Location_{2.1}$.
   5.2. MM-Disables $Persona_{2.1}$ from $M\text{-}Location_{2.2}$.
6. $User_3$ (Participant)
   6.1. MM-Embeds $Persona_{3.1}$ (A-V) to $M\text{-}Location_{3.1}$.
   6.2. MM-Disables $Persona_{3.1}$ from $M\text{-}Location_{3.2}$.

7.6.2 Workflow and Actions

Table 17 – Virtual Event workflow.

Who	Does	What	Where/comment
$User_1$ (Organiser)	Authors	$Entity_{1.1}$	(Environment for event)
	MM-Embeds	$Entity_{1.1}$	$M\text{-}Location_{1.1}$ (Vauditorium)
	Calls	$Service_{1.1}$	(Collects Preferences)
$human_2$ (Performer)	Registers	$User_2$	M-Environment
$User_2$ (Performer)	Authors	$Persona_{2.1}$ (AV)	
	Tracks	$Persona_{2.1}$ (AV)	$M\text{-}Location_{2.1}$ w/ SA
	MM-Embeds	$Persona_{2.1}$ (AV)	$M\text{-}Location_{2.2}$ (stage)
	MM-Disables	$Persona_{2.1}$ (AV)	$M\text{-}Location_{2.1}$
$human_3$ (Participant)	Registers	$User_3$	with M-Environment
$User_3$ (Participant)	Authors	$Persona_{3.1}$ (AV)	
	Tracks	$Persona_{3.1}$ (AV)	$M\text{-}Location_{3.1}$ w/ SA
	Transacts	Value	(to $User_1$ to buy ticket)
	MM-Embeds	$Persona_{3.1}$ (AV)	$M\text{-}Location_{3.2}$ (Vauditorium)
	MM-Disables	$Persona_{3.1}$ (AV)	$M\text{-}Location_{3.1}$
	MM-Sends	Object (A)	(Utters to $User_4$ (Participant))
$User_4$ (Participant)	MM-Sends	Object (A)	(Utters to $User_3$ (Participant))
$User_3$ (Participant)	Calls	$Service_{1.1}$	Expresses preferences
	MM-Embeds	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.3}$ (@ stage, for 5')
$User_1$ (Organiser)	Interprets	Users (Participants)	(Gets Participants Status)
	Embeds	Entities	(SFX)
	Transacts	Value	To $User_2$ (pays Performer)
$User_2$ (Performer)	MM-Embeds	$Persona_{2.1}$ (A-V)	$M\text{-}Location_{2.1}$ (back home)
	MM-Disables	$Persona_{2.1}$ (A-V)	From $M\text{-}Location_{2.2}$
$User_3$ (Participant)	MM-Embeds	$Persona_{3.1}$ (A-V)	$M\text{-}Location_{3.1}$ (back home)
	MM-Disables	$Persona_{3.1}$ (A-V)	From $M\text{-}Location_{3.2}$

7.6.3 Actions, Items, and Data Types

Actions	Items	Data Types
Author	User	Spatial Attitude
MM-Embed	Persona (A-V)	Amount
Call	Entity (A-V)	Currency
Register	Service	Value
Track	U-Location	Coordinates
Transact	M-Location	Personal Status
MM-Disable	Object (A)	Cognitive State
MM-Send	Value	Emotion
Interpret		Social Attitude

7.7 AR Tourist Guide

7.7.1 Description

This Use Case describes how this Technical Report can support a use case where a human intends to develop a tourist application by developing an App that alerts the holder of a smart phone where the App is installed and lets them view Entities and talk to autonomous agents metaverse agents residing at M-Locations:

1. $User_1$
    1. Buys $M\text{-}Location_{1.1}$ (parcel) in an M-Environment.
    2. Creates $Entity_{1.1}$ (landscape suitable for a virtual path through n sub-M-Locations).
    3. Embeds $Entity_{1.1}$ (landscape) on $M\text{-}Location_{1.1}$ (parcel).
    4. Sells $Entity_{1.1}$ (landscape) and $M\text{-}Location_{1.1}$ (parcel) to a $User_2$.
2. $User_2$
    1. Authors $Entity_{2.1}$ to $Entity_{2.n}$ for the M-Locations.
    2. Embeds the Entities at $M\text{-}Location_{2.1}$ to $M\text{-}Location_{2.n}$.
    3. Sells the result to $User_3$.
3. $human_4$
    1. Develops
        1. Map recording the pairs $M\text{-}Location_{2.i}$ – $U\text{-}Location_{2.i}$
        2. App alerting a $human_5$ holding the Device with the App installed that a key U-Location has been reached.
    2. Sells Map and App to $human_3$.
4. $User_3$ MM-Embeds one or more autonomous Personae at $M\text{-}Location_{2.1}$ to $M\text{-}Location_{2.n}$.
5. When $human_5$ gets close to a key U-Location:
    1.1. App prompts Device to Request $User_3$ to MU-Render the $Entity_{2.i}$ MM-Embedded at $M\text{-}Location_{2.i}$ to the key $U\text{-}Location_{2.i}$.
    1.2. $human_5$ interacts with MU-Rendered $Entity_{2.i}$ that may include an MM-Animated $Persona_{2.i}$.

7.7.2 Workflow

Table 18 – AR Tourist Guide workflow.

Who	Does	What	Where/comment
$User_1$	Transacts	$M\text{-}Location_{1.1}$	(Parcel in an M-Environment)
	Authors	$Entity_{1.1}$	(A landscape for the parcel)
	MM-Embeds	$Entity_{1.1}$	$M\text{-}Location_{1.1}$
	Transacts	$Entity_{1.1}$	$User_2$ (landscape)
	Transacts	$M\text{-}Location_{1.1}$	$User_2$ (parcel)
$User_2$	Authors	$Entity_{2.1}$ to $Entity_{2.n}$	Promotion material for U-Locations.
	MM-Embeds	$Entity_{2.1}$ to $Entity_{2.n}$	$M\text{-}Location_{2.1}$ to Location $_{2.n}$
	Writes	M-Locations	$Address_{2.1}$
	MM-Sends	$Address_{2.1}$	$User_4$
	Transacts	$Entity_{1.1}$	$User_4$ (landscape)
	Transacts	$M\text{-}Location_{1.1}$	$User_4$ (parcel)
	Transacts	$Entity_{2.1}$ to $Entity_{2.n}$	$User_4$
$human_3$	develops	$Map_{3.1}$	($U\text{-}location_{2.i}$-$M\text{-}Location_{2.i}$-$Metadata_{2.i}$)
	sells	Map and App	To $human_4$

$User_4$	MM-Embeds	$Persona_{4.1}$-$Persona_{4.n}$	$M\text{-}Location_{2.1}$ to $Location_{2.n}$ w/ SA
	MM-Animates	$Persona_{4.1}$-$Persona_{4.n}$	$M\text{-}Location_{2.1}$ to $M\text{-}Location_{2.n}$
$human_5$	downloads	App	(To Device)
	approaches	$U\text{-}Location_{2.i}$	(App's key point)
App	prompts	$Device_{5.1}$	
$Device_{5.1}$	MM-Send	$Message_{5.1}$	$User_4$ ($Persona_{4.i}$)
$Persona_{4.i}$	MU-Sends	$Entity_{2.i}$	$U\text{-}Location_{2.i}$
$human_5$	interacts		(W/ MU-Rendered $Entity_{4.i}$ and $Persona_{4.i}$)

7.7.3 Actions, Items, and Data Types

Actions	**Items**	**Data Types**
Transact	User	Spatial Attitude
Author	Entity	Amount
MM-Embed	Device	Currency
MM-Animate	App	Value
Write	M-Location	Coordinates
Send	U-Location	Spatial Attitude
MU-Render	Map	
MM-Send	Service	
	Persona	

7.8 Virtual Dance

7.8.1 Description

1. $User_2$ (dance teacher)
   1.1. Teaches dance in a virtual classroom.
   1.2. Works at $M\text{-}Location_{2.1}$ where its digital twin $Persona_{2.1}$ is Audio-Visually MM-Embedded.
   1.3. MM-Embeds and MM-Animates $Persona_{2.2}$ (A-V) (another of its Personae) at $M\text{-}Location_{2.2}$ as virtual secretary to attends to students coming to learn dance.
2. $User_1$ (dance student #1):
   2.1. MM-Embeds its $Persona_{1.1}$ (A-V) at $Location_{1.1}$ (its "home").
   2.2. Audio-Visual-Haptically MM-Embeds $Persona_{1.1}$ (A-V-H) at $Location_{1.2}$ close to $Location_{2.2}$.
   2.3. Sends $Object_{1.1}$ (A) to $Persona_{2.2}$ (greets virtual secretary).
3. Virtual secretary:
   3.1. Sends $Object_{2.1}$ (A) to dance students #1 (reciprocates greeting).
   3.2. Send $Object_{2.2}$ (A) to call regular dance teacher's $Persona_{2.1}$.
4. Dance teacher MM-Embeds (A-V-H) $Persona_{2.1}$ at $Location_{2.3}$ (classroom) where it dances with $Persona_{1.1}$ (dance student #1).
5. While $Persona_{1.1}$ (student #1) and $Persona_{2.1}$ (teacher) dance, $User_3$ (dance student #2):
   5.1. MM-Embeds (A-V) $Persona_{3.1}$ (its digital twin) at $Location_{3.1}$ (its "home").
   5.2. MM-Embeds (A-V-H) $Persona_{3.1}$ to $Location_{3.2}$ (close to $Location_{2.2}$ where the secretary is located).
6. After a while, $User_2$ (dance teacher):
   6.1. MM-Embeds (A-V-H) $Persona_{2.1}$ at $Location_{2.4}$, (close to $Location_{3.2}$ of dance student #2).

6.2. MM-Disables $Persona_{2.1}$ from $Location_{2.3}$ where it was dancing with $Persona_{1.1}$ (student #1).
6.3. MM-Embeds (A-V-H) and MM-Animates an autonomous $Persona_{2.3}$ replacing $Persona_{2.1}$ from $Location_{2.3}$ so that student #1 can continue practising dance.
6.4. Dances with $Persona_{3.1}$ (student #2).

7.8.2 Workflow

Table 19 – Virtual Dance workflow.

Who	Does	What	Where/(comment)
$User_2$ (Teacher)	Tracks	$Persona_{2.1}$ (AV)	$M\text{-}Location_{2.1}$
	MM-Embeds	$Persona_{2.2}$ (AV)	$M\text{-}Location_{2.2}$ w/ SA
	MM-Animates	$Persona_{2.2}$ (AV)	$M\text{-}Location_{2.2}$
$User_1$ (Student)	Tracks	$Persona_{1.1}$ (AV)	$M\text{-}Location_{1.1}$
	Transacts	$Value_{1.1}$	(Lesson fees)
	MM-Embeds	$Persona_{1.1}$ (AVH)	$M\text{-}Location_{1.2}$ w/ SA
	MM-Disables	$Persona_{1.1}$	$M\text{-}Location_{1.1}$
	MM-Sends	$Object_{1.1}$ (A)	$Persona_{2.2}$ (greetings)
$User_2$ ($Persona_{2.2}$)	MM-Sends	$Object_{2.1}$ (A)	$Persona_{1.1}$ (greetings)
	MM-Sends	$Object_{2.2}$ (A)	$Persona_{2.1}$ (alert)
$User_2$ ($Persona_{2.1}$)	MM-Embeds	$Persona_{2.1}$	$M\text{-}Location_{2.3}$ w/ SA
	MM-Disables	$Persona_{2.2}$	$M\text{-}Location_{2.2}$
	MM-Embeds	$Object_{2.3}$ (A)	$M\text{-}Location_{2.4}$ (music)
$Persona_{1.1}$			(dances)
$Persona_{2.1}$			(dances)
$User_3$ (Student)	Tracks	$Persona_{3.1}$ (AV)	$M\text{-}Location_{3.1}$
	Transacts	$Value_{3.1}$	(Lesson fees)
	MM-Embeds	$Persona_{3.1}$ (AVH)	$M\text{-}Location_{3.2}$ w/ SA
	MM-Disables	$Persona_{3.1}$	$M\text{-}Location_{3.1}$
$User_2$ (Teacher)	MM-Disables	$Persona_{2.1}$	$M\text{-}Location_{2.3}$
	MM-Embeds	$Persona_{2.3}$	$M\text{-}Location_{2.4}$ w/ SA
	Animates	$Persona_{2.3}$	$M\text{-}Location_{2.4}$
$Persona_{3.1}$			(dance)
$Persona_{2.1}$			(dance)

7.8.3 Actions, Items, and Data Types

Actions	Items	Data Types
MM-Embed	Persona (AV)	Spatial Attitude
MM-Animate	Persona (AVH)	Amount
MM-Send	M-Location	Currency
Track	U-Location	Value
Transact	Service	
MM-Disable	Value	
	Object (A)	

8 Functionality Profiles

8.1 Profile elements

Table 1 lists the currently identified Actions, Items and Data Types. Actions in italic require more than one Action to be executed. Actions preceded by a "-" are Basic Actions belonging to the Actions in italic.

Table 20 – Metaverse Actions, Entities, and Data Types

Actions	Items	Data Types
Authenticate	Account	Address
Author	Activity Data	Amount
Call	App	Cognitive State
Change	Asset	Coordinates
Create	Device	Currency
Destroy	Entity	Emotion
Discover	Event	Orientation
Inform	Experience	Personal Status
Interpret	Identifier	Point
MM-Add	Interaction	Point of View
MM-Animate	Item	Position
MM-Capture	Map	Social Attitude
MM-Embed	M-Environment	Spatial Attitude
MM-Enable	Message	Time
MM-Disable	M-Instance	
MM-Render	M-Location	
MM-Send	Model	
MU-Render	Object	
MU-Send	Persona	
MU-Send	Personal Profile	
Post	Process	
Read	Provenance	
Register	Request-Authenticate	
Track	Request-Discover	
Transact	Request-Inform	
UM-Animate	Request-Interpret	
UM-Capture	Response-Authenticate	
UM-Render	Response-Discover	
UM-Send	Response-Inform	
UM-Send	Response-Interpret	
Write	Rights	
	Rules	
	Scene	
	Service	
	Social Graph	
	Stream	
	Transaction	

	U-Environment	
	U-Location	
	User	
	User Data	
	Value	
	Wallet	

8.2 Profile structure

The structure of the Metaverse Functionality Profiles includes hierarchical Profiles and independent Profiles. Profiles may have Levels. As depicted in Figure 2, the currently identified Profiles are Baseline, Management, Finance, and High. Details are provided in the next Sections. The currently identified Levels for Baseline, Management, and High Profiles are Audio only, Audio-Visual, and Audio-Visual-Haptic.

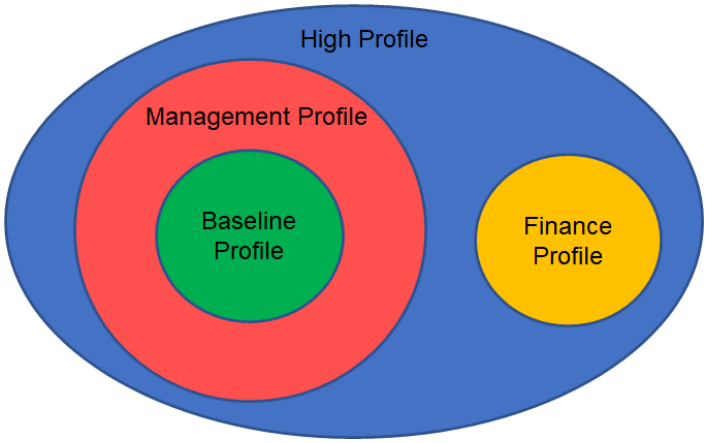

Figure 2 - the currently identified Functionality Profiles

Four Profiles serve well the needs conveyed by the identified Functionalities. As more of them will be added, the number of Profiles and potentially of Levels, is likely to increase.

8.3 Baseline Functionality Profile

The Baseline Functionality Profile enables a human equipped with a Device to allow their Users to:

1. Author Entities, e.g., Object Model.
2. Sense a scene at a U-Location:
   2.1. UM-Capture a scene.
   2.2. UM-Send Data.
3. MM-Embed Personae and Objects:
   3.1. MM-Add Persona and Object.
   3.2. Animate a Persona, with a Stream (UM-Animate) or using a Process (MM-Animate).
   3.3. Render Object at M-Location.
4. MM-Capture an M-Location.
5. MU-Send the M-Location MM-Captured by a User.
   5.1. MU-Send M-Location.
   5.2. Render M-Location at U-Location.
6. MM-Disable an Object.

This Profile supports baseline lecture, meeting, and hang-out Use Cases. Transactions and User management are not supported.

Table 21 lists the Actions, Entities, and Data Types of the Baseline Functionality Profile.

Table 21 – Actions, Entities, and Data Types of the Baseline Functionality Profile

Actions	Items	Data Types
Author	Device	Address
Call	Event	Coordinates
Create	Experience	Orientation
Destroy	Identifier	Point of View
MM-Add	Map	Position
MM-Animate	M-Location	Spatial Attitude
MM-Capture	Model	
MM-Embed	Object	
MM-Enable	Persona	
MM-Disable	Process	
MM-Render	Rights	
MM-Send	Rules	
MU-Render	Scene	
MU-Send	Service	
MU-Send	Social Graph	
Post	Stream	
Read	Transaction	
Register	U-Environment	
Track	U-Location	
Transact	User	
UM-Animate	User Data	
UM-Capture	Value	
UM-Render	Wallet	
UM-Send		
UM-Send		
Write		

8.4 Management Functionality Profile

The Management Functionality Profile supports all Actions, Items, and Data Types of the Baseline Profile and those enabling a controlled ecosystem where humans Register, Users are Authenticated, and advanced Services, such as Discover and Interpret, can be Called. As depicted in Figure 3, it is a superset of the Baseline Profile.

Table 22 – Actions, Entities, and Data Types of Management Profile

Actions	Items	Data Types
Authenticate	Account	Address
Author	Activity Data	Cognitive State
Call	App	Coordinates
Change	Asset	Emotion

Create	Device	Orientation
Destroy	Entity	Personal Status
Discover	Event	Point
Inform	Experience	Point of View
Interpret	Identifier	Position
MM-Add	Interaction	Social Attitude
MM-Animate	Map	Spatial Attitude
MM-Capture	M-Environment	Time
MM-Embed	Message	
MM-Enable	M-Instance	
MM-Disable	M-Location	
MM-Render	Model	
MM-Send	Object	
MU-Render	Persona	
MU-Send	Personal Profile	
MU-Send	Process	
Read	Request-Authenticate	
Register	Request-Discover	
Track	Request-Inform	
UM-Animate	Request-Interpret	
UM-Capture	Response-Authenticate	
UM-Render	Response-Discover	
UM-Send	Response-Inform	
UM-Send	Response-Interpret	
Write	Rights	
	Rules	
	Scene	
	Service	
	Social Graph	
	Stream	
	U-Environment	
	U-Location	
	User	
	User Data	

8.5 Finance Functionality Profile

The Financia Functionality Profile enables a User to Post Assets and make Transactions. As depicted in Figure 3, this Profile is independent of the Basic and management Profiles. It contains a subset of the Actions, Items, and Data Types of the Baseline Profile and adds Financia-related Actions, Items, and Data Types. Currently, this Profile does not have Levels.

Table 23 – Actions, Entities, and Data Types of the Financia Profile

Actions	Items	Data Types
Authenticate	Account	Amount
Author	Activity Data	Currency
Call	Asset	Time

Change	Device	
Create	Identifier	
Destroy	Item	
Discover	M-Location	
Inform	Object	
MM-Add	Provenance	
MM-Animate	Request-Authenticate	
MM-Capture	Request-Discover	
MM-Embed	Request-Inform	
MM-Enable	Response-Authenticate	
MM-Disable	Response-Discover	
MM-Render	Response-Inform	
MM-Send	Rights	
MU-Render	Rules	
MU-Send	Scene	
MU-Send	Service	
Post	Transaction	
Read	U-Environment	
Register	U-Location	
Track	User	
Transact	Value	
Write	Wallet	

8.6 High Functionality Profile

This Profile includes all other Profiles. The list of Actions, Entities, and Data Types required for this Profile is provided by Table 20.

9 Conclusions

This Technical Report provides the following foundational elements supporting the MPAI roadmap targeting Interoperability of Metaverse Instances/Environments. It is organised as follows:

1. Definitions
2. Metaverse walkthrough
3. Basic Metaverse elements:
   3.1. Actions
   3.2. Items
   3.3. Data Types
4. Use Cases
5. Functionality Profiles.

This Technical Report demonstrates the feasibility of the first two milestones of the proposed MPAI roadmap to Metaverse Interoperability. Currently, four Functionality Profiles have been identified to ssupport the selected Functionalities. As more Basic Metaverse elements are added, however, more Profiles are likely to be found necessary. Functionality Profiles can be extended and restructured as more Functionalities will be added.

The next step is the development of Technical Specification – MPAI Metaverse Model (MPAI-MMM) – Metaverse Architecture.

10 References

1. MPAI; Technical Report – MPAI Metaverse Model – Functionalities (MPAI-MMM); January 2023; https://mpai.community/standards/mpai-mmm/mpai-metaverse-model/mmm-functionalities/
2. Matt White; Synthetic Reality: AI and the Metaverse; 2023 February 16; https://matthewdwhite.medium.com/synthetic-reality-ai-and-the-metaverse-5c2acf5a3fe6
3. ISO; ISO/IEC 23005 – Media context and control.
4. MPAI; Technical Specification: The Governance of the MPAI Ecosystem V1, 2021; https://mpai.community/standards/resources/#GME.
5. MPAI; Technical Specification: Artificial Intelligence Framework (MPAI-AIF) V1.1; https://mpai.community/standards/resources/#AIF. Also available as IEEE Standard 3301-2022.

Annex 1 - Interoperability of Metaverse Instances

The main feature of Metaverse Functionality Profiles is to enable Interoperability between Metaverse Instances. The meaning of this feature is described by Figure 3, an adaptation of the MPEG-V Media Context and Control standard [2] to the current context representing how Metaverse Instance 1 (MI1) can interoperate with Metaverse Instance 2 (MI2) by converting Data represented in its native Data Formats into the CMS Data Formats. Of course, if MI1 represents its Data in the CMS Data Formats, interface 4 is no longer required.

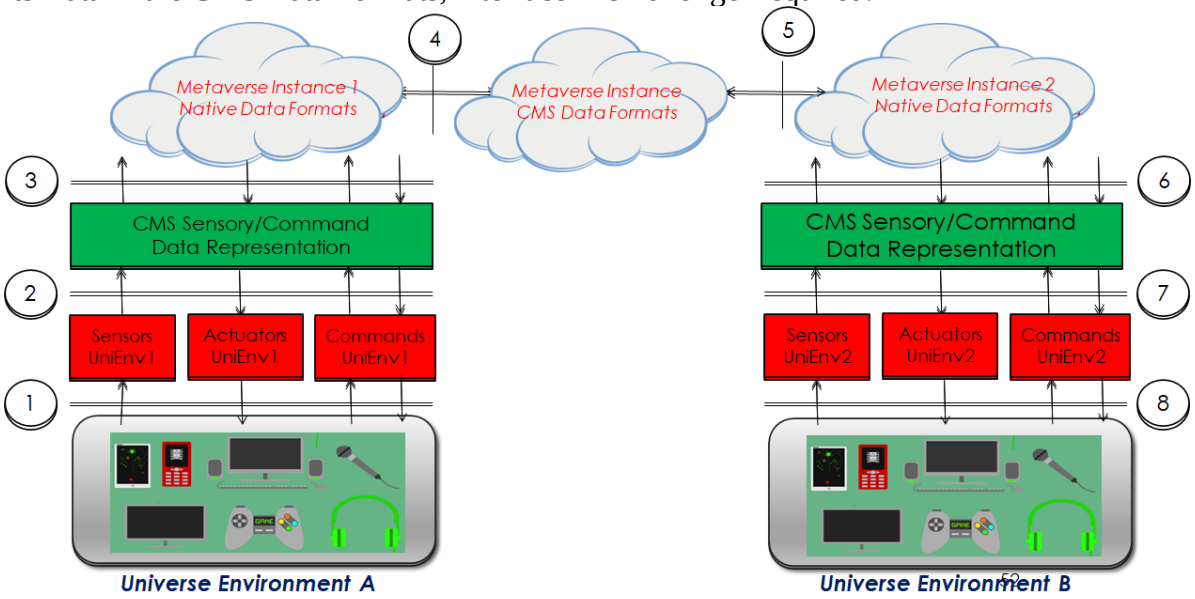

Figure 3 - Interoperability between two Metaverse Instances

The full workflow of Figure 3 can be described as follows:

1. Metaverse Instance 1 internally represents Data based on proprietary Data Formats 1 using Sensing/Actuation Data and Commands in the CMS Format obtained by converting Sensing/Actuation Data and Commands based on Data Formats A from Universe Environment A. Note that there can be a mismatch between:
   1.1. The Sensing Data and Commands from Universe Environment A and Metaverse Instance 1 because the Profile it implements may not be able to handle all Sensing and Command Items received from the Sensors of Universe Environment A.
   1.2. The Actuators of Universe Environment A and the Actuation Data and Commands generated by Metaverse Instance 1 because of their inability to handle the Items received.
2. Metaverse Environment 2 of Metaverse Instance 2 internally represents Data based on proprietary Data Formats 2. However, by converting its Data from Data Format 2 to the CMS Data Format, Universe Environment A can send Sensing Data to, and receive and user Actuation Data from Metaverse Instance B.
3. Metaverse Instance 1 can serve Universe Instance B, within the constraints set by sub-points 1.1. and 1.2., using the process of point 1. above.

The Profiles referenced above are *Technology* Profiles. This document, however, addresses the *Functionality* Profiles. An implementation of a Functionality Profile MI1 interoperates with an MI2 at the following conditions:

1. MI1 and MI2 are based on the same MFP, and
2. Utilise the same technologies to implement the same MFP Functionalities, or
3. Rely on a Service able to convert Data:

3.1. From MI1 to CMS to MI2.
3.2. From MI2 to CMS to MI1.

Mixed solutions of 2. and 3. are also possible.

Annex 2 - MPAI Basics

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

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

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

As a rule, MPAI standards include four documents: Technical Specification, Reference Software Specifications, Conformance Testing Specifications, and Performance Assessment Specifications. The last type of Specification includes standard operating procedures to enable users of MPAI Implementations to make informed decision about their applicability based on the notion of Performance, defined as a set of attributes characterising a reliable and trustworthy implementation.

In the following, If a Term begins with a small letter, it has the commonly used meaning and if with a capital letter, it has either the meaning defined in *Table 1* if it is specific to this Technical Report and in *Table 24* if it is common to all MPAI Standards.

In general, MPAI Application Standards are defined as aggregations – called AI Workflows (AIW) – of processing elements – called AI Modules (AIM) – executed in an AI Framework (AIF). MPAI defines Interoperability as the ability to replace an AIW or an AIM Implementation with a functionally equivalent Implementation.

MPAI also defines 3 Interoperability Levels of an AIF that executes an AIW. The AIW and its AIMs may have 3 Levels:
Level 1 – Implementer-specific and satisfying the MPAI-AIF Standard.
Level 2 – Specified by an MPAI Application Standard.
Level 3 – Specified by an MPAI Application Standard and certified by a Performance Assessor.

MPAI offers Users access to the promised benefits of AI with a guarantee of increased transparency, trust and reliability as the Interoperability Level of an Implementation moves from 1 to 3. Additional information on Interoperability Levels is provided in reference [4**Error! Reference source not found.**].

Figure 4 depicts the MPAI-AIF Reference Model under which Implementations of MPAI Application Standards and user-defined MPAI-AIF Conforming applications operate [5].
MPAI Application Standards normatively specify the Syntax and Semantics of the input and output data and the Function of the AIW and the AIMs, and the Connections between and among the AIMs of an AIW.

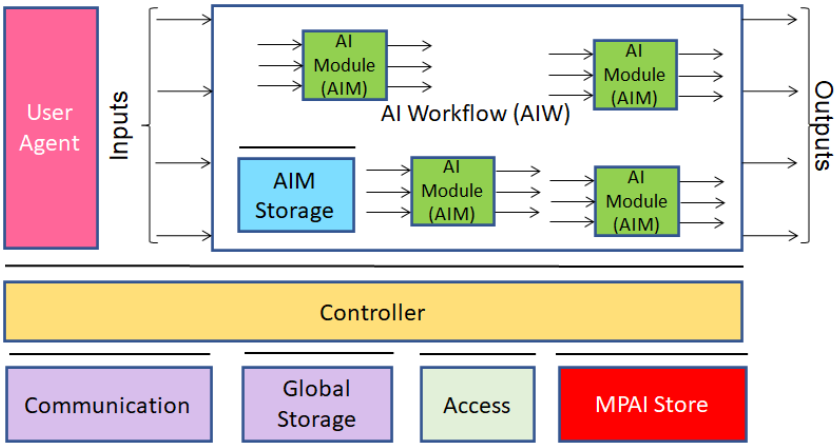

Figure 4 – The AI Framework (AIF) Reference Model

It should be noted that 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 Standards are designed to enable a User to obtain, via standard protocols, an Implementation of an AIW and of the set of corresponding AIMs and execute it in an AIF Implementation. The MPAI Store in *Figure 4* is the entity from which Implementations are downloaded. MPAI Standards assume that the AIF, AIW, and AIM Implementations may have been developed by independent implementers. A necessary condition for this to be possible, is that any AIF, AIW, and AIM implementations be uniquely identified. MPAI has appointed an ImplementerID Registration Authority (IIDRA) to assign unique ImplementerIDs (IID) to Implementers.[3]

A necessary condition to make possible the operations described in the paragraph above is the existence of an ecosystem composed of Conformance Testers, Performance Assessors, the IIDRA and an instance of the MPAI Store. Reference [4**Error! Reference source not found.**] provides a n example of such ecosystem.

[3] At the time of publication of this Technical Report, the MPAI Store was assigned as the IIDRA.

Annex 3 - MPAI-wide terms and definitions

The Terms used in this Technical Report whose first letter is capital and are not already included in Table 1, Table 2, Table 3, and Table 4 are defined in *Table 24*.

Table 24 – 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 AIMName (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
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.
Conformance Tester	An entity Testing 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 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.
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.
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.
Interoperability	The ability to functionally replace an AIM with another AIW having the same Interoperability Level
Interoperability Level	The attribute of an AIW and its AIMs to be executable in an AIF Implementation and to: 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 Means 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 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	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 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 4 - 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".

Life cycle of MPAI Standards

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

MPAI Standards may be modified at any time by corrigenda or new editions. A new edition, however, may not necessarily replace an existing MPAI standard. Visit the web page to determine the status of any given published MPAI Standard.

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

Coverage and Applicability of MPAI Standards

MPAI makes no warranties or representations of any kind concerning its Standards, and expressly disclaims all warranties, expressed or implied, concerning any of its Standards, including but not limited to the warranties of merchantability, fitness for a particular purpose, non-infringement etc. MPAI Standards are supplied "AS IS".

The existence of an MPAI Standard does not imply that there are no other ways to produce and distribute products and services in the scope of the Standard. Technical progress may render the technologies included in the MPAI Standard obsolete by the time the Standard is used, especially in a field as dynamic as AI. Therefore, those looking for standards in the Data Compression by Artificial Intelligence area should carefully assess the suitability of MPAI Standards for their needs.

IN NO EVENT SHALL MPAI BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND

ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

MPAI alerts users that practicing its Standards may infringe patents and other rights of third parties. Submitters of technologies to this standard have agreed to licence their Intellectual Property according to their respective Framework Licences.

Users of MPAI Standards should consider all applicable laws and regulations when using an MPAI Standard. The validity of Conformance Testing is strictly technical and refers to the correct implementation of the MPAI Standard. Moreover, positive Performance Assessment of an implementation applies exclusively in the context of the MPAI Governance and does not imply compliance with any regulatory requirements in the context of any jurisdiction. Therefore, it is the responsibility of the MPAI Standard implementer to observe or refer to the applicable regulatory requirements. By publishing an MPAI Standard, MPAI does not intend to promote actions that are not in compliance with applicable laws, and the Standard shall not be construed as doing so. In particular, users should evaluate MPAI Standards from the viewpoint of data privacy and data ownership in the context of their jurisdictions.

Implementers and users of MPAI Standards documents are responsible for determining and complying with all appropriate safety, security, environmental and health and all applicable laws and regulations.

Annex 5 - The Governance of the MPAI Ecosystem (Informative)

Level 1 Interoperability

With reference to **Error! Reference source not found.** MPAI issues and maintains a standard – c alled MPAI-AIF – whose components are:

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

A Level 1 Implementation shall be an Implementation of the MPAI-AIF Technical Specification executing AIWs composed of AIMs able to call the MPAI-AIF APIs.

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 shall be an Implementation of an MPAI Use Case, and the AIMs shall 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 role	- Verifies the Implementations' security. - Indicates unambiguously that Implementations are Level 3.

The MPAI ecosystem

The following *Figure 5* 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).

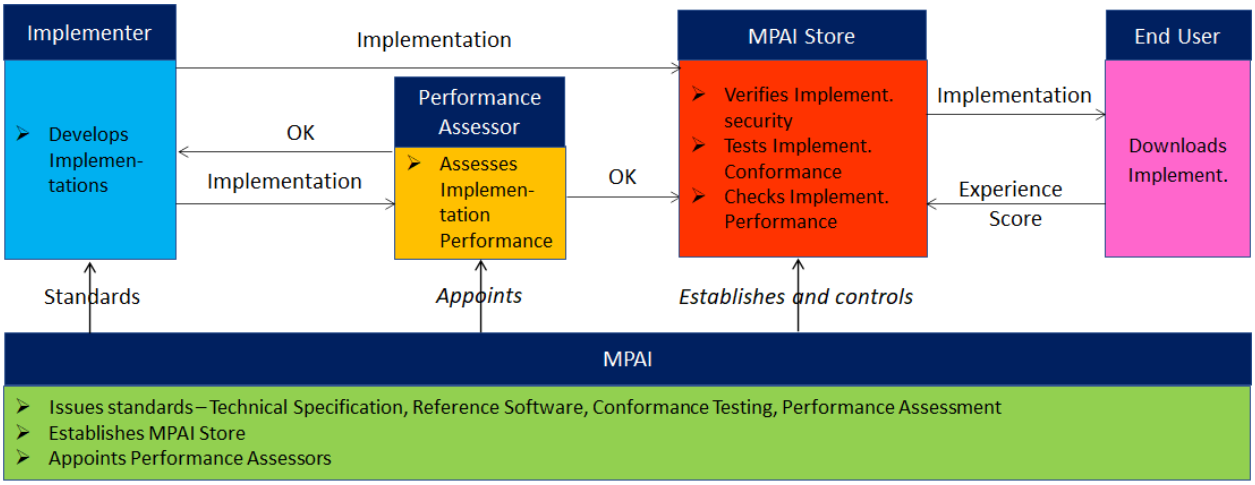

Figure 5 – The MPAI ecosystem operation