



Moving Picture, Audio and Data Coding
by Artificial Intelligence
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This document is a 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 conclusions finally approved by the 31st General Assembly (MPAI-31) on 2023/04/19.



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MPAI Technical Report

MPAI Metaverse Model (MPAI-MMM) Functionality Profiles

WD0.3

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Technical Report

MPAI Metaverse Model – Functionality Profiles

V1 (Under development)

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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, etc. 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. In the following, these are called Metaverse Instances and abbreviated as **M-Instances**.

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. Reference [1] is a Technical Report including definitions, assumptions guiding the MPAI-MMM project, a list of 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.

Many potential metaverse users with different needs might require different technologies to support these needs. Therefore, trying 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.

An assumption made by [1] is that metaverse standardisation should be based on Profiles, i.e., 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. This second document adds the notion of Level, i.e., a subdivision of a Profile indicating the completeness of the user experience provided by a Level.

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, see, e.g., [2] for an overview. To cope with this situation, **the second milestone** described in this document only targets **Functionality Profiles**, i.e., profiles that are defined 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 a Source requests a Destination to perform and of the response to such request.
- Chapter 5** Specifies the Metadata of the **Items** without specifying the Formats of the Data.
- Chapter 6** Specifies the **Data Types** used by requests.
- Chapter 7** Analyses some relevant **Use Cases**.
- Chapter 8** Provides a first set of **Functionality Profiles** with **Levels**.

Continuing the convention adopted in [1], terms beginning with a capital letter have the meaning defined in Table 1, Table 2, Table 3, or Table 4. Terms beginning with a small letter have the meaning commonly defined for the context in which they are used. E.g., *User* is defined in Table 3, *human* is 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 by completing the 4 steps above, the subsequent task of specifying Technology Profiles will be facilitated.

2 Definitions

This document adopts and extends the definitions used by MPAI-MMM Functionalities V1 [1].

Table 1 – General Terms and Definitions

| Terms | Definitions |
|--------|---------------------------|
| 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: <ul style="list-style-type: none"> - A Universe Environment to interact with a Metaverse Instance or - A Metaverse 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 a Metaverse Instance. |
| Functionality | An attribute of a Metaverse Instance expected to be enabled by a Common Metaverse Specifications Tool. |
| Human | |
| - <i>Digital</i> | Either a Digitised or a Virtual Human. |
| - <i>Digitised</i> | The digital representation of a human. |
| - <i>Virtual</i> | 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 entities 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. |
| - <i>Brain-Computer</i> | (BCI) A communication pathway that allows a human to interact with a Metaverse Instance by sensing and processing the electrical activity of the brain. |
| - <i>Haptic</i> | A communication pathway that allows a human to interact with a Metaverse Instance through bodily movements and sensations. |
| - <i>Speech</i> | A communication pathway that allows a human to interact with a Metaverse Instance using spoken language. |
| - <i>Visual</i> | A communication pathway that allows a human to interact with a Metaverse Instance through bodily movements and visual messages. |
| Interoperability | The ability of a Metaverse Instance to exchange 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 Device able to render an Entity in a Universe Environment. |
| - Ecosystem | The ensemble of entities and rules ensuring that Metaverse Instances operate in the interest of Metaverse Stakeholders. |
| - Enabling Service Layer | The set of Services such as payment, security, identity, privacy, etc. that enable operation of a Metaverse Instance. |
| - Environment | A portion of a Metaverse Instance. |
| - Experience Layer | The set of functions, such as Devices, that generate Experiences. |
| - Functionality | The ability of a Metaverse 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 | An implementation providing all or a subset of Functionalities. |
| - Item | A Data Type recognised by a Metaverse Instance. |
| - Infrastructure Layer | The set of functions such as network, transport, storage, and (cloud, edge) processing that enable a Metaverse Instance to operate. |
| - Level | A subdivision of a Profile that indicates the degree of completeness of the Experience provided by that Level. |
| - Manager | The human overseeing the operation of a Metaverse Instance. |
| - Operator | The human overseeing the operation of a Metaverse 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 a Metaverse 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 a Metaverse 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 a Metaverse Instance. |
| - State | The set of values and stored data of a Metaverse Instance at a given time. |
| - Tool | A Technology or group of Technologies enabling a Metaverse 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 | |

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|------------------------|---|
| - <i>Audio</i> | The digital representation of an object or a computer-generated Object that can be rendered to and perceived by a human ear. |
| - <i>Autonomous</i> | A Virtual Object with the ability to act (e.g., move, speak, respond, execute) with a degree of autonomy. |
| - <i>Composite</i> | An Object that includes more than one Object Type. |
| - <i>Digital</i> | A Digitised or a Virtual Object. |
| - <i>Digitised</i> | The digital representation of an object. |
| - <i>Haptic</i> | An Object with the haptic features of an object able to be rendered to provide haptic sensations in a human. |
| - <i>Human</i> | An Object representing a human. |
| - <i>Speech</i> | The digital representation of a sound emitted by the vocal tract of a human or generated by a computer with similar audio characteristics. |
| - <i>Type</i> | One of Audio, Visual, Haptic, Olfaction, and Gustation. |
| - <i>Virtual</i> | A computer-generated Object that is not a Digitised Object. |
| - <i>Visual</i> | The digital representation of an object captured by an electromagnetic or high-frequency audio signal or a 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 | |
| - <i>Functionality</i> | The grouping of Functionalities offered by a Metaverse Profile. |
| - <i>Technology</i> | The grouping of Technologies offered by a Metaverse Profile. |
| Representation | Data that represent an entity of a Universe Environment in a Metaverse Instance. |
| Sense of | |
| - <i>Agency</i> | The subjective awareness of being able to decide, execute, and control one's own actions in a Metaverse Environment. |
| - <i>Embodiment</i> | The engagement of senses to form a complete Environment Experience. |
| - <i>Presence</i> | The feeling of being in a Metaverse 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 | |
| - <i>Fungible</i> | A representation of an Asset that is interchangeable with other Assets of the same type. |
| - <i>Non-Fungible</i> | (NFT) A unique digital identifier of an Asset that: <ul style="list-style-type: none"> - 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. |
| Use Case | An example of the use of a Metaverse Instance in an application domain. |
| User | |
| - <i>Keys</i> | 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. |

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| User Identifier | |
| - <i>Decentralised</i> | An Identifier that enables the verifiable association with a User without requiring a centralised registry. |
| - <i>Self-Sovereign</i> | 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 | |
| - <i>Crypto</i> | 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 a User 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 the Entity MM-Embedded at an M-Location. |

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| 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 requesting that a Service enable the MM-Rendering of an MM-Added Entity. |
| MM-Remove | The Action of requesting that a Service stop MM-Enabling an Entity Embedded at an M-Location. |
| MM-Render | The Action of requesting that a Service present the Entities at an M-Location. |
| MM-Send | The Action of forwarding Data/Metadata or an Item. |
| MU-Render | The Action of requesting that a Device present an Entity at a U-Location. |
| MU-Send | The Composite Action of MU-Streaming an Entity to a Device and MU-Rendering the Entity at a U-Location |
| MU-Stream | The Action of requesting that a Service stream an Entity 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: <ol style="list-style-type: none"> 1. A Service to MM-Add a Persona at an M-Location with a Spatial Attitude. 2. A Device to Sense a U-Location. 3. A Service to UM-Animate the Persona. 4. A Service to MM-Capture the Entities at the M-Location. 5. A Device to MU-Render the Entity at a U-Location. |
| Transact | The Action of a User1 requesting that a Service: <ol style="list-style-type: none"> 1. Assign Rights on an Asset to User2. 2. Cause: <ol style="list-style-type: none"> 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 that a Service change the features of an Entity MM-Embedded at an M-Location with a Spatial Attitude by applying a Stream. |
| UM-Capture | The Action of requesting that a Device request a Sensor to acquire Media from a scene at a U-Location. |
| UM-Render | The Composite Action of: <ol style="list-style-type: none"> 1. Capturing a scene at U-Location. 2. Sending Data and Metadata. 3. Creating an Entity from Sent Data and Metadata. 4. MM-Embedding the Entity at M-Location with Spatial Attitude. 5. MM-Rendering the Entities at the M-Location. |
| UM-Send | The Composite Action of: <ol style="list-style-type: none"> 1. Capturing a scene at a U-Location. 2. Sending Data and Metadata. 3. Creating an Entity from Sent Data and Metadata. 4. MM-Embedding Entity at M-Location with Spatial Attitude. |

| | |
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| UM-Stream | The Action of requesting that a Device stream Data and Metadata. |
| 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 that may be the object of a Transaction. |
| Device | A Process able to: <ul style="list-style-type: none"> 1. UM-Capture Data from a U-Location 2. UM-Stream Data and Metadata to a User. and/or <ul style="list-style-type: none"> 1. MU-Stream 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 includes Metadata that may include Rights. |
| 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: <ul style="list-style-type: none"> 1. Receive: <ul style="list-style-type: none"> 1.1. Items and/or Data 1.2. The Right to Call the Process 2. Produce Items or Data. |

| | |
|-----------------------|--|
| Provenance | The list of all Transactions executed on an Asset starting from the first and including the last. |
| Request-Authenticate | An Item containing the request to a Service to “Authenticate Entity”. |
| 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 Entity”. |
| Response-Authenticate | An Item that contains the response of a Service to an “Authenticate Entity” 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 Entity” request. |
| Response-Interpret | An Item containing the response to the request to Interpret an Entity. |
| 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 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. 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 decimal 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 real 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

This chapter illustrates the operation of M-Instances 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 used without engaging in a definition and vice-versa.
5. The walkthrough uses verbs to indicate the interactions of a Process in the Metaverse, from the Metaverse to the Universe (the real world) and from the Universe to the Metaverse by prefixing MM-, MU-, and UM- to the verb.

3.1 M-Instances

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

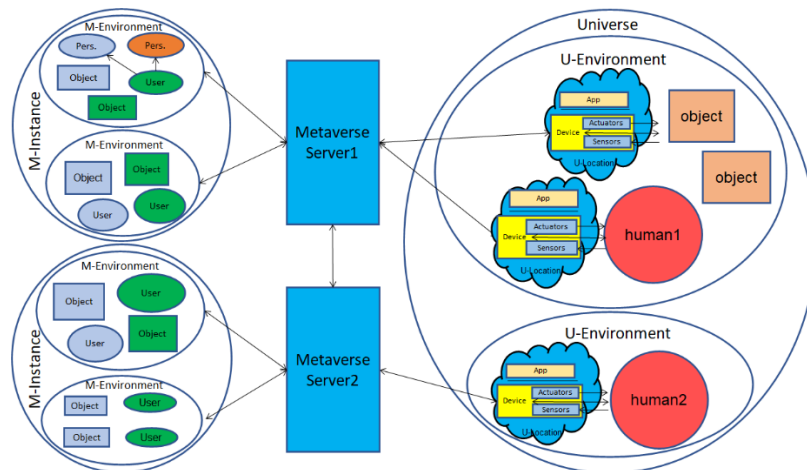


Figure 1 – A Metaverse Scenario of this Technical Report

Universe on the right-hand side of Figure 1 indicates the real world where humans and objects are potentially connected to one or more **Metaverse Servers** through **Devices** that **UM-Capture** scenes with their **Sensors** and **Render Entities** through 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. The two colours of the **M-Environment** at top-left indicating **Personae**, signal the fact that a **User** can be rendered as either a **Persona** that reflects the movements of the human or as an autonomous **Persona**. An **M-Environment** is a portion of an **M-Instance**.

An **M-Instance** is populated by **Objects** potentially having a **Device-enabled** relationship with one or more **U-Environments** or else synthetically generated by an **M-Instance**. A **U-Environment** is an identified portion of the **Universe**. 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**. In Figure 1, humans, objects, and **Devices** of a **U-Environment** can connect to one or more **Metaverse Servers** and may join **M-Environments**.

M-Instances are digital spaces generated by **Services** where **Processes** are executed. This Technical Report has identified three types of **Process**:

- **Service**, i.e., a **Process** offering functionalities necessary for the proper functioning on an **M-Instance/Environment**, e.g., content **Authoring**. May be internal or external.
- **Device**, i.e., a **Process** having either or both the capabilities to **UM-Capture** (i.e., acquire **Data** from a **U-Location**) **Media** and **UM-Stream** **Data** from the **Device** to a **User**, and/or receive **MU-Streamed** **Entities** and **MU-Render** **Media** (i.e., present **Media** at a **U-Location** with a **Spatial Attitude**).
- **User**, i.e., a **Process** representing a human who has an **Account** in an **M-Instance/Environment**. A **User** is **MM-Rendered** as a **Persona** (a **Model** of a human that can be **Audio** only, **Audio-Visual**, or **Audio-Visual-Haptic**) **UM-Animated** (i.e., having the features and position of the **Model** modified) by **Streams** provided by a **Device**, or by **MM-Animated** by an autonomous agent. A **User** exists after a human **Registers** with an **M-Instance/Environment**. An **M-Instance/Environment** may allow a human to have more than one **User** per **Account**. Different **Users** of an **Account** may have different **Rights**.

A **Process** may request another **Process** to perform **Actions** on **Items**, i.e., **Data** having a **Format** recognised by a **Metaverse Instance** as specified in Chapter 5.

Please note that an M-Instance can be implemented so that it executed 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 version of this Technical Report.

3.2 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**, a container of Currency units.
2. **Account** is an Item that unequivocally associates a Registered human with the subset of Items provided by them.
 - 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 that issued the Account.
 - 2.3. An M-Instance/M-Environment may allow a human to have more than one Account.

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 an M-Instance/M-Environment 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). However, the Rules also may prevent a human Registered on an M-Instance from joining another M-Instance.

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.

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 that may include the Rights. **Action** is the transformation or creation of an Item. Processes communicate and interact with other Processes by **MM-Sending** each other Items, and Data and Metadata.

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. Items can be identified across M-Locations (An identifiable delimited portion of a Metaverse Environment.), M-Environments, and **M-Locations**, by virtue of the following structure of their Identifiers: [M-InstanceID] [M-EnvironmentID] [M-LocationID] [Item Identifier].

It should be noted that Actions, Items, and Data Types specified in this Technical Report only reflect a subset of the Functionalities considered so far in [1]. Their number is likely to increase as more Functionalities will be included in future Versions of this Technical Report.

3.3 Actions

A Process performs **Actions** on Items, and Data and Metadata inside an M-Instance to the extent allowed by the Rights held held by the Process in the M-Instance. It can also perform Actions in other M-Instances to the extent allowed by the Rights it 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, that can be:

- 1 **Changed**, i.e., its Rights are modified.
- 2 **Created** by, e.g.:
 - 2.1 A Device Sending Data and Metadata to a Metaverse Environment to a Service.
 - 2.2 A Service Sending the ID of an Entity that includes the Sent Data and Metadata.
Create may be the last step of the UM-Send Composite Action that includes the following Actions: UM-Capture Media to a Device, UM-Stream Data and Metadata to a User, Create an Entity, and MM-Embedd Entity at an M-Location with a Spatial Attitude..
Note that the Create Action is required as Data and Metadata need to be converted to an Entity because they are not immediately usable in a Metaverse Environment:
- 2.3 **UM-Stream** is the Action of a Device making Data and Metadata available to a User.
- 2.4 Data can be an Animation Stream coming from the human twin via a Device. The Device adds Metadata, e.g., Device ID and Rights to Act on the Animation Stream.
- 2.5 The Metadata provided by the Device can be MM-Sent to a Service to Create an Item or to modify the Metadata of an existing Item.
- 2.6 The **Destroy** Action makes an Item unavailable.
- 3 **Discovered**, i.e., by Calling a Service and providing a Request-Discover.
- 4 Be **Informed** about an Item, i.e., get the Metadata of the Item.
- 5 **Write**, i.e., store 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 on a Marketplace.
- **Transact** an Asset.

A User can Call a Service to perform Actions on **Entities**, i.e., Items that can be MM-Captured. The Entity can be:

1. **Authored** by a User Calling an Authoring Tool Service to Author an Entity with accompanying Rights to Act on it.
2. UM-Animated, i.e., its features are changed by a **Stream** of Data.
3. **MM-Added**, i.e., added to an M-Location with a Spatial Attitude without MM-Rendering it.
4. **MM-Rendered** if an Entity MM-Added at an M-Location is Sent to a User.
5. **MM-Embedded**, i.e., MM-Added and MM-Enabled in one stroke.

6. **MM-Enabled**, i.e., able to be MM-Rendered.
7. **MM-Removed**, i.e., the MM-Rendering of the Entity has been stopped.
8. **Authenticated**, i.e., a User is given evidence that an Entity is what it states it is.
9. **Interpreted** by a Service interpreting an Entity, e.g., translating a Speech Object.
10. **Informed** by a Service providing the Metadata of the Entity.

A Device can be requested to:

- **MU-Send** an Entity, i.e., **MU-Stream** (i.e., stream to a Device) an Entity MM-Embedded at an M-Location and have it MU-Rendered by an Actuator to a **U-Location** (i.e., an identifiable delimited portion of a.U-Environment) with a Spatial Attitude.
- **UM-Send** Media, i.e., UM-Capture a scene as Data from at a U-Location, UM-Stream Data and Metadata (provided by the Device), Create an Entity, MM-Embed the Entity at an M-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 Device to Sense a U-Location.
3. A Service to UM-Animate the Persona.
4. A Service to MM-Capture the Entities at the M-Location.
5. A Device to MU-Render the Entities at a U-Location.

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

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. Actions on Entities: <ol style="list-style-type: none"> 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 1.10. MM-Enable 1.11. MM-Remove 1.12. MU-Send 1.13. MU-Stream 1.14. MM-Render 1.15. MM-Send 1.16. MU-Render 1.17. MU-Send 1.18. MU-Stream 1.19. Track | <ol style="list-style-type: none"> 2. Actions on Assets: <ol style="list-style-type: none"> 2.1. Post 2.2. Transact 3. Actions on imported data: <ol style="list-style-type: none"> 3.1. UM-Animate 3.2. UM-Capture 3.3. UM-Stream 3.4. UM-Send 4. Action on Process: <ol style="list-style-type: none"> 4.1. Call 5. Generic Actions on Items: <ol style="list-style-type: none"> 5.1. Read 5.2. Write 5.3. Change 5.4. Destroy 5.5. Discover 5.6. Inform 5.7. Register |
|---|--|

3.4 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 collection of Entities MM-Embedded at an M-Location from Start Time until End Time.
2. **Experience:** An Event as MM-Rendered to a User and the User's Interactions with the Entities of the Entity spawning 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. **Object 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.

Persona: An Object Model that may include an Avatar Model, a Speech Model, and a Haptic Model. It can be visually audibly, and haptically MM-Rendered as:

 - 4.4. UM-Animated by Streams originated by the human.
 - 4.5. MM-Animated.

A User may appear simultaneously as:

 - 4.6. The same or a different Persona UM-Animated by the same Stream at different M-Locations.
 - 4.7. 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.
 - 4.8. The same or a different Persona, one UM-Animated by a Stream and the other autonomously UM-Animated.
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 to a Device from an M-Location.

The third type of Item has space and time attributes:

1. M-Instance: an implementation of metaverse specifications.
2. M-Environment: A portion of an M-Instance identified by [M-InstanceID] [M-EnvironmentID].
3. M-Location: A 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: A 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 can be Transacted.
2. **Provenance:** the list of Transactions executed on an Asset starting from the first and including the last.
3. **Transaction:** An Item representing the change of state of the Account and Rights of one or more Users and potentially of the Service facilitating/enabling the Transaction. It is the result of a User MM-Embedding an Asset at an M-Location or Posting it to a Marketplace.
4. **Value:** An Amount expressed in a Currency.
5. **Wallet:** A container of Currency units.

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

1. **Account:** An Item that unequivocally identifies a human with a set of Items provided by the human.
2. Activity Data.
3. **Request-Authenticate:** An Item that contains the request to a Service to “Authenticate Entity”.
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 Entity”.
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 Entity” 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 Entity” request.
10. **Message:** An Item whose Data is an application-specific message Sent by Source to Destination.
11. Personal Profile.
12. Social Graph.
13. Rights.
14. Rules.

The sixth type of Item includes:

1. **App:** A Program executed on a Device.
2. **Device:** An Item with the following characteristics:
 - 2.1. It has four main functions:
 - 2.1.1. UM-Capture Data from a U-Location.
 - 2.1.2. UM-Stream Data and Metadata to a User.
 - 2.1.3. MU-Stream an Entity from an M-Location.
 - 2.1.4. MU-Render an Entity at a U-Location.
 - 2.2. It may include Audio-Visual-Haptic Sensors and Actuators (other senses are currently not supported).
3. **Process:** An instance of a Program being executed. User, Device, and Service are Processes. Processes may need to be certified to execute in a Metaverse Instance.
4. **Service:** A Process whose execution provides Functionalities. It can be provided internally by the M-Instance/M-Environment or externally.

3.5 Data Types

Actions and Items may use of several Data Types defined in the following:

1. **Address:** A URL.
2. **Amount:** A decimal number expressing a Value in a Currency.
3. **Coordinates:** A set of real 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). The Destination, in the same M-Environment or M-Instance, or in a different M-Instance, will execute the request depending on the Rights of the Source to have the request executed.

This Technical Report preserves the different User, Device, and Service names – instead of using the generic name “Process” – to facilitate understanding of the function and execution 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 chain of Actions.

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

Table 5 - Format of an Action request

| | |
|--------|---|
| Source | <u>User</u> (ID=UserID) \vee <u>Device</u> (ID=DeviceID) \vee <u>Service</u> (ID=ServiceID) |
|--------|---|

| | |
|-------------|---|
| Destination | <u>User</u> (ID=UserID) v <u>Device</u> (ID=DeviceID) v <u>Service</u> (ID=ServiceID) |
| Action | <i>Act</i> |
| InItem | <u>Item</u> (ID=ItemID) |
| InLocation | M-LocationID v U-LocationID v <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Item</u> (ID=ItemID) |
| OutLocation | M-LocationID v U-LocationID v <u>Device</u> (ID=DeviceID) v <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (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 demand. |
| Destination | The Process receiving the demand. |
| Action | The Action that Source requests the Destination perform on the InItems. The Destination verifies the Rights on the InItems before performing the requested Action. |
| InItems | Items or Data&Metadata provided as input to the request Action. |
| InLocation | The Locations of the InItems. |
| OutLocation | The Locations of the OutItems. |
| OutRights | The Rights on the InItems requested by the Source. |

Note1: The payload of a requested Action need not contain all the elements above.

Note2: TheOut Rights 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: Act.=Actuator, D=Device, Mdata=Metadata, MLoc=M-Location, P=Process, S=Service, SA=Spatial Attitude, U=User, ULoc=Universe Location, Unsp.= Unspecified.

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 | Rights | MLoc | - | S | Rights |
| Create | U-D | S | Create | Data&Mdata | Address-D | Item | S | Rights |
| Destroy | U | S | Destroy | Item | S | - | - | - |
| Discover | U | S | Discover | DiscoverReq | S | DiscoverResp | S | Rights |
| Inform | U | S | Inform | Entity | MLoc | Mdata | S | Rights |
| Interpret | U | S | InterprReq | Entity | MLoc | InterpretResp | S | 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-Enable | U | S | MM-Enable | Entity | MLoc | Entity | MLoc | Rights |
| MM-Embed | U | S | MM-Add & MM-Enable | Entity & SA | S | Entity | MLoc | Rights |
| MM-Remove | U | S | MM-Remove | Entity | MLoc | - | - | - |
| MM-Render | U | S | MM-Render | Entity | MLoc | Entity | U | Rights |
| MM-Send | P | P | Send | Item | P | Item | P | Rights Mdata |
| MU-Render | D | Act. | MU-Render | Entity | D | Media | ULoc | Mdata |
| MU-Send | U | D | MU-Send | Entity | MLoc | Entity | D | Rights |
| | D | Act. | MU-Render | Data | D | media | ULoc | Mdata |
| MU-Stream | U | S | MU-Stream | Entity | MLoc | Entity | D | Rights |
| Track | U | S | MM-Embed | Persona & SA | MLoc | Persona | MLoc | Rights |
| | U | D | UM-Sense | scene | ULoc | Stream | U | Rights |
| | U | S | UM-Animate | Entity & Stream & SA | MLoc | Entity | MLoc | Rights |
| | U | S | MM-Enable | Entity | MLoc | Entity | U | Rights |
| | U | D | Actuate | Entity | U | Media | ULoc | Rights |
| 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 |
| 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 | U | D | UM-Capture | scene | ULoc | Media | D | - |
| | D | U | UM-Stream | 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-Stream | U | D | UM-Stream | 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 | Action result | <u>Item</u> (ID=ItemID) |
| | Item location | <u>Service</u> (ID=ServiceID) v M-Location v U-LocationID |
| | Parameter | <u>Item</u> (ID=ItemID ₁) |

| | | | | | | | | | | | | | | |
|------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | x | x | | | | |
| MM-Animate | x | x | x | x | x | | x | | | x | | | x | |
| MM-Capture | x | x | x | x | x | | | | | x | | | | |
| MM-Embed | x | x | x | x | x | x | | | x | x | | | | |
| MM-Enable | x | x | | x | x | x | | | | x | | | | |
| MM-Remove | x | x | | x | x | x | | | | x | | | | |
| MM-Render | x | x | x | | | | | | | | x | | | |
| MM-Send | x | | | x | x | x | | | | | | | | |
| MU-Render | | | | | | | | | | | x | | | |
| MU-Send | x | x | x | x | x | x | x | | | | x | | | |
| MU-Stream | x | x | x | x | x | x | | | | x | | | | |
| Post | x | x | x | x | x | x | | | | x | | | | |
| Read | x | x | | x | x | x | | | | | | x | | |
| Register | x | | | | | | | x | | | | | | x |
| Track | x | x | | x | x | x | | | | | x | | | |
| Transact | x | x | x | | | | | x | | | | | | |
| UM-Animate | x | x | | x | x | | x | | | x | | | x | |
| UM-Capture | x | x | | x | x | x | | | | | | | | |
| UM-Render | x | x | x | x | x | x | | | x | x | x | x | | |
| UM-Send | x | x | | x | | x | | | x | x | x | | | |
| UM-Stream | x | | | x | x | x | | | | | | | | |
| Write | x | x | x | | | | | | | | | x | | |

Note1: This document 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 | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Authenticate</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Response-Authenticate</u> (ID=Response-AuthenticateID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|---|
| Success | Action result | <u>Response-Authenticate</u> (ID=Response-AuthenticateID) |
|---------|---------------|---|

| | | |
|-------|---------------|-------------------------------|
| | Item location | <u>Service</u> (ID=ServiceID) |
| 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 it.

Payload:

| | |
|-------------|-----------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Author</i> |
| InItem | Item (ID=ItemID) ∨ Data |
| InLocation | <u>User</u> (ID=UserID) ∨ Address |
| OutItem | Entity (ID= EntityID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Entity</u> (ID=EntityID) |
| | Item location | <u>Service</u> (ID=ServiceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | Wallet error | Insufficient Value |

4.4 Call

Definition:

The Action of requesting that a Service start.

Payload:

| | |
|------------------|---|
| Source | <u>User</u> (ID=UserID) ∨ <u>Service</u> (ID=ServiceID) |
| Destination | <u>Service</u> (ID=ServiceID) ∨ Process (ID=ProcessID) |
| Requested Action | <i>Call</i> |
| InItem | Item (ID=ItemID) ∨ Data |
| InLocation | <u>User</u> (ID=UserID) ∨ <u>Service</u> (ID=ServiceID) ∨ Address |
| OutItem | <u>Service</u> (ID=ServiceID) |
| OutLocation | <u>Unspecified</u> |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-----------------------|
| Success | Action result | Service Called |
| Error | Request | Faulty |
| | Rights | Missing or incomplete |

4.5 Change

Definition:

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

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Change</i> |
| InItem | <u>User</u> (ID=UserID) |
| InLocation | M-LocationID |
| OutItem | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Rights</u> (ID=ItemID) |
| | Item location | <u>Service</u> (ID=ServiceID) |
| | Parameters | <u>Rights</u> (ID=RightsID) |
| 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 Data and Metadata.

Payload:

| | |
|-------------|---------------------------------|
| Source | <u>Process</u> (ID= Process ID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Create</i> |
| InItems | Data & Metadata |
| InLocation | <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Item</u> (ID=ItemID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| | Item Location | <u>Service</u> (ID=ServiceID) |
| 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 | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Requested Action | <i>Destroy</i> |
| InItem | (ID=ItemID) |

Response:

| | | |
|---------|---------------|-------------------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) unavailable |
| 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 | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Discover</i> |
| InItem | <u>Request-Discover</u> (ID=Request-DiscoverID) |
| InLocation | <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Response-Discover</u> (ID=Response-DiscoverID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| 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 | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Inform</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Metadata</u> |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | Metadata |
| | Item location | <u>Service</u> (ID=ServiceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.10 Interpret

Definition:

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.

Payload:

| | |
|-------------|---|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Interpret</i> |
| InItem | <u>InterprRequest</u> (ID=InterprRequestID) |
| OutItem | <u>InterprResponse</u> (ID=InterprResponseID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|---|
| Success | Action result | <u>InterprResponse</u> (ID=InterprResponseID) |
| | Item location | <u>Service</u> (ID=ServiceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.11 MM-Add

Definition:

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

Payload:

| | |
|-------------|--|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Add</i> |
| InItem | <u>Entity</u> (ID=EntityID) & Spatial Attitude |
| InLocation | <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|------------------------------------|
| Success | Action result | <u>Entity</u> (ID=EntityID) |
| | Item location | M-LocationID |
| | Parameter | Spatial Attitude |
| 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 | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Animate</i> |
| InItem | <u>Entity</u> (ID=EntityID) & Spatial Attitude |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|--|
| Success | Action result | <u>Entity</u> (ID=EntityID) |
| | Item location | M-LocationID |
| 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 the Entities MM-Embedded at an M-Location.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Capture</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|--|
| Success | Action result | <u>Entity</u> (ID=EntityID) |
| | Item location | <u>Device</u> (ID=DeviceID) |
| | Parameter | <u>Item</u> (ID=ItemID) [Items required for rendering] |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.14 MM-Enable

Definition:

The Action of requesting that a Service enable the MM-Rendering of an Entity MM-Embedded at an M-Location.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Enable</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-----------------------------|
| Success | Action result | <u>Entity</u> (ID=EntityID) |
| | Item location | M-LocationID |
| 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, MM-Enable and MM-Render an Entity at an M-Location.

Payload:

| | |
|-------------|---|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Embed</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | <u>Service</u> (ID=ServiceID), Spatial Attitude |
| OutItem | <u>Entity</u> (ID=ItemID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Action | <i>MM-Enable</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|------------------------------------|
| Success | Action result | Entity (ID=EntityID) |
| | Item location | M-LocationID |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | Clash | Entity clashes with another Entity |
| | M-Location | Out of range |

4.16 MM-Remove

Definition:

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

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Remove</i> |
| InItem | Item (ID=ItemID) |
| InLocation | <u>Entity</u> (ID=EntityID) |
| OutItem | M-LocationID |

Response:

| | | |
|---------|---------------|--|
| Success | Action result | <u>Entity</u> (ID=EntityID) MM-Removed |
| | Item Location | M-LocationID |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | M-Location | Out of range |

4.17 MM-Render

Definition:

The Action of requesting that a Device present an Entity at a U-Location.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Render</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | M-LocationID |

Response:

| | | |
|---------|---------------|---|
| Success | Action result | <u>Entity</u> (ID=EntityID) MM-Rendered |
| | Item Location | M-LocationID |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | M-Location | Out of range |

4.18 MM-Send

Definition:

The Action of forwarding Data/Metadata or an Item.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>Process</u> (ID=ProcessID) |
| Destination | <u>Process</u> (ID=ProcessID) |
| Action | <i>Send</i> |
| InItem | <u>Item</u> (ID=ItemID) |
| InLocation | <u>Process</u> (ID=ProcessID) |
| OutItem | <u>Item</u> (ID=ItemID) |
| OutLocation | <u>Process</u> (ID=ProcessID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| | Item location | <u>Process</u> (ID=ProcessID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.19 MU-Render

Definition:

The Action of requesting that a Device present an Entity at a U-Location.

Payload:

| | |
|-------------|-----------------------------|
| Source | <u>Device</u> (ID=DeviceID) |
| Destination | Actuator |
| Action | <i>Render</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | <u>Device</u> (ID=DeviceID) |
| OutItem | Media |
| OutLocation | U-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-----------------------|
| Success | Action result | Media at U-Location |
| | Item location | U-Location |
| | Parameters | Spatial Attitude |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.20 MU-Send

Definition:

The Combined Action of:

1. User MU-Streaming an Entity to a Device with Parameters.
2. Device Rendering Entity at a U-Location.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MU-Stream</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | <u>Device</u> (ID=DeviceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>Device</u> (ID=DeviceID) |

| | |
|-------------|-----------------------------|
| Destination | Actuator |
| Action | <i>Render</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | <u>Device</u> (ID=DeviceID) |
| OutItem | Media |
| OutLocation | U-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

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

4.21 MU-Stream

Definition:

The Action of requesting that a Service stream an Entity MM-Embedded at an M-Location to a Device.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MU-Stream</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | <u>Device</u> (ID=DeviceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|-----------------------------|
| Success | Action result | Entity (ID=EntityID) |
| | Item location | <u>Device</u> (ID=DeviceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.22 Post

Definition:

The Action of requesting that a Marketplace include an Asset.

Payload:

| | |
|-------------|---|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Post</i> |
| InItem | <u>Asset</u> (ID=AssetID) |
| InLocation | <u>User</u> (ID=UserID) ∨ <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Asset</u> (ID=AssetID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|---|
| Success | Action result | <u>Asset</u> (ID=AssetID) |
| | Item location | M-Location, <u>Service</u> (ID=ServiceID) |
| | Parameter | Address |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.23 Read

Definition:

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

Payload:

| | |
|------------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Requested Action | <i>Read</i> |
| InItem | Data and Metadata |
| InLocation | Address |
| OutItem | Data & Metadata |
| OutLocation | <u>User</u> (ID=UserID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| | Item location | <u>Service</u> (ID=ServiceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.24 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 | <u>Service</u> (ID=ServiceID) |
| Requested Action | <i>Register</i> |
| InItem | User Data |
| InLocation | Address |
| OutItem | <u>Account</u> (ID=AccountID) |
| OutLocation | <u>Service</u> (ID=ServiceID) |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|--------------------|
| Success | Action result | Account |
| Error | User Data | Faulty |
| | Wallet | Insufficient Value |

4.25 Track

The Composite Action of:

1. Requesting a Service to MM-Add a Persona at an M-Location with a Spatial Attitude.
2. Requesting a Device to UN-Send a human at a U-Location.
3. Requesting a Service to UM-Animate the Persona.
4. Requesting a Service to MM-Capture the Entity at the M-Location.
5. Requesting a Device to MU-Render the Entity at a U-Location.

Request:

| | |
|-------------|--|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Add</i> |
| InItem | <u>Persona</u> (ID=PersonaID) & Spatial Attitude |
| InLocation | <u>Service</u> (ID=ServiceID) |
| OutItem | <u>Persona</u> (ID=PersonaID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Device</u> (ID=DeviceID) |
| Action | <i>MU-Send</i> |
| InItem | scene |
| InLocation | U-LocationID |
| OutItem | <u>Stream</u> (ID=StreamID) |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>UM-Animate</i> |
| InItem | <u>Persona</u> (ID=PersonaID) |
| InLocation | M-LocationID |

| | |
|-------------|-------------------------------|
| OutItem | <u>Persona</u> (ID=PersonaID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Capture</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Device</u> (ID=DeviceID) |
| Action | <i>MU-Send</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | Media |
| OutLocation | U-LocationID |
| OutRights | Metadata |

Response:

| | | |
|---------|---------------|-----------------------|
| Success | Action result | Media |
| | Item location | U-LocationID |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | M-LocationID | Out of range |
| | U-LocationID | Out of range |

4.26 Transact

Definition:

The Action of a User1 requesting that a Service:

3. Assign Rights on an Asset to User2.
4. Cause:
 - 4.1. Wallet1 of User1 to be increased by Value1.
 - 4.2. Wallet2 of User2 to be decreased by Value2.
 - 4.3. Wallet3 of the Service enabling/facilitating the Transaction to be increased by Value3 (optionally).

Payload:

| | |
|-------------|--|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Transact</i> |
| InItem | Asset (ID=AssetID) |
| InLocation | M-LocationID v <u>Service</u> (ID=ServiceID) |

| | |
|-------------|----------------------|
| OutItem | Asset (ID=AssetID) |
| OutLocation | User (ID=UserID) |
| OutRights | Rights (ID=RightsID) |

Response:

| | | |
|---------|---------------|---|
| Success | Action result | Asset (ID=AssetID) |
| | Item location | User (ID=UserID) |
| | Parameter | Rights (ID=RightsID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | Wallet | User ₂ Wallet has insufficient Value |

4.27 UM-Animate

Definition:

The Action of requesting that a Service change the features of an Entity MM-Embedded at an M-Location with a Spatial Attitude by applying a Stream.

Payload:

| | |
|-------------|--|
| Source | User (ID=UserID) |
| Destination | Service (ID=ServiceID) |
| Action | UM-Animate |
| InItems | Entity (ID=EntityID) \wedge Stream (ID=StreamID) |
| InLocation | M-LocationID |
| OutItem | Entity (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | Rights (ID=RightsID) |

Response:

| | | |
|---------|------------------|--|
| Success | Action result | Entity (ID=EntityID) |
| | Item location | Service (ID=ServiceID), M-LocationID |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | Unsupported Item | Unsupported Animation Stream Data Type. |
| | Item mismatch | Entity Data Type and Animation Stream Data Type. |

4.28 UM-Capture

Definition:

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

Payload:

| | |
|--------|------------------|
| Source | User (ID=UserID) |
|--------|------------------|

| | |
|-------------|-----------------------------|
| Destination | <u>Device</u> (ID=DeviceID) |
| Action | <i>UM-Capture</i> |
| InItem | Media |
| InLocation | U-LocationID |
| OutItem | Data & Metadata |
| OutLocation | <u>Device</u> (ID=DeviceID) |

Response:

| | | |
|---------|---------------|-----------------------------|
| Success | Action result | Data & Metadata |
| | Item location | <u>Device</u> (ID=DeviceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |
| | U-Location | Out of range |

4.29 UM-Render

Definition:

The Action of requesting that:

1. A Sensor UM-Send Media from a scene a U-Location.
2. A Device UM-Stream Data and Metadata.
3. A Service Create and Entity.
4. A Service Embed and Entity at an M-Location with a Spatial Attitude.
5. A Service Render The Entity.

Request:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Device</u> (ID=DeviceID) |
| Action | <i>UM-Capture</i> |
| InItem | Media |
| InLocation | U-LocationID |
| OutItem | Data & Metadata |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | Metadata |
| Source | <u>Device</u> (ID=DeviceID) |
| Destination | <u>User</u> (ID=UserID) |
| Action | <i>UM-Stream</i> |
| InItem | Data & Metadata |
| InLocation | <u>Device</u> (ID=DeviceID) |
| OutItem | Data & Metadata |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | Metadata |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Create</i> |

| | |
|-------------|---|
| InItem | Data & Metadata |
| InLocation | <u>User</u> (ID=UserID) |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Embed</i> |
| InItem | <u>Entity</u> (ID=EntityID), Spatial Attitude |
| InLocation | <u>User</u> (ID=UserID) |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Render</i> |
| InItem | <u>Entity</u> (ID=EntityID) |
| InLocation | M-LocationID |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|------------------------------------|
| Success | Action result | Entity (ID=EntityID) |
| | Item location | M-LocationID |
| | Parameters | Spatial Attitude |
| 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 |

4.30 UM-Send

Definition:

The Composite Action of:

1. Capturing a scene at a U-Location.
2. Sending Data and Metadata.
3. Creating an Entity from Sent Data and Metadata.
4. MM-Embedding Entity at M-Location with Spatial Attitude.

Request:

| | |
|-------------|-----------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Device</u> (ID=DeviceID) |

| | |
|-------------|---|
| Action | <i>UM-Capture</i> |
| InItem | Media |
| InLocation | U-LocationID |
| OutItem | Data & Metadata |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | Metadata |
| Source | <u>Device</u> (ID=DeviceID) |
| Destination | <u>User</u> (ID=UserID) |
| Action | <i>UM-Stream</i> |
| InItem | Data & Metadata |
| InLocation | <u>Device</u> (ID=DeviceID) |
| OutItem | Data & Metadata |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | Metadata |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Create</i> |
| InItem | Data & Metadata |
| InLocation | <u>User</u> (ID=UserID) |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | <u>User</u> (ID=UserID) |
| OutRights | <u>Rights</u> (ID=RightsID) |
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>MM-Embed</i> |
| InItem | <u>Entity</u> (ID=EntityID), Spatial Attitude |
| InLocation | <u>User</u> (ID=UserID) |
| OutItem | <u>Entity</u> (ID=EntityID) |
| OutLocation | M-LocationID |
| OutRights | <u>Rights</u> (ID=RightsID) |

Response:

| | | |
|---------|---------------|------------------------------------|
| Success | Action result | Entity (ID=EntityID) |
| | Item location | M-LocationID |
| | Parameters | Spatial Attitude |
| 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 |

4.31 UM-Stream

Definition:

The Action of requesting that a Device stream Data and Metadata to a Service.

Payload:

| | |
|-------------|-------------------------------|
| Source | <u>User</u> (ID=UserID) |
| Destination | <u>Device</u> (ID=DeviceID) |
| Action | <i>UM-Stream</i> |
| InItem | Data & Metadata |
| InLocation | <u>Device</u> (ID=DeviceID) |
| OutItem | Data & Metadata |
| OutLocation | <u>Service</u> (ID=ServiceID) |

Response:

| | | |
|---------|---------------|-------------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| | Item location | <u>Service</u> (ID=ServiceID) |
| Error | Request | Faulty |
| | IDs | Incorrect |
| | Rights | Missing or incomplete |

4.32 Write

Definition:

The Action of storing an Item at an Address.

Payload:

| | |
|-------------|--|
| Source | <u>Process</u> (ID=ProcessID) |
| Destination | <u>Service</u> (ID=ServiceID) |
| Action | <i>Write</i> |
| InItem | Item (ID=ItemID) |
| InLocation | M-LocationID v <u>Process</u> (ID=ProcessID) |
| OutItem | Item (ID=ItemID) |
| OutLocation | Address |

Response:

| | | |
|---------|---------------|-------------------------|
| Success | Action result | <u>Item</u> (ID=ItemID) |
| | Item location | Address |
| 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:

| | | | | | | | | | | | | | | | | | | | |
|-----------------------|---|---|---|---|---|--|--|---|---|---|---|---|---|---|---|--|---|---|---|
| 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-Authenticate | 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-Authenticate | x | x | x | x | x | | | | | | | | | | | | | | |
| Response-Discover | x | x | x | x | x | | | | | | | | | | | | | | |
| Response-Interpret | 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 | | | | | | | | | | | | | | | | |
| Wallet | x | x | | | | | | | | | | | | | | | | | |

5.2 Account

| Elements | Definitions | |
|----------|--|--|
| Purpose | An Item that is unequivocally associated to a human who has Registered. A User may have more than one Account with one or more Services. | |
| 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 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: <ol style="list-style-type: none"> UM-Capture Data from a U-Location UM-Stream Data and Metadata to a User. and/or <ol style="list-style-type: none"> MU-Stream an Entity from an M-Location to the Device. 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. |
| | Descr.Mdata | Any description of Device. |

5.7 Event

| | | |
|----------|--|---|
| Purpose | An Entity containing an M-Location, its Entities, and their Animations 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 Entity containing an Event as MM-Captured by a User and the User Interactions with the Entities of the Event. | | | |
| Data | Time ₁ | Entity ₁ | Interaction ₁ | M-Location ₁ |
| | Time ₂ | Entity ₂ | Interaction ₂ | M-Location ₂ |
| | Time _n | Entity _n | Interaction _n | M-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 | <p>[M-InstanceID] [M-EnvironmentID] [ItemID] [M-Location].</p> <p>[M-Location] is only attached to Entities.</p> <p>The Format of an Identifiers depends on the Technology it is based on, e.g.:</p> <ol style="list-style-type: none"> 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-Location ₁ | Time ₁ |
| | Action ₂ | Entity ₂ | M-Location ₂ | Time ₂ |
| | Action _n | Entity _n | M-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-Stream, Interpret, MU-Stream, MM-Enable, Post, MM-Remove, 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 M-Environment

| | | |
|----------|---|---|
| Purpose | An identifiable 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). |

5.12 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. |

5.13 M-Location

| | | |
|----------|---|---|
| Purpose | A delimited identifiable 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. |

5.14 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. |

5.15 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. |

5.16 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: <ol style="list-style-type: none"> 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”. |
| | Auth.ToolID | The ID of the Service “who provided the Authoring tool”. |
| | DescrMdata | Any description of the Model. |

5.17 Object

| | | |
|----------|--|--|
| Purpose | An Entity representing an object. Currently, the following types of Objects are supported: Audio, Visual, and Haptic. | |
| Data | <ol style="list-style-type: none"> 1. Audio Data representation <ol style="list-style-type: none"> 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 <ol style="list-style-type: none"> 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. |

5.18 Personal Profile

| | | |
|----------|--|---|
| Purpose | An Item containing the Data about the human represented by User. | |
| Data | <ol style="list-style-type: none"> 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. |

5.19 Process

| | | |
|----------|---|--|
| Purpose | An Item that: <ol style="list-style-type: none"> 1. Receives: <ol style="list-style-type: none"> 1.1. Items and/or Data 1.2. 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. |

5.20 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. | |

5.21 Request-Authenticate

| | | |
|----------|---|---|
| Purpose | An Item containing the request to a Service to “Authenticate Entity”. | |
| 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. |

5.22 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. |

5.23 Request-Inform

| | | |
|----------|--|---|
| Purpose | An Item that contains the request to a Service to “Inform Entity”. | |
| 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. |

5.24 Request-Interpret

| | | |
|----------|--|---|
| Purpose | An Item containing a description of the request to “Interpret Entity”. | |
| 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. |

5.25 Response-Authenticate

| | | |
|----------|--|---|
| Purpose | An Item that contains the response of a Service to an “Authenticate Entity” 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. |
| | Descr.Mdata | Any description of the Response-Authenticate Item. |

5.26 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. |
| | Descr.Mdata | Any description of the Response-Discover Item. |

5.27 Response-Inform

| | | |
|----------|--|--|
| Purpose | An Item that contains the response of a Service to an “Inform Entity” 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 Informy Service. |

| | | |
|--|-------------|--|
| | OutRightsID | The ID of the Rights to Act on the Response-Inform Item granted to the User. |
| | Descr.Mdata | Any description of the Response-Inform Item. |

5.28 Response-Interpret

| | | |
|----------|--|---|
| Purpose | An Item containing the response to the request to Interpret an Entity. | |
| 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 theInterprety Service. |
| | OutRightsID | The ID of the Rights to Act on the Response-Interpret Item granted to the User. |
| | Descr.Mdata | Any description of the Response-Interpret Item. |

5.29 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. |

5.30 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. |

5.31 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. |

5.32 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. |

5.33 Social Graph

| | | |
|----------|--|---|
| Purpose | A representation of a User’s network of connections with Items, Processes, and Services. | |
| Data | TBD | |
| Metadata | Social GraphID | 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. |

5.34 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. |

5.35 Transaction

| | |
|---------|--|
| Purpose | <p>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:</p> <ol style="list-style-type: none"> 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. |

5.36 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. |

5.37 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. |

5.38 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. | |

5.39 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. | |

5.40 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

6.1 Address

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

6.2 Amount

| | | | |
|----------|--|--|--|
| Purpose | A decimal 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. | |
| | Descriptive Metadata | Any description of the Cognitive State. | |

6.4 Coordinates

| | | | |
|---------|---|--|--|
| Purpose | A set of real numbers representing a Position in a Metaverse Environment using a coordinate system. | | |
| Data | TBD | | |

| | | | |
|----------|----------------------|---|--|
| Metadata | Coordinate System | The ID of the coordinate system. | |
| | Descriptive Metadata | 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. | |
| | Descriptive Metadata | 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". | |
| | Descriptive Metadata | 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 | CoordinateSystemID | 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. |
| | Descriptive Metadata | 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 |

6.14 Value

| | |
|----------|---|
| Purpose | The Amount and the Currency the Amount refers to. |
| Data | Amount-Currency |
| Metadata | No metadata |

7 Use Cases

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.

7.1 Virtual Lecture

7.1.1 Description

1. human₁ (Manager):
 - 1.1. Registers with M-Environment
2. User₁ (Manager):
 - 2.1. Authors an Entity (virtual classroom).
 - 2.2. MM-Embeds the Entity at M-Location_{1,1}.
3. human₂ (Student):
 - 3.1. Registers with Metaverse Environment.

4. User₂ (Student):
 - 4.1. Tracks Persona_{2,1} (A-V) at Location_{2,1} with SA.
 - 4.2. Pays to attend and make a copy of their Experiences at the lecture.
 - 4.3. MM-Embeds Persona_{2,1} (A-V) at Location_{2,2} (a seat in the classroom) with SA.
5. human₃ (Teacher):
 - 5.1. Registers with Metaverse Environment.
6. User₃ (Teacher):
 - 6.1. Tracks Persona_{3,1} (A-V) at Location_{3,1} with SA.
 - 6.2. MM-Embeds Persona_{3,1} (A-V) at Location_{3,1} with SA.
 - 6.3. MM-Embeds to M-Location_{3,2} (desk in classroom).
 - 6.4. Holds a lecture at M-Location_{3,2}.
 - 6.5. Presents an animated 3D experiment model at M-Location_{3,3} (close to M-Location_{3,2}).
7. Student
 - 7.1. MM-Adds Persona_{2,1} (A-V) at M-Location_{2,2} (close to Teacher for better view).
 - 7.2. Writes Experience_{2,1} at Address.
8. Teacher is paid for giving the lecture.

7.1.2 Workflow and Action

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-Removes | 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-Removes | 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-Removes | 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-Removes | Persona _{2,1} (A-V) | Location _{2,2} |

7.1.3 Actions, Items, and Data Types

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

7.2 Virtual Meeting

7.2.1 Description

1. User₁ (Meeting Manager)
 - 1.1. MM-Embeds meeting room at M-Location_{1,1}.
 - 1.2. MM-Embeds Persona_{1,1} (Virtual Secretary) at M-Location_{1,2}.
 - 1.3. Calls Process_{1,1} to MM-Animate Virtual Secretary.
2. User₂ (Meeting participant):
 - 2.1. Registers with M-Environment.
 - 2.2. Tracks Persona_{2,1} (A-V) at Location_{2,1} (meeting room) with SA.
 - 2.3. MM-Embeds Persona_{2,1} (A-V) to M-Location_{2,2} with SA.
 - 2.4. MM-Removes Persona_{2,1} (A-V) from Location_{2,1}.
 - 2.5. Interprets (requests translation of speech of) User₃'s Persona_{3,1}.
 - 2.6. MM-Embeds Entity_{2,1} (3D presentation) at M-Location_{2,3} (in the room).
 - 2.7. 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-Location_{1,3} for participants to read and comment.

7.2.2 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-Location _{1,1} |
| | MM-Embeds | Persona _{1,1} | (Virtual Secretary) M-Location _{1,2} |
| | MM-Animates | Persona _{1,1} | Operates Virtual Secretary. |
| | MM-Captures | M-Location _{1,1} | |
| human ₂ (Participant) | Registers | | with M-Environment |
| User ₂ (Participant) | Tracks | Persona _{2,1} (A-V) | M-Location _{2,1} w/ SA |
| | MM-Embeds | Persona _{2,1} (A-V) | M-Location _{2,2} w/ SA |
| | MM-Removes | Persona _{2,1} (A-V) | Location _{2,1} |
| User ₁ (Manager) | Authenticates | User ₂ | |

| | | | |
|---------------------------------|---------------|------------------------------|---|
| User ₃ (Participant) | Tracks | Persona _{3,1} (A-V) | M-Location _{3,1} w/ SA |
| | MM-Embeds | Persona _{3,1} (A-V) | M-Location _{3,2} w/ SA |
| User ₁ (Manager) | Authenticates | User ₃ | |
| User ₃ (Participant) | MM-Removes | User ₃ | M-Location _{3,1} |
| User ₂ (Participant) | Interprets | Persona _{3,1} | (Requests translation) |
| | MM-Embeds | Entity _{2,1} | (3D presentation) M-Location _{2,2} |
| | MM-Animates | Entity _{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-Location _{1,3} (in the room) |
| | MM-Removes | Persona _{1,1} | M-Location _{1,2} |
| User ₂ (Participant) | Writes | Event | Address _{2,1} |
| | MM-Embeds | Persona _{2,1} (A-V) | M-Location _{2,1} (back home) |
| | MM-Removes | Persona _{2,1} (A-V) | Location _{2,2} |
| User ₃ (Participant) | MM-Embeds | Persona _{3,1} (A-V) | M-Location _{2,1} (back home) |
| | MM-Removes | Persona _{3,1} (A-V) | Location _{3,2} (back home) |

7.2.3 Actions, Items, and Data Types

| Actions | Items | Data Types |
|--------------|---------|------------------|
| MM-Embed | User | Spatial Attitude |
| MM-Animate | Persona | Position |
| Register | Entity | Orientation |
| Track | Service | Coordinates |
| MM-Remove | | |
| Interpret | | |
| Authenticate | | |
| Write | | |
| MM-Capture | | |

7.3 Hybrid working

7.3.1 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.

7.3.2 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-Location _{1,1} |

| | | | |
|------------------------------|---------------|------------------------------|--|
| | MM-Embeds | Persona _{1.1} | M-Location _{1.2} |
| | Calls | Service _{1.1} | (To Authenticate R-Worker) |
| | Calls | Service _{1.2} | (To Authenticate V-Worker) |
| User ₂ (R-Worker) | Tracks | Persona _{2.1} (A-V) | M-Location _{2.1} w/ SA |
| User ₃ (V-Worker) | Tracks | Persona _{3.1} (A-V) | M-Location _{3.1} w/ SA |
| | MM-Embeds | Persona _{3.1} | M-Location _{3.2} (V-Office) |
| 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-Location _{3.3} (talk “in person”) |
| | MM-Removes | Persona _{3.1} (A-V) | M-Location _{3.2} |
| | MM-Embeds | Persona _{3.1} | M-Location _{3.4} (V-Meeting) |
| | MM-Removes | Persona _{3.1} (A-V) | M-Location _{3.3} |
| User ₂ (R-Worker) | MM-Embeds | Persona _{2.1} | M-Location _{3.4} |
| | MM-Removes | Persona _{3.1} (A-V) | M-Location _{2.2} |
| | MM-Embeds | Entity _{2.1} | (Whiteboard) M-Location _{3.4} |
| | Calls | Service _{2.1} | To operate Whiteboard |
| | MM-Embeds | Persona _{2.1} (A-V) | M-Location _{2.1} (back home) |
| | MM-Removes | 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-Removes | Persona _{3.1} (A-V) | From M-Location _{3.4} |

7.3.3 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-Remove | Object (A) | |
| MM-Send | Service | |

7.4 eSports Tournament

7.4.1 Description

1. User₁ (Site Manager)
 - 1.1. Registers with M-Environment.
 - 1.2. Authors and MM-Embeds Entity_{1.1} (game landscape).
2. User₂ (Game Manager)
 - 2.1. Registers with M-Environment.
 - 2.2. MM-Embeds and MM-Animates Personae_{2.i} at M-Locations_{2.i} (Autonomous characters).
 - 2.3. Calls Service_{2.1} to control virtual cameras and microphones.
 - 2.4. MU-Sends Entity_{1.1} to:
 - 2.4.1. U-Location_{2.1} via Device_{1.1} (screen).
 - 2.4.2. Various U-Locations (via streaming).
3. Two teams with 5 players each:
 - 3.1. human₃ (a Player of team₁ located at U-Location_{2.1}) Registers at M-Environment

- 3.2. human₄ (a Player of team₂ located at U-Location_{3,1}) Registers at M-Environment.
4. User₂ (Game Manager) MM-Embeds in Entity_{1,1} ten Personae (digital twins of the ten players of the 2 teams)
 - 4.1. UM-Animated by the players using controllers.
 - 4.2. Wearing a costume.
 - 4.3. With different:
 - 4.3.1. Roles (e.g., magician, warrior, soldier, etc.).
 - 4.3.2. Forms and physical features.
 - 4.3.3. Abilities (e.g., cast spells, shoot, fly, jump).
5. User₂ (Game Manager) MM-Embeds and UM-Animates autonomous characters (e.g., dragon, monsters, various creatures) in Entity_{1,1}.
6. User₃ (Player)
 - 6.1. Registers with M-Environment.
 - 6.2. Tracks Persona_{3,1} (A-V) at Location_{3,1} with Spatial Attitude.
 - 6.3. Calls Process_{3,1} (specific of roles, abilities, etc.)

7.4.2 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-Location _{3,1} with SA |

7.4.3 Actions, Items, and Data Types

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

7.5 Virtual Event

7.5.1 Description

1. User₁ (Organiser)
 - 1.1. Authors Entity_{1,1} (event's environment).
 - 1.2. MM-Embeds Entity_{1,1} at M-Location_{1,1} (virtual auditorium).

- 1.3. Calls Service_{1.1} (to collect Users' Preferences).
2. User₂ (Performer)
 - 2.1. Registers with M-Environment.
 - 2.2. Authors Persona_{2.1} (A-V).
 - 2.3. Tracks Persona_{2.1} (A-V) at Location_{2.1} with Spatial Attitude with U-Location_{2.1} (human₂'s location).
 - 2.4. MM-Removes Persona_{2.1} from Location_{2.1}.
3. User₃ (Participant)
 - 3.1. Registers with M-Environment.
 - 3.2. Authors Persona_{3.1} (A-V).
 - 3.3. Transacts (buys event ticket).
 - 3.4. Tracks Persona_{3.1} (A-V) at Location_{3.1} with Spatial Attitude with U-Location_{3.1} (human₃'s location).
 - 3.5. MM-Removes Persona_{3.1} (A-V) from Location_{3.1}.
 - 3.6. MM-Sends Object_{3.1} (A) with User₄ (Participant).
 - 3.7. Calls Service_{1.1} (expresses preferences).
 - 3.8. MM-Adds (A-V) at Location_{3.2} (close to stage for 5 minutes).
4. User₁ (Organiser)
 - 4.1. MM-Removes Persona_{3.1} from Location_{3.2}.
 - 4.2. Calls Service_{1.1} (Collects preferences).
 - 4.3. Interprets Participant Status (all participants).
 - 4.4. MM-Embeds Audio-Visual Entities (SFX).
 - 4.5. Transacts Value to User₂.
5. User₂ (Performer)
 - 5.1. MM-Embeds Persona_{2.1} (A-V) to M-Location_{2.1}.
 - 5.2. MM-Removes Persona_{2.1} from M-Location_{2.2}.
6. User₃ (Participant)
 - 6.1. MM-Embeds Persona_{3.1} (A-V) to M-Location_{3.1}.
 - 6.2. MM-Removes Persona_{3.1} from M-Location_{3.2}.

7.5.2 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-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-Location _{2.1} w/ SA |
| | MM-Embeds | Persona _{2.1} (AV) | M-Location _{2.2} (stage) |
| | MM-Removes | Persona _{2.1} (AV) | M-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-Location _{3.1} w/ SA |
| | Transacts | Value | (to User ₁ to buy ticket) |
| | MM-Embeds | Persona _{3.1} (AV) | M-Location _{3.2} (Vauditorium) |

| | | | |
|---------------------------------|------------|------------------------------|---|
| | MM-Removes | Persona _{3,1} (A-V) | M-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-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-Location _{2,1} (back home) |
| | MM-Removes | Persona _{2,1} (A-V) | From M-Location _{2,2} |
| User ₃ (Participant) | MM-Embeds | Persona _{3,1} (A-V) | M-Location _{3,1} (back home) |
| | MM-Removes | Persona _{3,1} (A-V) | From M-Location _{3,2} |

7.5.3 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-Remove | Object (A) | Cognitive State |
| MM-Send | Value | Emotion |
| Interpret | | Social Attitude |

7.6 AR Tourist Guide

7.6.1 Description

This Use Case describes how this Technical Report can support:

1. User₁ creating a landscape suitable for placing a virtual path through n M-Locations and selling the virtual path to a User₂.
2. User₂ buying a parcel, placing the landscape on it, developing Entities for the M-Locations, placing the Entities at the M-Locations, and selling the result to User₃.
3. human₄ developing and selling to human₃ a Map recording an M-Location for each U-Location and an App alerting any human₅ holding the Device with the App that a key U-Location has been reached.
4. User₃ MM-Embedding one or more autonomous Personae at the M-Locations.
5. human₅ when getting close to a key U-Location:
 - 1.1. App prompts Device to Request User₃ to MU-Send at the U-Location the Entity MM-Embedded at M-Location_i.
 - 1.2. human₅ interacts with MU-Rendered Entity that may include an MM-Animated Persona.

7.6.2 Workflow

Table 18 – AR Tourist Guide workflow.

| Who | Does | What | Where/comment |
|-----|------|------|---------------|
|-----|------|------|---------------|

| | | | |
|-----------------------|-------------|---|--|
| User ₁ | Transacts | Entity _{1,1} | (Parcel in an M-Environment) |
| | Authors | Entity _{1,2} | (A landscape for the parcel) |
| | MM-Embeds | Entity _{1,2} in Entity _{1,1} | |
| | Transacts | Entity _{1,2} in Entity _{1,1} | (Sells landscape and parcel to User ₂) |
| User ₂ | Authors | Entity _{2,1} to Entity _{2,n} | Promotion material for U-Locations. |
| | MM-Embeds | Entity _{2,1} to Entity _{2,n} | (Entity _{1,1} 's M-Location _{2,1} to Location _{2,n}) |
| | Writes | M-Locations | (Address known to User ₄) |
| | Transacts | Entity _{1,1} , Entity _{1,2} , Entity _{2,i} | (Parcel+landscape+ all Entity _{2,i} to User ₄) |
| human ₃ | develops | Map _{3,1} | (U-location _{2,i} -M-Location _{2,i} -Metadata _{2,i}) |
| | sells | Map and App | To human ₄ |
| User ₄ | MM-Embeds | Persona _{4,1} to Persona _{4,n} | M-Location _{2,1} to Location _{2,n} |
| | MM-Animates | Persona _{4,1} to Persona _{4,n} | M-Location _{2,1} , M-Location _{2,n} |
| human ₅ | downloads | App | (To Device) |
| | approaches | U-Location _{2,i} | (App's keypoint) |
| App | prompts | Device _{5,1} | |
| Device _{5,1} | MM-Send | Message _{5,1} | User ₄ |
| User _{4,i} | MU-Sends | Entity _{2,i} | U-Location _{2,i} |
| human ₅ | interacts | | (W/ MU-Rendered Entity _{4,i} and Persona _{4,i}) |

7.6.3 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 | |
| MU-Send | Map | |
| MM-Send | Service | |
| | Persona | |
| | | |

7.7 Virtual Dance

7.7.1 Description

1. User₂ (dance teacher)
 - 1.1. Teaches dance in a virtual classroom.
 - 1.2. It works at M-Location_{2,1} where its digital twin Persona_{2,1} is Audio-Visually MM-Embedded (A-V).

- 1.3. While User₂ is at work, another of its Personae (Persona_{2.2}) is MM-Embedded (A-V) and MM-Animated as a secretary at M-Location_{2.2} to attends to students coming to learn dance.
2. User₁ (dance student #1):
 - 2.1. Is MM-Embedded (A-V) as its Persona_{1.1} at Location_{1.1} (its “home”).
 - 2.2. Audio-Visual-Haptically MM-Embeds (A-V-H) Persona_{1.1} to Location_{1.2} close to Location_{2.2}.
 - 2.3. Greets the virtual secretary Persona_{2.2} by Sending Object_{1.1} (A) with it.
3. Virtual secretary:
 - 3.1. Reciprocates by Sending Object_{2.1} (A) with dance students #1.
 - 3.2. Calls the regular dance teacher’s Persona_{2.1} by Sending Object_{2.2} (A).
4. Dance teacher MM-Embeds (A-V-H) Persona_{2.1} to Location_{2.3} at classroom where it dances with Persona_{1.1} (dance student #1).
5. While Persona_{1.1} (student #1) and Persona_{2.1} (teacher) dance, User₃ (dance student #2) MM-Embeds (A-V) its digital twin Persona_{3.1} at Location_{3.1} (its “home”), 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, User₂ (dance teacher):
 - 6.1. MM-Embeds (A-V-H) Persona_{2.1} at Location_{2.4}, (close to Location_{3.2}).
 - 6.2. MM-Removes 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 a new 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).

7.7.2 Workflow

| Who | Does | What | Where/(comment) |
|---|-------------|--------------------------------|---------------------------------------|
| User ₂ (Teacher) | MM-Adds | Persona _{2.1} (A-V) | M-Location _{2.1} w/ SA |
| | Tracks | Persona _{2.1} (AV) | M-Location _{2.1} |
| | MM-Captures | M-Location _{2.1} | |
| | MM-Adds | Persona _{2.2} (A-V) | M-Location _{2.2} w/ SA |
| | Calls | Service _{2.1} | (MM-Animates Persona _{2.2}) |
| User ₁ (Student) | MM-Adds | Persona _{1.1} (A-V) | M-Location _{1.1} w/ SA |
| | Tracks | Persona _{1.1} (AV) | M-Location _{1.1} |
| | MM-Captures | M-Location _{1.1} | |
| | Transacts | Value | (Lesson fees) |
| | MM-Adds | Persona _{1.1} (A-V-H) | M-Location _{1.2} w/ SA |
| | MM-Captures | M-Location _{1.2} | |
| | MM-Removes | Persona _{1.1} | M-Location _{1.1} |
| | Sends | Object _{1.1} (A) | Persona _{2.1} (greetings) |
| User ₂ (Persona _{2.2}) | Sends | Object _{2.1} (A) | Persona _{1.1} (greetings) |
| | Sends | Object _{2.2} (A) | Persona _{2.2} (alert) |
| User ₂ (Persona _{2.1}) | MM-Adds | Persona _{2.1} | M-Location _{2.3} |
| | MM-Captures | M-Location _{2.3} | |
| | MM-Removes | Persona _{2.2} | M-Location _{2.2} |
| | MM-Embeds | Object _{2.3} (A) | M-Location _{2.4} (music) |
| Persona _{1.1} | | | (dance) |
| Persona _{2.1} | | | (dance) |

| | | | |
|-----------------------------|------------|--------------------------------|---------------------------------------|
| User ₃ (Student) | MM-Embeds | Persona _{3.1} (A-V) | M-Location _{3.1} w/ SA |
| | Tracks | Persona _{3.1} (AV) | M-Location _{3.1} |
| | Transacts | Value | (Lesson fees) |
| | MM-Adds | Persona _{3.1} (A-V-H) | M-Location _{3.2} w/ SA |
| | MM-Removes | Persona _{3.1} | M-Location _{3.1} |
| | MM-Sends | Object _{3.1} (A) | Persona _{2.1} (greetings) |
| User ₂ (Teacher) | MM-Sends | Object _{3.1} (A) | Persona _{3.1} (greetings) |
| | MM-Removes | Persona _{2.1} | M-Location _{2.3} |
| | MM-Embeds | Persona _{2.3} | M-Location _{2.3} w/ SA |
| | Calls | Service _{2.2} | (MM-Animates Persona _{2.3}) |
| | MM-Embeds | Persona _{2.1} | M-Location _{2.4} w/ SA |
| Persona _{3.1} | | | (dance) |
| Persona _{2.1} | | | (dance) |

7.7.3 Actions, Items, and Data Types

| Actions | Items | Data Types |
|----------------|-----------------|-------------------|
| MM-Embed | Persona (A-V) | Spatial Attitude |
| Track | Persona (A-V-H) | Amount |
| MM-Send | M-Location | Currency |
| MM-Animate | U-Location | Value |
| Transact | Service | |
| MM-Remove | 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 19 – 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-Remove | M-Instance | |
| MM-Render | M-Location | |
| MM-Send | Model | |
| MU-Render | Object | |
| MU-Send | Persona | |
| MU-Stream | 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-Stream | 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.

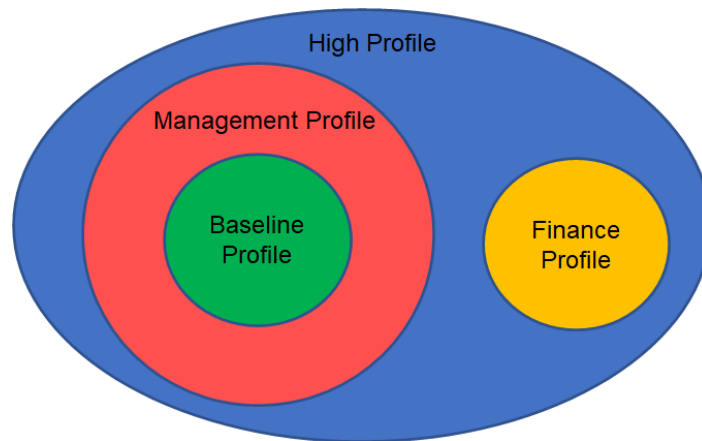


Figure 2 - the currently identified Functionality Profiles

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-Stream 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-Stream M-Location.
 - 5.2. Render M-Location at U-Location.
6. MM-Remove an Object.

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

Table 20 lists the Actions, Entities, and Data Types of the Baseline Functionality Profile.

Table 20 – 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-Remove | Process | |
| MM-Render | Rights | |
| MM-Send | Rules | |
| MU-Render | Scene | |
| MU-Send | Service | |
| MU-Stream | 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-Stream | | |
| 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 21 – 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-Remove | M-Location | |
| MM-Render | Model | |
| MM-Send | Object | |
| MU-Render | Persona | |

| | | |
|------------|-----------------------|--|
| MU-Send | Personal Profile | |
| MU-Stream | 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-Stream | 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 22 – 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-Remove | Response-Discover | |
| MM-Render | Response-Inform | |
| MM-Send | Rights | |
| MU-Render | Rules | |

| | | |
|-----------|---------------|--|
| MU-Send | Scene | |
| MU-Stream | 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 19.

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 support 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.

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.

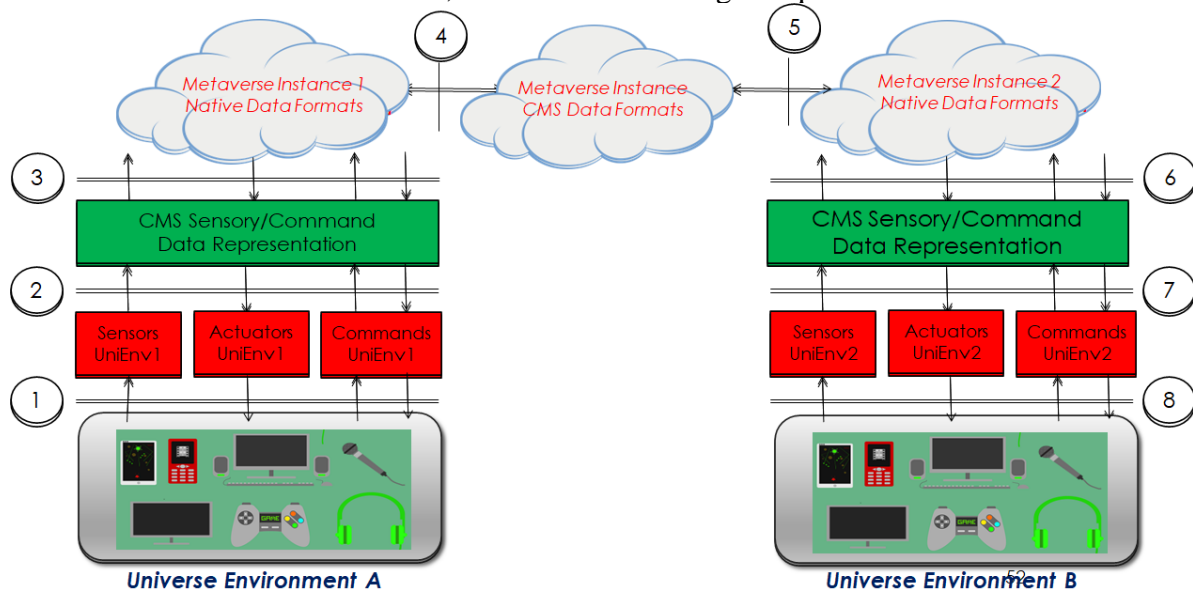


Figure 3 - Interoperability between two Metaverse Instances

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 23* 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.

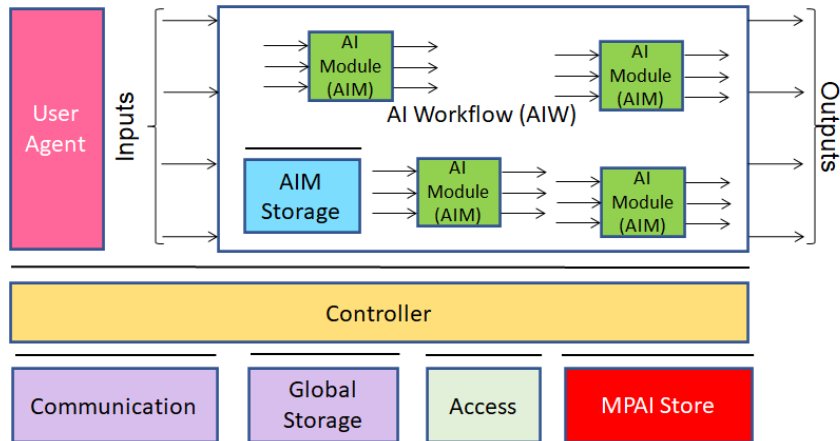


Figure 4 – The AI Framework (AIF) Reference Model

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.¹

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 [4Error! Reference source not found.] provides an example of such ecosystem.

¹ 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 23*.

Table 23 – 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 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 | <ol style="list-style-type: none"> 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 | <p>The attribute of an AIW and its AIMs to be executable in an AIF Implementation and to:</p> <ol style="list-style-type: none"> 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 their 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: <ol style="list-style-type: none"> 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.

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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 – called MPAI-AIF – whose components are:

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

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).

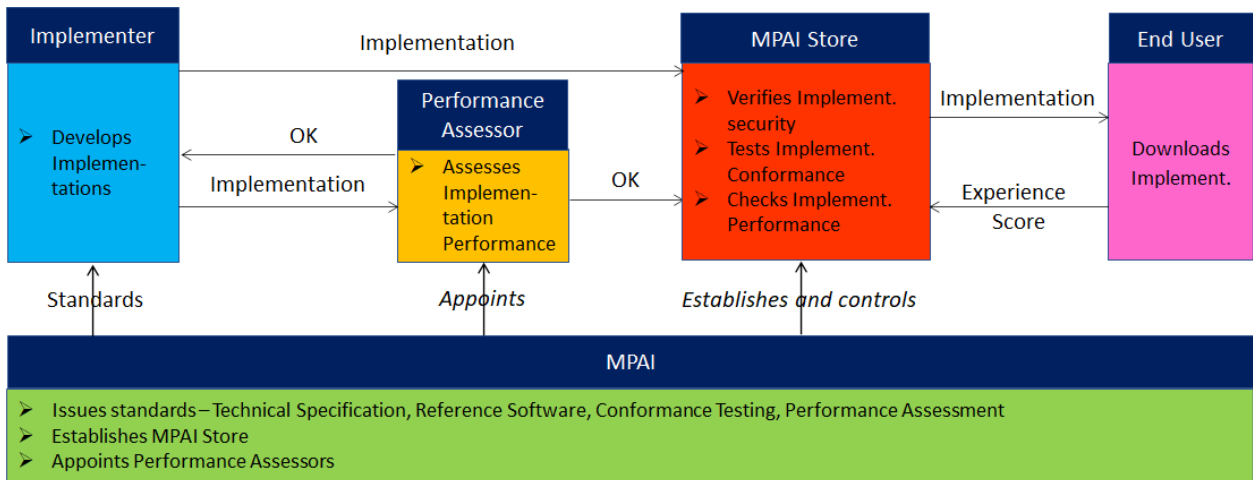


Figure 5 – The MPAI ecosystem operation