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This document is a working draft of Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Architecture published with a request for Community Comments. Comments should be sent to the [MPAI Secretariat](#) by 2023/09/28T23:59 UTC to enable MPAI to consider comments for potential inclusion in the final text of the Technical Specification planned to be approved for publication by the 36<sup>th</sup> General Assembly (2023/09/29).

The draft Standard will be presented online on September 01 at 08 and 15 UTC.



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## **MPAI Technical Specification**

### **MPAI Metaverse Model (MPAI-MMM) Architecture**

<b>WD for Community Comments</b>
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# MPAI Metaverse Model – Architecture

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## 1 Introduction (Informative)

Metaverse is a word conveying different meanings to different persons. In this document the word metaverse is characterised as a system that captures data from the real world (in the following, called Universe<sup>1</sup>), processes it, and combines it with internally-generated data to create virtual environments that users can interact with. So far, the developers of many systems responding to this characterisation have made technology decisions that best responded to their needs, often without considering the choices that other developers might have made for similar purposes.

Recently, however, there have been mounting concerns that such metaverse “walled gardens” do not fully exploit the opportunities offered by current and expected technologies. Calls have been made to make metaverse instances (in the following, M-Instances) “Interoperable”.

MPAI – Moving Picture, Audio, and Data Coding by Artificial Intelligence – the international, unaffiliated, non-profit organisation developing standards for AI-based data coding – has provided initial contributions to M-Instance Interoperability with two Technical Reports:

1. **Technical Report: MPAI Metaverse Model (MPAI-MMM) – Functionalities** [1] has introduced the following elements:
  - 1.1. A set of definitions.
  - 1.2. A set of assumptions, the most important of which are that metaverse:
    - 1.2.1. Is a broad notion that may be used by different industries for different purposes.
    - 1.2.2. Needs technologies, some of which do not even exist with satisfactory performance.
    - 1.2.3. The notion of profile may help improve Interoperability.
  - 1.3. A collection of high-level use cases.
  - 1.4. A collection of exemplary service providers.
  - 1.5. An organised set of ~150 Functionalities.
  - 1.6. A review of the main metaverse-enabling technologies.
  - 1.7. An analysis of metaverse governance needs.
  - 1.8. The MPAI metaverse standardisation roadmap.
2. **Technical Report: MPAI Metaverse Model (MPAI-MMM) – Functionality Profiles** [11] has introduced the following elements:
  - 2.1. A revised and extended list of definitions.
  - 2.2. An operation model of the metaverse based on the notion of Processes performing or requesting other Processes to perform Actions on Items (Items are Data supported by an M-Instance).
  - 2.3. A specification of a first set of Actions, Items, and Data Types enabling:
    - 2.3.1. Detailed descriptions of Use Cases using Actions, Items, and Data Types.
    - 2.3.2. The definition of Functionality Profiles, i.e., subsets of Actions, Items, and Data Types that satisfy a selected subset of identified Functionalities.
  - 2.4. A collection of representative use cases tested against the Operation Model.
  - 2.5. Four initial Functionality Profiles.

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<sup>1</sup> Words beginning with a capital letter are defined in Chapter 3.

**Technical Specification – MPAI Metaverse Model (MPAI-MMM) – Architecture** provides initial means to achieve M-Instance Interoperability by specifying the Functional Requirements of Processes, Items, Actions, and Data Types that allow Interoperation of two or more M-Instances implementing the Operation Model, executing Processes, and producing Data with Formats that comply with the Functional Requirements of this Technical Specification, possibly via a Conversion Service.

## 2 Scope

Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Architecture enables two or more Metaverse Instances (M-Instances) to interoperate if they:

1. Rely on the same Operation Model.
2. Use either:
  - 2.1. The same Technologies.
  - 2.2. Independent Technologies but accessing appropriate Conversion Services.
3. Provide the Functionalities of a Functional Profile of this Technical Specification to the extent enabled by the MPAI-MMM – Architecture Profile architecture.

Technical Specification: MPAI Metaverse Model (MPAI-MMM) – Architecture specifies:

1. Terms (Normative).
2. Metaverse Functionalities (Informative).
3. Metaverse Operation Model (Normative).
4. Functional Requirements of:
  - 4.1. Processes, i.e., Programs executing in an M-Instance (Normative).
  - 4.2. Items, i.e., Data and Metadata supported by an M-Instance (Normative).
  - 4.3. Actions, i.e., Functionalities provided by Processes (Normative).
  - 4.4. Data Types, i.e., Data used in Actions and Items (Normative).
5. Use Cases (Informative).
6. Functional Profiles (Normative).

This Technical Specification has been developed by the MMM group of the Requirements Standing Committee. MPAI may decide to publish extensions or new versions of this Technical Specification, or other Technical Specifications of the MPAI-MMM series.

## 3 Definitions

Terms beginning with a capital letter have the meaning defined in Table 1. Terms beginning with a small letter have the meaning commonly defined for the context in which they are used. For instance, Table 1 defines *Object*, *Scene*, and *User* but does not define *object*, *scene*, and *human*.

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

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



*Table 1 – General Terms and Definitions*

<b>Terms</b>	<b>Definitions</b>
Account	An Item that uniquely references a Registered human.
Action	A Functionality provided by a Process.
- Authenticate	The Action of requesting that a Service confirm that an Entity is what it claims to be.
- Author	The Action of Calling a Service to obtain an Entity with associated OutRights to Act on the Entity.
- Change	The Action of requesting that a Service modify the Rights of a User and provide OutRights, e.g., to further Change the Rights.
- Convert	The Action of requesting that a Service change the Format of the Data of an Item into a Format specified by a FormatID.
- Discover	The Action of requesting that a Service provide a DiscoveryOut Item containing: 1. The IDs of the Items relevant to the User's request to Discover expressed in the DiscoverIn Item 2. The OutRights to Act on the DiscoverOut Item.
- Execute	The Action of requesting that a Process execute a Contract.
- Hide	The Action of requesting that a Service make the ID of an Item unavailable and provide OutRights, e.g., to make the ID available again.
- Identify	The Action of requesting that a Service produce an Item from Data & Metadata.
- UM-Import	The Action of a User requesting that a Service read Data & Metadata stored at an Address.
- Inform	The Action of requesting that a Service provide an InformOut Item containing information about an InItem, such as the Metadata of the InItem, with the OutRights to Act on the InformOut Item.
- Interpret	The Action of requesting that a Service provide an InterpretOut Item containing interpretation of an InItem, such as translation or extraction of Personal Status, with the OutRights to Act on the InterpretOut Item.
- MM-Add	The Action of requesting that a Service add an Entity at an M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Added Entity.
- MM-Animate	The Action of requesting that a Service change the features of a Model MM-Embedded at an M-Location with a Stream and provide the OutRights to Act on the MM-Added Entity.
- MM-Disable	The Action of requesting that a Service stop MM-Enabling selected Entities Embedded at an M-Location and provide OutRights to Act on the MM-Disabled Entities.
- MM-Embed	The Composite Action of requesting that a Service MM-Add and MM-Enable an Entity either located at a Service or at an M-Location at a destination M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Embedded Entity.
- MM-Enable	The Action of requesting that a Service accept requests to MM-Send selected Entities MM-Added at an M-Location or to MM-Embed those selected Entities at a destination M-Location and provide OutRights to act on the M-Entities.
- MM-Send	The Action of requesting that a Process forward an Item or Data/Metadata to a Process with appropriate granting Rights.

- Modify	The Action of requesting that a Service produce a new Item from an existing Item by providing new Data and Metadata with the OutRights to further Act on the new Item.
- MU-Actuate	The Action of requesting that a Device present an Entity available at a Device to a U-Location as Media with a Spatial Attitude.
- MU-Render	The Composite Action of requesting that: 1. A Service MM-Send selected Entities Embedded at an M-Location to a Device. 2. The Device MU-Actuate at a U-Location with a Spatial Attitude the Entity received.
- MU-Send	The Action of requesting that a Process transmit an Item to a Device or store an Item at an Address.
- Post	The Action of requesting that a Marketplace include an Asset to its repository of Assets.
- Register	The Action of a human requesting that an M-Instance grant their Users the Rights to perform Actions in the M-Instance.
- Resolve	The Action of requesting that a Service forward a Request-Action or a Response-Action to a Resolution Service in another M-Instance.
- Track	The Composite Action of requesting that a Service: 1. MM-Embed a Model at an M-Location with a Spatial Attitude. 2. MU-Animate the Model MM-Embedded at an M-Location. 3. MU-Render specified Entities at the M-Location to a U-Location.
- Transact	The Action of a User <sub>1</sub> requesting that a Service: 1. Assign Rights on an Asset to User <sub>2</sub> (“buyer”). 2. Cause: 2.1. Wallet <sub>1</sub> of User <sub>1</sub> (“seller”) to be increased by Value <sub>1</sub> . 2.2. Wallet <sub>2</sub> of User <sub>2</sub> to be decreased by Value <sub>2</sub> . Wallet <sub>3</sub> of the Service enabling/facilitating the Transaction to be increased by Value <sub>3</sub> (optionally).
- UM-Animate	The Composite Action of a User requesting: 1. A Device to 1.1. UM-Capture an animation stream extracted from a scene at a U-Location. 1.2. UM-Send the animation stream and Metadata to a User. 2. A Service to Identify the Animation Stream. 3. A Service to MM-Animate the Model MM-Embedded at the M-Location using the Animation Stream.
- UM-Capture	The Action of requesting that a Device capture Media from a scene at a U-Location.
- UM-Render	The Composite Action of a User requesting: 1. A Device to: 1.1. UM-Capture a scene at U-Location. 1.2. MM-Send Data and Device-provided Metadata to a User. 2. A Service to: 2.1. Identify an Entity from UM-Sent Data and Metadata. 2.2. MM-Embed the Entity at an M-Location with a Spatial Attitude.
- UM-Send	The Action of a Device acquiring Data & Metadata from an Address.
- Validate	The Action of requesting that a Service verify that a Process has the Rights to perform or request a Process to perform an Action on an Item.
Avatar	A rendered User (synonym of Persona).

Blockchain	A shared immutable ledger stored on a peer-to-peer network of computers.
Certification	The attestation that a Process or Item has specified characteristics.
Connected Autonomous Vehicle	(CAV) A vehicle able to autonomously reach a U-Location by using its own sensing and processing capabilities to generate an M-Instance, sharing its M-Instance with other CAVs and issuing actuation commands.
Conversion	The process of changing the Format of Data.
Data	Information represented in digital form.
- Format	The syntax and semantics of Data.
DataMdata	The combination of Data and Metadata that is not (yet) an Item.
Data Type	Data used in Actions and Items.
- Address	The URL of a storage facility.
- Amount	A number expressing a Value in a Currency.
- Cognitive State	The representation of a User's Personal Status that reflects the way they understand the Environment, such as "Confused", "Dubious", "Convinced".
- Coordinates	A set of numbers representing a Position in a Metaverse Environment using a coordinate system.
- Currency	A medium of exchange enabling Transactions in a Metaverse Environment.
- 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 a 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 Persona watching an Environment.
- Position	The Coordinates of a point in a Metaverse Environment using a Coordinate system.
- Social Attitude	The representation of a User's Personal Status related to the way it intends to position vis-à-vis an M-Environment, e.g., "Respectful", "Confrontational", "Soothing".
- Spatial Attitude	The Position and Orientation of an Entity, and their velocities and accelerations.
- Time	The representation of the measure of time.
Decentralised	
- Application	(dApp) A Process that runs on a decentralised computing system.
- Autonomous Organisation	(DAO) An organisation without centralised leadership, where the main governing rules are typically encoded by means of a Smart Contract.
- Finance	(DeFi) A financial technology based on a secure infrastructure of distributed ledgers like those used by crypto currencies.
- System	A set of dApps enabling a group of Users to make decisions without a centralised entity.
Device	Equipment enabling: <ul style="list-style-type: none"> <li>- A U-Environment to interact with an M-Instance and/or</li> <li>- An M-Instance to interact with a U-Environment.</li> </ul>
Duty	A moral or legal obligation to act or behave.
Entitlement	The state of a User having certain Rights in an M-Instance.

Functional requirement	Re-	A Functionality that is expected to be provided by an entity.
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 actors of the Metaverse Ecosystem.
Information and Communication Technologies		(ICT) Technologies that enable the processing and distribution of information via the network.
Interface		A communication pathway enabling systems to interact.
- <i>Brain-Computer</i>		(BCI) A communication pathway that allows a human to interact with an M-Instance by sensing and processing the electrical activity of the brain.
- <i>Haptic</i>		A communication pathway that allows a human to interact with an M-Instance through bodily movements and sensations.
- <i>Speech</i>		A communication pathway that allows a human to interact with an M-Instance using spoken language.
- <i>Visual</i>		A communication pathway that allows a human to interact with an M-Instance through bodily movements and visual messages.
Interoperability		The ability of an M-Instance to exchange and make use of the data of another M-Instance.
Item		Data and Metadata supported and identified by an M-Instance.
- Account		An Item that uniquely references a human who has Registered. A User may have more than one Account with one or more Services.
- Activity Data		An Item containing the record of all the Actions made by a User.
- Asset		An Item that may be the object of a Transaction. It may be MM-Embedded at an M-Location or Posted to a Service.
- AuthenticateIn		An Item containing: 1. The Entity or the ID of the Entity to be Authenticated. 2. Information related to the rendering of AuthenticateOut.
- AuthenticateOut		An Item containing the result of processing the Request-Authenticate Action and its rendering.
- Contract		A Program and its Metadata stored on a Device. It is activated by an external entity, e.g., a User, or another activated Contract.
- DiscoverIn		An Item containing: 1. A description of the Items to be Discovered. 2. Information related to the rendering of DiscoverOut.
- DiscoverOut		An Item containing the description of the Items Discovered and information related to its rendering.
- Entity		Any of the following Items that can be MU-Rendered: Object, Model, Scene, Event, and Experience.
- Event		An Entity that includes selected Entities at an M-Location and their Animations during a period.
- Experience		An Entity comprising User-selected Entities of an Event and the User Interactions with the Entities of the Event.
- Identifier		An Item that uniquely references an Item in an M-Instance.
- InformIn		An Item containing:

	<ol style="list-style-type: none"> <li>1. A description of the Item about which information is requested.</li> <li>2. Information related to the rendering of InformOut.</li> </ol>
- InformOut	An Item containing the description of the Item object of an InformIn.
- Interaction	An Item containing the Request-Action issued by a User on an Entity at an M-Locations and the corresponding Times.
- InterpretIn	An Item containing: <ol style="list-style-type: none"> <li>1. The ID or the Item to be Interpreted.</li> <li>2. Information related to the rendering of InterpretOut.</li> </ol>
- InterpretOut	An Item containing the description of the Item object of an InterpretIn Item.
- Ledger	An Item containing a list of Transactions involving Assets.
- Map	An Item containing a structure establishing a correspondence between U-Locations with M-Locations.
- M-Environment	An Identified subset of an M-Instance.
- Message	An Item containing application-specific Data MM-Sent by a Source Process to a Destination Process.
- M-Instance	An implementation of the Common Metaverse Specifications.
- M-Location	An Identified delimited space of an M-Environment.
- Model	An Object representing an object with its features ready to be MM-Animated or UM-Animated.
- Object	An Item with at least one of Audio, Visual, or Haptic perceptibility attributes.
- Obligation	An Item expressing the promise of a Process to perform Actions on Items at M-Locations during a Time.
- Persona	A Model representing a human.
- Personal Profile	An Item containing the Data about the human represented by a User.
- Program	Data that can be executed
- Provenance	The Ledger associated with a specific Asset.
- Request-Action	An Item of the request to a Process to perform an Action as defined in this document.
- Response-Action	An Item containing the response of a Process to a Request-Action as defined in this document.
- Rights	An Item expressing the Process's authorisation to perform Actions on Items at M-Locations during a Time.
- Rules	An Item expressing the terms and conditions under which a User operates in an M-Instance or M-Environment.
- Scene	A possibly hierarchical Composition of Objects having Spatial Attitudes.
- Social Graph	A representation of a User's network of connections with Items, M-Locations, and Processes.
- Stream	An Item made by a continuous flow of Data.
- Transaction	Item representing the changed state of the Accounts and the Rights of a seller User and a buyer User on an Asset and optionally of the Service facilitating/enabling the Transaction
- U-Location	An identifiable delimited portion of the Universe.
- 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.

Level	A subdivision of a Profile indicating the completeness of the user experience provided by the Profile.
Media	<ol style="list-style-type: none"> <li>1. Data acquired by a Device using a Sensor.</li> <li>2. Data converted by a Device from an Item to a format that can be presented.</li> </ol>
Metadata	An attribute of Data, e.g., of a User, an Environment, an Object, or a Service.
Metaverse	<p>A set of Processes providing some or all the following functions:</p> <ol style="list-style-type: none"> <li>1. To sense data from U-Locations.</li> <li>2. To process the sensed data and produce Data.</li> <li>3. To produce one or more M-Environments populated by Objects that can be either digitised or virtual, the latter with or without autonomy.</li> <li>4. To process Objects from the M-Instance or potentially from other M-Instances to affect U- and/or M-Environments using Object in ways that are: <ol style="list-style-type: none"> <li>4.1. Consistent with the goals set for the M-Instance.</li> <li>4.2. Effected within the capabilities of the M-Instance.</li> <li>4.3. Complying with the Rules set for the M-Instance.</li> </ol> </li> </ol>
- Actuator	A component of a Device able to MU-Render an Entity and environment Data to a U-Environment.
- Asset	An Item Embedded at an M-Location or Posted to a Service that may be the object of a Transaction.
- Ecosystem	The ensemble of entities and rules ensuring that Metaverse Instances operate in the interest of Metaverse Stakeholders.
- Enabling Service Layer	The set of Services such as payment, security, identity, privacy, etc. that enable operation of an M-Instance.
- Entity	Any of the following Items that can be MU-Rendered: Scene, Object, Model, Event, and Experience.
- Environment	(M-Environment) A portion of an M-Instance run by a Registration system.
- Experience Layer	The set of functions, such as Devices, that generate Experiences.
- Functionality	The attribute of a Process of being endowed with the capability of performing particular Action(s).
- Industry	The collection of players that support the design, development, deployment, operation, and content and service provisioning to Metaverse Instances.
- Instance	(M-Instance) An implementation providing all or a subset of the Metaverse Functionalities.
- Interoperability	The ability of M-Instance #1 to use data from and as intended by M-Instance #2. Interoperability can be Direct or Mediated by a Conversion Service.
- Infrastructure Layer	The set of functions such as network, transport, storage, and (cloud, edge) processing that enable an M-Instance to operate.
- Item	Metaverse-specific Data that may include Metadata that may include Rights.
- Level	A subdivision of a Profile that indicates the degree of completeness of the user experience provided by that Level.
- Location	(M-Location) An identifiable delimited portion of the Metaverse.
- Manager	The entity overseeing the operation of an M-Instance.

- Operation Model	The components and sequence of steps involved in an M-Instance provides Functionalities.
- Operator	The entity overseeing the operation of an M-Environment.
- Partner	A User participating in activities of a Metaverse Operator (i.e., a business customer of an Operator)
- Platform Layer	The set of Services, such as content creation, content discovery, and content access functions that enable an M-Instance to operate.
- Process	The instance of a program being executed.
- Profile	A recognised subset of the Functionalities (Functionality Profile) or Technologies (Technology Profile) specified by the Common Metaverse Specifications.
- Sensor	A Device able to UM-Capture a scene and other environment information as Data.
- Specification	The collection of standards specifying the Technologies and Technology Profiles enabling Metaverse Interoperability.
- Stakeholder	An entity performing a function aimed at achieving a goal in an M-Instance.
- State	The set of values and stored data of an M-Instance at a given time.
- Tool	A Technology or group of Technologies enabling an M-Instance to provide a Functionality.
- Technology	A structured application of scientific and/or technical methods that supports a Functionality.
- User	One or a set of Processes representing a human.
Object	
- <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 animated by a Process giving it 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 computer-generated that can be rendered to and perceived by a human eye.
Oracle	A Service providing information from a U-Environment to a Blockchain.
Privacy	The Rights of a User to keep their Personal Data secret.
Process	
- App	An application-specific Program executed on a Device.
- Capability	The characteristics of a Process.
- Device	A Process able to: 1. UM-Capture Data from a U-Location 2. UM-Send Data and Metadata to a User. and/or

	1. MM-Send an Entity from an M-Location to the Device. 2. MU-Render an Entity at a U-Location.
- Service	A Process that can be called to provide specific Functionalities.
- User	A Process representing a human that is UM-Animated by a Stream or MM-Animated by an autonomous agent.
- App	An application-specific Program executed on a Device.
- User	A Process representing a UM-Captured human as a Persona that are either UM-Animated by a Stream or MM-Animated by an autonomous agent.
Profile	A set of base standards and/or their subsets.
- <i>Functionality</i>	The grouping of Functionalities offered by a Metaverse Profile.
- <i>Technology</i>	The grouping of Technologies offered by a Metaverse Profile.
Registration	The provisioning by a human of a subset of User Data to an M-Instance/Environment to obtain an Account.
Render	The process of making an Item perceptible by human senses.
Representation	Data that represent an entity of a U-Environment in an M-Instance.
Sense of	
- Agency	The subjective awareness of being able to decide, execute, and control one's own actions in an M-Environment.
- Embodiment	The engagement of senses to form a complete Environment Experience.
- Presence	The feeling of being in an M-Environment with other Digital Humans for real.
Service	
- <i>Conversion</i>	A Service converting the Data produced by an M-Instance <sub>A</sub> into Data understood and acted upon by M-Instance <sub>B</sub> as intended by M-Instance <sub>A</sub> .
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"> <li>- Cannot be copied (i.e., a copy is known to be a copy), substituted, or subdivided.</li> <li>- Is recorded in a digital ledger.</li> <li>- Is used to certify Object authenticity and ownership.</li> </ul>
Trust-less system	A system allowing a User to make reliable Transactions without trusting or knowing the parties the User makes Transactions with.
Universe	The physical world.
- Location	(U-Location) An identifiable delimited portion of the Universe.
Use Case	An example of how an application domain can be supported by an M-Instance/Environment.
User Keys	The pair of public and private keys where the public key is used to encrypt, and the private key is used to both encrypt and decrypt Data.
User Identifier	
- <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.

## 4 References

### 4.1 Normative reference

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2. MPAI; The MPAI Patent Policy; <https://mpai.community/about/the-mpai-patent-policy/>.
3. Framework Licence: MPAI Metaverse Model (MPAI-MMM) – Architecture V1; <https://mpai.community/standards/mpai-mmm/framework-licence/>.

### 4.2 Informative references

4. MPAI; Technical Specification – Governance of the MPAI Ecosystem (MPAI-GME); <https://mpai.community/standards/mpai-gme/>
5. MPAI; Technical Specification – AI Framework (MPAI-AIF); <https://mpai.community/standards/mpai-aif/>
6. MPAI; Technical Specification – Avatar Representation and Animation (MPAI-ARA) – Architecture; September 2023; <https://mpai.community/standards/mpai-ara/>
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10. MPAI; Technical Report – MPAI Metaverse Model (MPAI-MMM) – Functionalities; January 2023; <https://mpai.community/standards/mpai-mmm/mpai-metaverse-model-mmm-functionality-profiles-mpai-metaverse-model-mmm-functionalities/>
11. MPAI; Technical Report – MPAI Metaverse Model (MPAI-MMM) – Functionality Profiles; May 2023; <https://mpai.community/standards/mpai-mmm/mpai-metaverse-model-mmm-functionality-profiles/>
12. Khronos; Graphics Language Transmission Format (glTF); October 2021; <https://registry.khronos.org/glTF/specs/2.0/glTF-2.0.html>

## 5 Metaverse Functionalities

This Chapter collects the Functionalities of an M-Instance supported by this Technical Specification. Terms beginning with a small letter have the common meaning, Terms beginning with a capital letter are defined in Chapter 3.

Particularly important is a characterisation of an M-Instance as:

1. A set of Processes providing some or all the following functions:
  - 1.1. Sensing data from U-Locations using Devices.
  - 1.2. Processing the sensed data and producing Items.
  - 1.3. Producing one or more M-Environments populated by Items either imported or internally generated.

- 1.4. Processing Objects from the M-Instance or potentially from other M-Instances to affect U- and/or M-Environments in ways that are:
  - 1.4.1. Consistent with the goals set for the M-Instance.
  - 1.4.2. Effected within the capabilities of the M-Instance.
  - 1.4.3. In compliance with the Rules set for the M-Instance.
2. A human, possibly on behalf of a legal entity, may Register with an M-Instance.
3. The M-Instance may:
  - 3.1. Request:
    - 3.1.1. A subset of the human's Personal Profile.
    - 3.1.2. WalletIDs
    - 3.1.3. Users
    - 3.1.4. Personae
  - 3.2. Create an Account with AccountID.
4. The Account may include:
  - 4.1. The subset of the human's Personal Profile.
  - 4.2. WalletIDs
    - 4.2.1. Users
    - 4.2.2. Personae
  - 4.3. Rights and Obligations
5. Rights may include:
  - 5.1. The maximum number of:
    - 5.1.1. Users a human can deploy.
    - 5.1.2. Personae a User can be rendered as.
    - 5.1.3. Concurrent Users and Objects an M-Location can support.
  - 5.2. The ability to:
    - 5.2.1. Create persistent (as opposed to ephemeral) Scenes at M-Locations.
    - 5.2.2. Store, search, and retrieve Experiences.
    - 5.2.3. Develop economic activities.
    - 5.2.4. Book M-Locations for a duration.
    - 5.2.5. Support persistent storage.
    - 5.2.6. Connect with or import Processes to an M-Instance.
    - 5.2.7. Make Transactions to acquire Rights.
6. Processes are:
  - 6.1. Devices: they connect U-Locations with M-Locations and vice-versa.
  - 6.2. Users: they represent humans and are humans' agents in the M-Instance or on Devices.
  - 6.3. Apps: they run on Devices. A User may be an App running on a Device.
  - 6.4. Services: they are generic Processes providing Functionalities.
7. Certification:
  - 7.1. Contracts may be imported to an M-Instance if they have passed a Certification Process.
  - 7.2. Processes may be connected or imported to an M-Instance if they have passed a Certification Process.
8. M-Instance Rules may include:
  - 8.1. The User Data retention, processing, and access policy.

- 8.2. The Rights and Obligations, e.g., ethical behaviour of Users.
  - 8.3. The permission-based or permission-less access policy to M-Environments.
  - 8.4. The trustful or trust-less relationship between Users and M-Instance.
  - 8.5. The subset of User Data required for each Account type.
  - 8.6. The sanctions applied to a User whose Actions do not comply with the Rules.
9. (Perception) A User may, depending on the Rights it holds:
    - 9.1. Perceive scenes at U-Locations as captured by Devices endowed with audio, visual, haptic, and BCI capabilities, and the spatial attitudes of their objects.
    - 9.2. Receive Messages from a U-Location as a result of an event there.
    - 9.3. Import audio, speech, visual, and haptic models.
    - 9.4. Perceive Entities.
    - 9.5. Render perceived Entities at a U-Location with spatial attitudes.
    - 9.6. Import Data and Metadata from and export Items to an Address.
  10. (Interaction) A User may, depending on the Rights it holds:
    - 10.1. Interrogate a Process about its Functionalities.
    - 10.2. Interact with Entities.
    - 10.3. Send public or private Speech, Visual, and Haptic Messages to Users.
    - 10.4. Send selected Entities to a User.
    - 10.5. Place Entities with Spatial Attitudes.
    - 10.6. Animates Models.
  11. (Service call) A User may, depending on the Rights it holds, perform or request a Service to perform:
    - 11.1. Author an Item.
    - 11.2. Authenticate an Item.
    - 11.3. Change the Rights of a Process.
    - 11.4. Discover Objects, Processes, Events, or Experiences.
    - 11.5. Find the Transactions involving an Asset under specified conditions.
    - 11.6. Obtain an interpretation of an Item, e.g.:

<b>Request</b>	<b>From</b>	<b>To</b>
Extract	Text	Personal Status
Extract	Speech	Text
Translate	Text or Speech	Text or Speech
Extract	Face and/or Gesture	Personal Status

- 11.7. Obtain Conversion of an Item from a Format to another Format.
  - 11.8. Obtain information about a Process or an Item.
  - 11.9. Obtain a recommendation of Processes or Items.
  - 11.10. Record all the Actions made by a User (Activity Data) at an M-Location during a time.
  - 11.11. Create a representation of a User's network of connections with Items, M-Locations, and Processes (Social Graph).
  - 11.12. Posts an Item that can be Transacted (Asset) to a marketplace.
  - 11.13. Retrieve Objects, Events, or Experiences.
  - 11.14. Store Objects, Events, or Experiences.
12. A User may formulate:
    - 12.1. The information it intends to obtain from a Service.

- 12.2. The Rights it intends to acquire on the response of the Service.
- 12.3. How the response should be rendered.

13. A User may acquire, or have as part of its Account the Rights to:

- 13.1. Perform or request another User to perform Actions on Items.
- 13.2. Develop an economic activity in an M-Environment.
- 13.3. Make an Asset out of an Item.
- 13.4. Make a Transaction on an Asset specifying which Rights to the Asset it grants to the buyer.
- 13.5. Make an agreement with another user, e.g., via a Contract.
- 13.6. Copy or Modify, i.e., change Data (e.g., by editing it) and/or Metadata of an Item.
- 13.7. Change the settings and attributes of Entities of an M-Locations (e.g., SFX during a concert).
- 13.8. Set the Point of View from which it perceives a Scene.
- 13.9. Make inaccessible to any User an Item for which it has Rights.
- 13.10. Make or request a Process to make Actions in its own or another M-Instance.
- 13.11. Be rendered as one of the Personae uploaded at registration time.

14. A Process may request a Process in another M-Instance to perform Actions.

15. A Persona may:

- 15.1. Faithfully reproduce the visual appearance of the human.
- 15.2. Have their visual appearance altered, compared to that of the human.
- 15.3. Have an unrelated visual appearance.
- 15.4. Display a presumptive Personal Status in speech, face, and gesture.
- 15.5. Be driven by the movements of the human.
- 15.6. Be driven by a Process.

16. An M-Location may be:

- 16.1. Private, i.e., only a User or a group of Users have Rights to it.
- 16.2. Public, i.e., a Metaverse Operator or a User grant anybody the Rights to enter, move in, and perceive the M-Location.
- 16.3. Persistent
- 16.4. Ephemeral.

17. An Object may:

- 17.1. Be Virtual, i.e., Authored in an M-Instance.
- 17.2. Be Digitised, i.e., Digital Twins of objects.
- 17.3. Be Autonomous, i.e., Animated by a Process.
- 17.4. Have Audio, Visual, or Haptic attributes, or combinations of these attributes.

18. An Identifier:

- 18.1. Uniquely references an Item, an M-Location, or a Process.
- 18.2. May be issued by a central, distributed, or no authority.
- 18.3. May have a Format accepted by more than one M-Instance.
- 18.4. May enable to trace the Identifier of an Item back to the Item that spawned the Asset.
- 18.5. May enable to trace the Identifier of a Modified Item back to the Item that spawned the Modified Item.

19. User Data may have a scalable representation to enable an easy extraction of a subset.

20. An M-Instance:

- 20.1. May operate in a centralised or decentralised way.
- 20.2. Monitors:
  - 20.2.1. The Rights held by Processes on Processes to Act on Items at M-Locations.
  - 20.2.2. The Entities placed at M-Locations with a Spatial Attitude.
- 20.3. Should be secure, e.g., to prevent malicious Users from:
  - 20.3.1. Accessing the Account of a human who is not the human represented by the User.
  - 20.3.2. Taking control of a Process.
  - 20.3.3. Acting on Items for which it does not have Rights.
- 20.4. Should withstand denial of service attacks.

## 6 Metaverse Operation Model

An M-Instance is an Information and Communication Technology platform with the following general functions:

- 1. To sense data from U-Locations.
- 2. To process the sensed data and produce Data.
- 3. To produce one or more M-Environments populated by Objects that can be either digitised or virtual, the latter with or without autonomy.
- 4. To process Objects from the M-Instance or potentially from other M-Instances.
- 5. To affect U- and/or M-Environments using Objects in ways that are:
  - 5.1. Consistent with the goals set for the M-Instance.
  - 5.2. Within the Capabilities of the M-Instance.
  - 5.3. According to the Rules of the M-Instance.
  - 5.4. Respecting applicable laws and regulations.

and operating as and providing the Functionalities of this Technical Specification.

An M-Instance:

- 1. May make its Capabilities known.
- 2. May be administratively subdivided in M-Environments.
- 3. May allow a human to Register with the M-Instance or an M-Environment.
- 4. May request a Registering human to provide a subset of their Personal Profile.
- 5. Is implemented as a set of Processes:
  - 5.1. Providing Functionalities defined by this Technical Specification.
  - 5.2. Composed of:
    - 5.2.1. A Program having a Format supported by the M-Instance.
    - 5.2.2. Metadata describing the Program and containing the following as a minimum:

*Table 2 – Minimum Metadata of a Process*

Metadata elements	Details
ProcessID	The ID of the Process.
UserID	The ID of the User having Rights to Act on the Process.
InRightsID	The ID of the User's Rights to Act granted to the Process.
OutRightsID	The ID of the Rights a User may acquire on the Process.
DescrMdata	Any description of the Process.

- 5.3. Performing Actions on Items if they hold the Rights to do that.
- 5.4. Requesting other Processes to perform Actions by transmitting a standard Request-Action Item and responding to a Request-Action with a Response-Action:

Table 3 – Elements of Request-Action and Response-Action

Request-Action	Response-Action	Details
Request-Action ID	Response-Action ID	Unique ID
Emission Time	Emission Time	Tine of Issuance
Source Process ID	Source Process ID	Requesting Process ID
Destination Process ID	Destination Process ID	Requested Process ID
InItems	OutItems	In/Output Items required by the Action
InLocations		Locations of InItems
OutLocations		Locations of OutItems
OutRights		Expected Rights on OutItems

5.5. Performing the Request if:

5.5.1. The requesting Process holds the Rights that are required to perform the request.

5.5.2. The requested Process holds Rights to perform the requested Action on the Item.

6. May support four types of Processes:

6.1. The User Process represents and is under the control of a human who has Registered with the M-Instance. A User may run on the M-Instance or on a Device connected to the M-Instance.

6.2. Device is one or more Processes running on a physical device connecting M-Locations to U-Locations, specifically the Registered human, by:

6.2.1. Capturing scenes as Media and providing Media as Data/Metadata – U-Location to M-Location). Data/Metadata shall be Identified as an Item to enable Processes to perform Actions.

6.2.2. Receiving an Entity and rending it as Media with a Spatial Attitude (Position and Orientation) – M-Location to a U-Location.

6.3. Service provides specific functionalities.

6.4. App runs on a Device. A Device may run the User Process as an App.

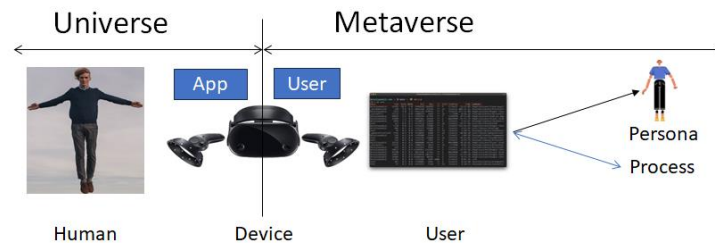


Figure 1 - The human-device-user-persona chain

7. Provides Functionalities through Processes performing Actions on Items containing:

7.1. Data whose Format is supported by the M-Instance.

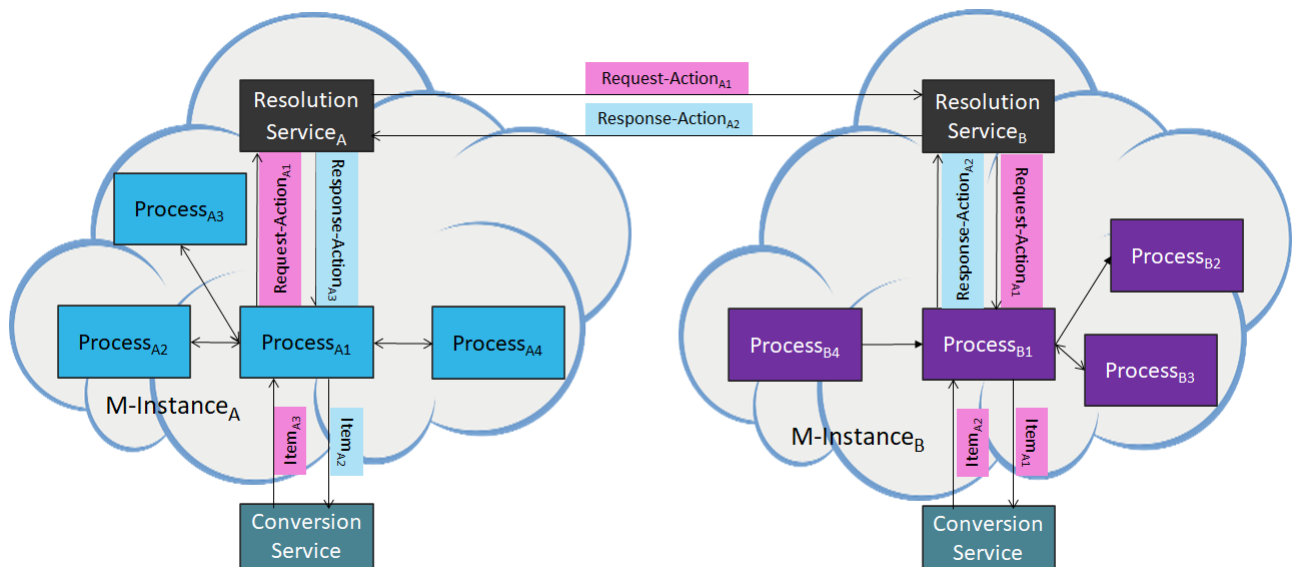
7.2. Metadata describing the Item and containing the following as a minimum:

Table 4 - Minimum Metadata for Item

Metadata elements	Details
ItemID	The ID of the Item.
UserID	The ID of the User having Rights to Act on the Item.
InRightsID	The ID of the User's Rights to Act granted to the Item.
OutRightsID	The ID of the Rights a User may acquire on the Item.
DescrMdata	Any description of the Item.

8. Enables a Process:

- 8.1. To communicate to a Process in another M-Instance through an M-Instance's Resolution Service.
- 8.2. To obtain conversion of the Format of an Item's Data by calling a Conversion Service.
- 8.3. To specify their communication needs by:
  - 8.3.1. Requesting the needed maximum and average bitrate value.
  - 8.3.2. Reserving the needed bitrate for a time and a location.
  - 8.3.3. Requesting that the same simultaneous Experience be provided to a specified number of Devices.
9. Identifies Processes/Items with one Identifier and, optionally, with more than one Identifier. Each Identifier uniquely refers to one Process/Item.
10. Creates Items by processing the sensed data and the autonomously produced data.
11. Employs Data Types to represent entities such as Amount (of a Currency), length, area, and volume etc.
12. Gives a Registered human the Rights to deploy one or more:
  - 12.1. Users and Devices each with M-Instance-specific Rights.
  - 12.2. Personae, i.e., human-like, or humanoid Models used by deployed Users to render themselves.
13. Establishes Rules that the Users in the M-Instance shall comply with.



*Figure 2 - Resolution and Conversion Services*

14. May penalise Users for lack of compliance with the Rules.
15. May allow a Process to perform, or request another Process to perform, Actions on Items even in the absence of Rights.
16. May require that Processes be certified for use in the M-Instance.

Future versions of this document may specify:

1. Profiles of Actions and Items.
2. Additional Actions and Items.

## 7 Functional Requirements of Processes

### 7.1 App

<b>Purpose</b>	An application-specific Program executed on a Device.		
<b>Functional Requirements</b>	The Manager of the M-Instance in which an App will be deployed may request that the Device be subject to certification.		
<b>Metadata</b>	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 granted to the App.	
	OutRightsID	The ID of the Rights a User may acquire on the App.	
	DescrMdata	Any description of the App.	

### 7.2 Device

<b>Purpose</b>	A Process able to: 1. UM-Capture Data from a U-Location 2. UM-Send Data and Metadata to a User. and/or 1. MM-Send an Entity from an M-Location to the Device. 2. MU-Render an Entity at a U-Location.		
<b>Functional Requirements</b>	To connect and interoperate with an M-Instance, a Device needs to 1. Exchange Capabilities with the M-Instance. 2. Use the same Item Data Formats or rely on a Conversion Service. The Manager of the M-Instance to which a Device connect may request that the Device be subject to certification.		
<b>Metadata</b>	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 granted to the Device.	
	OutRightsID	The ID of the Rights a User may acquire on the Device.	
	DescrMdata	Any description of Device.	

### 7.3 Service

<b>Purpose</b>	A Process that can be called to provide specific Functionalities.		
<b>Functional Requirements</b>	A Service may be: 1. One of the Services natively supported by an M-Instance. 2. Hosted by the M-Instance but provided by a third party. A hosted Service may be subject to certification by the Manager of the M-Instance or an entity delegated by them.		
<b>Metadata</b>	ServiceID	The ID of the Service.	
	UserID	The ID of the User having Rights to Act on the Service.	
	InRightsID	The ID of the User's Rights to Act granted to the Service.	
	OutRightsID	The ID of the Rights to Act on the Service a User may acquire.	
	DescrMdata	Any description of the Rights.	

### 7.4 User

<b>Purpose</b>	A Process representing a human.		
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<b>Functional Requirements</b>	1. A User may perform the following functions: 1.1. The interface of the human with the M-Instance. 1.2. Render the User as a Persona: 1.2.1. UM-Animated by a Stream. 1.2.2. MM-Animated by an autonomous agent. 2. Animation results from an MM-/UM-Animate Action and enabled by a Program run by the User. 3. The Animation Program may be provided: 3.1. By the human. 3.2. By the M-Instance. The Manager of the M-Instance where a User running a proprietary Program is deployed may request that the Program be subject to certification.		
<b>Metadata</b>	UserID	ID of User.	
	RightsID	ID of Rights held by User	
	AccountIDs	IDs of Accounts where the User can operate.	
	WalletIDs	IDs of Wallets held by User.	
	UserDataID	ID of User Data.	
	DescrMdata	Any description of the User.	

## 8 Functional Requirements of Items

### 8.1 General Items

#### 8.1.1 M-Instance

<b>Purpose</b>	An implementation of MPAI-Metaverse Model – Architecture.		
<b>Functional Requirements</b>	An M-Instance may: 1. Implement a subset of MPAI-Metaverse Model – Architecture (i.e., a Functional Profile). 2. Add Functionalities not supported by MPAI-Metaverse Model – Architecture. In this case full Interoperability with another M-Instance may not be achieve 3. Enable the creation of M-Environments.		
<b>Metadata</b>	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 User Rights “to Act on the M-Instance”.	
	OutRightsID	The ID of the Rights a User may acquire on the M-Instance.	

#### 8.1.2 M-Capabilities

<b>Purpose</b>	An Item expressing the ability of an M-Instance to perform an Action on an Item.		
<b>Functional Requirements</b>	An M-Instance/M-Environment may show its Capabilities, including Profile and the Data Formats used by the Items.		
<b>Metadata</b>	M-CapabilitiesID	The ID of the Rights.	
	UserID	The IDs of the Process “having Rights to Capabilities”.	
	OutRightsID	The ID of the Rights a User may acquire.	
	DescrMdata	Any description of the Rights.	

### 8.1.3 M-Environment

<b>Purpose</b>	An Identified administrative subset of an M-Instance.		
<b>Functional Requirements</b>	An M-Environment may allow the definition, Identification, and access to M-Locations.		
<b>Metadata</b>	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 User Rights “to Act on the M-Environment”.	
	OutRightsID	The ID of the Rights a User may acquire on the M-Environment.	

### 8.1.4 Identifier

<b>Purpose</b>	An Item that uniquely references an Item in an M-Instance.		
<b>Functional Requirements</b>	An Item can have more than one Identifier. An Identifier of an Item may have a hierarchical structure: 1. M-InstanceID 2. M-EnvironmentID 3. M-LocationID 4. ItemID. An Identifier of an Item shall have a hierarchical structure: 1. M-InstanceID 2. M-EnvironmentID 3. M-Location 4. ProcessID 5. ItemID.		
<b>Metadata</b>	No Metadata		

### 8.1.5 Rules

<b>Purpose</b>	An Item expressing the terms and conditions under which a human deploys a User in an M-Instance or M-Environment.		
<b>Functional Requirements</b>	The Rules 1. Shall express the permissions, obligations, and prohibitions with respect to Actions performed by a User on Items. 2. May grant a User the ability to 2.1. Make Transactions. 2.2. Export Items to another Metaverse.		
<b>Metadata</b>	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”.	
	DescrMdata	Any descriptive Metadata.	

### 8.1.6 Rights

<b>Purpose</b>	An Item expressing: 1. The ability of a Process to perform Actions on an Item during a Time and at an M-Location.		
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	2. The possibility that an Item be subjected to an Action by a Process during a Time at an M-Location.		
<b>Functional Requirements</b>	Rules may waive the need for certain Processes to hold certain Rights to perform certain Actions at certain Times.		
<b>Metadata</b>	RightsID	The ID of the Rights.	
	UserID	The IDs of the Process “having Rights”.	
	OutRightsID	The ID of the Rights a User may acquire.	
	DescrMdata	Any description of the Rights.	

### 8.1.7 Program

<b>Purpose</b>	Data that can be executed.		
<b>Functional Requirements</b>	The code: 1. Shall be executable in the M-Instance. 2. May be subject to certification before being admitted to the M-Instance.		
<b>Metadata</b>	ProgramID	The ID of the Program.	
	UserID	The ID of the User who “has Rights to Execute the Program”.	
	InRightsID	The ID of the Rights “to Act on the Program”.	
	OutRightsID	The ID of the Rights “to Act on the Program” a User may acquire.	
	DescrMdata	Any descriptive Metadata.	

### 8.1.8 Contract

<b>Purpose</b>	A Program and its Metadata stored on a Device. It is activated by an external entity, e.g., a User, or another activated Contract.		
<b>Functional Requirements</b>	The Data of a Contract shall be in a form that allows its execution in the M-Instance. A Contract may be subject to a certification carried out by or on behalf of the M-Instance Manager before it can be imported into an M-Instance.		
<b>Metadata</b>	AssetID	The ID of the Contract.	
	UserID	The ID of the User “having Rights to Act on the Contract”.	
	InRightsID	The ID of the User’s Rights to Act on the Contract.	
	OutRightsID	The ID of the Rights a User may acquire on the Contract.	
	DescrMdata	Any description of the Contract.	

## 8.2 Human and User-related Items

### 8.2.1 Account

<b>Purpose</b>	An Item that uniquely references a human who has Registered.	
<b>Functional Requirements</b>	A User may have more than one Account with one or more M-Instances or M-Environments. An Account shall include: 1. The ID of the Registered human. 2. An M-Instance-specific subset of the Registered human’s User Data. 3. The Rights held by each Users in the M-Instance/M-Environment. 4. The IDs of Devices, Apps, and Users, and Personae.	
<b>Metadata</b>	AccountID	The ID of the Account.
	humanID	The ID of the Account holder.

	RightsIDs	The ID of the Users' Rights in the M-Instance.
	M-InstanceID	The ID of the M-Instance the Account refers to.
	DescrMdata	Any description of the Account.

### 8.2.2 Activity Data

<b>Purpose</b>	An Item containing the record of all the Actions made by a User.	
<b>Functional Requirements</b>	Activity Data shall include: 1. The M-Instance ID. 2. The duration the Activity Data refer to. 3. The list of Interactions.	
<b>Metadata</b>	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.
	M-InstanceID	The ID of the M-Instance the Account refers to.
	DescrMdata	Any description of the Activity Data.

### 8.2.3 Personal Profile

<b>Purpose</b>	An Item containing the Data about the human represented by a User.	
<b>Functional Requirements</b>	The Personal Profile may include: 1. First Name 2. Last Name 3. Address 4. Nationality. 5. Age.	
<b>Metadata</b>	PersonalDataID	The ID of the Personal Data.
	humanID	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.

### 8.2.4 Social Graph

<b>Purpose</b>	A representation of a User's network of connections with Items and Processes.	
<b>Functional Requirements</b>	The Social Graph should represent the Times of Interactions with: 1. Items and Users at M-Locations. 2. Devices. 3. Services.	
<b>Metadata</b>	SocialGraphID	The ID of the Social Graph.
	UserID	The ID of the User "having Rights on the Social Graph".
	inRightsID	The ID of the Rights "to Act on the Social Graph".
	OutRightsID	The ID of the Rights "to Act on the Social Graph" a User may acquire.
	DescrMdata	Any description of the Social Graph.

### 8.2.5 User Data

<b>Purpose</b>	An Item containing Activity Data, Personae, Social Graph, and User Profile of a User.		
<b>Functional Requirements</b>	User Data include the following Data: <ol style="list-style-type: none"> <li>1. Rights and Obligations held by the human with their Account.</li> <li>2. The Personal Profile of the human.</li> <li>3. The Personae that the Users of the human may assume.</li> <li>4. The Activity Data of the Users of the human.</li> <li>5. The Social Graphs of the Users of the human.</li> </ol>		
<b>Metadata</b>	UserDataID	ID of UserData.	
	UserID	ID of User having Rights on UserData	
	RightsID	ID of Rights held by User	
	PersonalProfileID	ID of Personal Profile.	
	PersonaIDs	IDs of Personae held User.	
	ActivityDataID	ID of Activity Data	
	SocialGraphID	ID of SocialGraph	
	DescrMdata	Any description of the User.	

## 8.3 Items for Process Interaction

### 8.3.1 Message

<b>Purpose</b>	An Item a Source Process MM-Sends to a Destination Process.		
<b>Functional Requirements</b>	A Message may contain: <ol style="list-style-type: none"> <li>1. An Item, or</li> <li>2. Data and Metadata</li> </ol>		
<b>Metadata</b>	MessageID	The ID of the Message.	
	Descriptive Metadata	Any description of the Message.	

### 8.3.2 P-Capabilities

<b>Purpose</b>	An Items containing a description of the characteristics of a Process.		
<b>Functional Requirements</b>	<ol style="list-style-type: none"> <li>1. Provision of the P-Capabilities Item is optional.</li> <li>2. The characteristics are:               <ol style="list-style-type: none"> <li>2.1. Device:                   <ol style="list-style-type: none"> <li>2.1.1. Apps on board.</li> </ol> </li> <li>2.2. User:                   <ol style="list-style-type: none"> <li>2.2.1. Human the User represents.</li> </ol> </li> <li>2.3. All Processes                   <ol style="list-style-type: none"> <li>2.3.1. List of Actions that can be performed.</li> <li>2.3.2. List of Items supported with Data Formats.</li> <li>2.3.3. List of Data Types supported.</li> <li>2.3.4. The cost of performing an Action.</li> </ol> </li> </ol> </li> </ol>		
<b>Metadata</b>	PCapabilityID	The ID of P-Capabilities of a Process.	
	Descriptive Metadata	Any description of the P-Capabilities.	

### 8.3.3 Request-Action

<b>Purpose</b>	An Item containing the request to a Process to perform Action as defined in this document.		
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<b>Functional Requirements</b>	A Request-Action shall include: <ol style="list-style-type: none"> <li>1. Time the Request-Action was issued.</li> <li>2. The Source ProcessID.</li> <li>3. The Destination ProcessID.</li> <li>4. The Action requested.</li> <li>5. The ItemIDs relevant to the Action.</li> <li>6. The Locations of the Items.</li> <li>7. The Locations of the output Items produced by the Request-Action.</li> <li>8. The requested Rights on the output Items.</li> </ol>		
<b>Metadata</b>	Request-ActionID	The ID of the Request-Action.	
	DescrMdata	Any descriptive Metadata.	

### 8.3.4 Response-Action

<b>Purpose</b>	An Item containing the response of a Process to a Request-Action as defined in this document.		
<b>Functional Requirements</b>	The Response-Item shall include: <ol style="list-style-type: none"> <li>1. Time the Response-Action was issued.</li> <li>2. The Source ProcessID (Source refers to the Process that issued the request).</li> <li>3. The Destination ProcessID.</li> <li>4. The output Items produced by the Request-Action.</li> <li>5. Error messages.</li> </ol>		
<b>Metadata</b>	Request-ActionID	The ID of the Response-Action.	
	DescrMdata	Any descriptive Metadata.	

## 8.4 Items for Service access

### 8.4.1 AuthenticateIn

<b>Purpose</b>	An Item containing: <ol style="list-style-type: none"> <li>1. The Entity or the ID of the Entity to be Authenticated.</li> <li>2. Information related to the rendering of AuthenticateOut (optional).</li> </ol>		
<b>Functional Requirements</b>	The Entity to be Authenticated can be: <ol style="list-style-type: none"> <li>1. Speech produced by a User.</li> <li>2. The visual appearance of a User.</li> <li>3. ...</li> </ol> Information on the rendering of InterpretOut may be provided by: <ol style="list-style-type: none"> <li>1. Media type (text, speech, image, etc.) used for rendering.</li> <li>2. Spatial Attitude of the Object rendering AuthenticateOut.</li> </ol>		
<b>Metadata</b>	AuthenticateInID	The ID of the AuthenticateIn Item.	
	UserID	The ID of the User generating the AuthenticateIn Item.	
	ServiceID	The ID of the Service providing Authentication Services.	
	RightsID	The ID of the Rights “to Act on the AuthenticateIn Item” granted to the Authentication Service.	
	DescrMdata	Any description of the AuthenticateIn Item.	

### 8.4.2 AuthenticateOut

<b>Purpose</b>	An Item containing the result of the Service Acting on the Request-Authenticate Item and information about its rendering.		
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<b>Functional Requirements</b>	AuthenticateOut shall be: <ol style="list-style-type: none"> <li>Made available to the User as Item, and</li> <li>Rendered to the User as a perceptible Object as specified in AuthenticateIn.</li> </ol>	
<b>Metadata</b>	Autheti- cateOutID	The ID of the Request-Authenticate Item.
	ServiceID	The ID of the Service providing the AuthenticateOut Item.
	UserID	The ID of the User having requested the AuthenticateOut Item.
	RightsID	The ID of the Rights “to Act on the AuthenticateOut Item” granted to UserID.
	Descr- Mdata	Any description of the AuthenticateOut Item.

### 8.4.3 DiscoverIn

<b>Purpose</b>	An Item containing: <ol style="list-style-type: none"> <li>A description of the Items to be Discovered or recommended.</li> <li>Information related to the rendering of DiscoverOut.</li> </ol>	
<b>Functional Requirements</b>	Items candidate for Discovery may be described by: <ol style="list-style-type: none"> <li>Verbal/text description</li> <li>Similar Items</li> <li>Belonging to specific M-Instances/M-Environments/M-Locations</li> <li>Belonging to specific sections of Activity Data.</li> </ol> Information on DiscoverOut Rendering may be provided by: <ol style="list-style-type: none"> <li>Media type used for rendering.</li> <li>Spatial Attitude of the Object rendering DiscoverOut.</li> </ol>	
<b>Metadata</b>	DiscoverInID	The ID of the DiscoverIn Item.
	UserID	The ID of the User generating the DiscoverIn Item.
	ServiceID	The ID of the Service providing Discovery Services.
	RightsID	The ID of the Rights “to Act on the DiscoverIn Item” granted to the Discovery Service.
	DescrMdata	Any description of the DiscoverIn Item.

### 8.4.4 DiscoverOut

<b>Purpose</b>	An Item containing the description of the Items Discovered and information related to its rendering.	
<b>Functional Requirements</b>	Discovered Items shall be: <ol style="list-style-type: none"> <li>Described by the IDs of the Items Discovered.</li> <li>Rendered to the User as a perceptible Object.</li> </ol>	
<b>Metadata</b>	DiscoverOutID	The ID of the Request-Discover Item.
	ServiceID	The ID of the Service providing the DiscoverOut Item.
	UserID	The ID of the User having requested the DiscoverOut Item.
	RightsID	The ID of the Rights “to Act on the DiscoverOut Item” granted to UserID.
	DescrMdata	Any description of the DiscoverOut Item.

### 8.4.5 InformIn

<b>Purpose</b>	An Item containing: <ol style="list-style-type: none"> <li>A description of the Item about which information is requested.</li> <li>Information related to the rendering of InformOut.</li> </ol>	
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<b>Functional Requirements</b>	InformIn may refer to: <ol style="list-style-type: none"> <li>1. Item Metadata</li> <li>2. Any other information that a Service may have on the Item.</li> </ol> Information on rendering of InformOut may be provided by: <ol style="list-style-type: none"> <li>1. Media type used for rendering.</li> <li>2. Spatial Attitude of InformOut rendered Object.</li> </ol>	
<b>Metadata</b>	InformInID	The ID of the InformIn Item.
	UserID	The ID of the User generating the InformIn Item.
	ServiceID	The ID of the Service providing Inform Services.
	RightsID	The ID of the Rights “to Act on the InformIn Item” granted to the Inform Service.
	DescrMdata	Any description of the InformIn Item.

#### 8.4.6 InformOut

<b>Purpose</b>	An Item containing the description of the Item object of an InformIn.	
<b>Functional Requirements</b>	InformOut shall be: <ol style="list-style-type: none"> <li>1. Made available to the User as an Item, or</li> <li>2. Rendered to the User as a perceptible Object.</li> </ol>	
<b>Metadata</b>	InformOutID	The ID of the InformOut Item.
	ServiceID	The ID of the Service providing the InformOut Item.
	UserID	The ID of the User having requested the InformIn Item.
	RightsID	The ID of the Rights “to Act on the InformOut Item” granted to UserID.
	DescrMdata	Any description of the InformOut Item.

#### 8.4.7 InterpretIn

<b>Purpose</b>	An Item containing: <ol style="list-style-type: none"> <li>1. The ID or the Item to be Interpreted.</li> <li>2. Information related to the rendering of InterpretOut.</li> </ol>	
<b>Functional Requirements</b>	Items candidate for Discovery may be described by: Item or ItemID. Information on InterpretOut Rendering may be provided by: <ol style="list-style-type: none"> <li>1. Media type used for rendering.</li> <li>2. Spatial Attitude of InterpretOut rendered Object.</li> </ol>	
<b>Metadata</b>	DiscoverInID	The ID of the DiscoverIn Item.
	UserID	The ID of the User generating the DiscoverIn Item.
	ServiceID	The ID of the Service providing Discovery Services.
	RightsID	The ID of the Rights “to Act on the DiscoverIn Item” granted to the Discovery Service.
	DescrMdata	Any description of the DiscoverIn Item.

#### 8.4.8 InterpretOut

<b>Purpose</b>	An Item containing the description of the Item object of an InterpretIn Item.	
<b>Functional Requirements</b>	Interpreted Items shall be: <ol style="list-style-type: none"> <li>1. Described by the IDs of the Interpreted Item.</li> <li>2. Rendered to the User as a perceptible Object.</li> </ol>	
<b>Metadata</b>	DiscoverOutID	The ID of the Request-Discover Item.
	ServiceID	The ID of the Service providing the DiscoverOut Item.
	UserID	The ID of the User having requested the DiscoverOut Item.



	RightsID	The ID of the Rights “to Act on the DiscoverOut Item” granted to UserID.
	DescrMdata	Any description of the DiscoverOut Item.

## 8.5 Finance-related Items

### 8.5.1 Asset

<b>Purpose</b>	An Item that may be the object of a Transaction.	
<b>Functional Requirements</b>	An Asset may be: <ol style="list-style-type: none"> <li>1. MM-Embedded at an M-Location.</li> <li>2. Posted to a Service (e.g., a marketplace).</li> </ol> An Asset shall: <ol style="list-style-type: none"> <li>1. Preserve the Data Formats of the Item that has spawned it.</li> <li>2. Include the date it was created.</li> </ol>	
<b>Metadata</b>	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.
	ProvenanceID	The ID of the Provenance of the Asset.
	DescrMdata	Any description of the Asset.

### 8.5.2 Ledger

<b>Purpose</b>	An Item containing a list of Transactions involving Assets.	
<b>Functional Requirements</b>	The list of entries of a Ledger is based on: <ol style="list-style-type: none"> <li>1. The types of Item included in the Ledger.</li> <li>2. The Items at an M-Location.</li> <li>3. The Users to which a Ledger refers.</li> <li>4. The duration in time to which a Ledger refers.</li> <li>5. The Items in a DiscoverOut Item.</li> </ol>	
<b>Metadata</b>	LedgerID	The ID of the Ledger.
	UserID	The ID of the User who “has Rights on the Ledger”.
	InRightsID	The ID of the Rights “to Act on the Ledger”.
	OutRightsID	The ID of the Rights “to Act on the Ledger” a User may acquire.
	DescrMdata	Any descriptive Metadata.

### 8.5.3 Provenance

<b>Purpose</b>	The Ledger associated and included in the metadata of a specific Asset.	
<b>Functional Requirements</b>	The Provenance Item shall include the list of all Transactions executed: <ol style="list-style-type: none"> <li>1. On an Asset.</li> <li>2. Starting from the first Transaction and including the last.</li> <li>3. The Marketplace on which a Transaction was performed.</li> </ol>	
<b>Metadata</b>	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.

#### 8.5.4 Transaction

<b>Purpose</b>	Item representing the changed state of the Wallets and the Rights of a seller User and a buyer User on an Asset and optionally of the Service facilitating/enabling the Transaction		
<b>Functional Requirements</b>	The Transaction shall represent: <ol style="list-style-type: none"> <li>1. The Time the Transaction is performed.</li> <li>2. The Value moving into the Wallet of User 1 (seller).</li> <li>3. The Value moved from the Wallet of User2 (buyer).</li> <li>4. The Value moved into the Wallet of User 3 (service) - optional.</li> <li>5. The Time the Value has moved to the seller Wallet.</li> <li>6. The Time the Value has moved from the buyer Wallet.</li> <li>7. The Rights to Act on the Asset owned by User1 after Time.</li> <li>8. The Rights to Act on the Asset owned by User2 after Time.</li> </ol>		
<b>Metadata</b>	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.	

#### 8.5.5 Value

<b>Purpose</b>	An Amount and the Currency with which the Amount is expressed.		
<b>Functional Requirements</b>	Value shall have a representation that enables the expression of the Amount and the Currency used to represent the Amount.		
<b>Metadata</b>	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.	

#### 8.5.6 Wallet

<b>Purpose</b>	A container of Values.		
<b>Functional Requirements</b>	A Wallet shall enable the representation of the Amounts in each Currency.		
<b>Metadata</b>	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.	

### 8.6 Perception-related Items

#### 8.6.1 Event

<b>Purpose</b>	An Entity that includes selected Entities at an M-Location and their Animations during a period.
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<b>Functional Requirements</b>	An Event shall include: <ol style="list-style-type: none"> <li>1. Start Time and End Time.</li> <li>2. M-LocationID.</li> <li>3. List of selected Entities and their Animations.</li> </ol>		
<b>Metadata</b>	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.	

### 8.6.2 Experience

<b>Purpose</b>	An Entity comprising User-selected Entities of an Event and the User Interactions with the Entities of the Event.		
<b>Functional Requirements</b>	An Experience shall include: <ol style="list-style-type: none"> <li>1. ID of User who</li> <li>2. The ID of the User who has selected Entities and performed Interactions.</li> <li>3. Start Time and End Time</li> <li>4. EventID</li> <li>5. List of selected Entities, their Animations, and User Interactions.</li> </ol>		
<b>Metadata</b>	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.	

### 8.6.3 Interaction

<b>Purpose</b>	An Item containing the Request-Action issued by a User on an Entity at an M-Location and the corresponding Time.		
<b>Functional Requirements</b>	Interaction shall include the Request-Action Item.		
<b>Metadata</b>	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.	

### 8.6.4 Map

<b>Purpose</b>	An Item whose structure establishes a correspondence between U-Locations with M-Locations.		
<b>Functional Requirements</b>	A Map shall include a list containing for each U-LocationID the M-Location(s) corresponding with the U-Location: <ol style="list-style-type: none"> <li>1.1. The U-LocationID and the corresponding M-LocationID(s).</li> <li>1.2. Metadata related to the U-LocationID.</li> <li>1.3. Metadata related to the M-LocationID.</li> </ol>		
<b>Metadata</b>	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”.

### 8.6.5 Model

<b>Purpose</b>	An Object representing an object in the Universe whose features are ready to be MM-Animated or UM-Animated.	
<b>Functional Requirements</b>	A Model shall include: <ol style="list-style-type: none"> <li>1. The type(s) of Media (Audio-Visual-Haptic) composing the Model.</li> <li>2. The type of Model, e.g.: <ol style="list-style-type: none"> <li>2.1. An inanimate Object (e.g., a table)</li> <li>2.2. An autonomous Object (e.g., a robot)</li> <li>2.3. An animal, possibly with high accuracy.</li> <li>2.4. A human, possibly with high accuracy.</li> </ol> </li> </ol>	
<b>Metadata</b>	ModelID	The ID of the Object Model.
	UserID	The ID of the User “having Rights to Act on Object Model”.
	InRightsID	The ID of the Rights “to Act on the Object Model”.
	OutRightsID	The ID of the Rights a User may acquire on the Object Model.
	AuthorID	The ID of the User “who Authored the Object Model”.
	Author-ingToolID	The ID of the Service “who provided the Authoring tool”.
	DescrMdata	Any description of the Model.

### 8.6.6 Object

<b>Purpose</b>	An Item with at least one Audio, Visual and Haptics perceptibility attribute.	
<b>Functional Requirements</b>	An Object shall include: <ol style="list-style-type: none"> <li>1. The type(s) of Media (Audio-Visual-Haptic) composing the Model.</li> <li>2. The Data representation <ol style="list-style-type: none"> <li>2.1. Audio Data representation, e.g.: <ol style="list-style-type: none"> <li>2.1.1. Mono (e.g., speech)</li> <li>2.1.2. Stereo</li> <li>2.1.3. Multichannel</li> <li>2.1.4. Microphone array</li> <li>2.1.5. Spatial Audio</li> </ol> </li> <li>2.2. Visual Data representation, e.g.: <ol style="list-style-type: none"> <li>2.2.1. Still</li> <li>2.2.2. Mono</li> <li>2.2.3. Camera array</li> <li>2.2.4. Light field</li> <li>2.2.5. Holography</li> </ol> </li> <li>2.3. Haptic Data representation.</li> </ol> </li> <li>3. The type of Object, e.g.: <ol style="list-style-type: none"> <li>3.1. An inanimate Object (e.g., a table)</li> <li>3.2. An autonomous Object (e.g., a robot)</li> <li>3.3. An animal, possibly with high accuracy</li> <li>3.4. A human, possibly with high accuracy</li> </ol> </li> <li>4. The Data Format used.</li> </ol>	

<b>Metadata</b>	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”.
	Authoring-ToolID	The ID of the Service “who provided the Authoring tool”
	DescrMdata	Any description of the Object.

### 8.6.7 Scene

<b>Purpose</b>	A possibly hierarchical Composition of Objects having Spatial Attitudes.	
<b>Functional Requirements</b>	1. It should be possible to MM-Embed a Scene at a specified M-Location. 2. The Objects in the Scene may: 2.1. Have a Spatial Attitude. 2.2. Be MM/UM-Animated.	
<b>Metadata</b>	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.

### 8.6.8 Stream

<b>Purpose</b>	An Item made by a continuous flow of Data.	
<b>Functional Requirements</b>	Streams may be scalable in space and time. Streams may be used to: 1. Animate a Model. 2. Represent a Digitised Object in an M-Instance.	
<b>Metadata</b>	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.

### 8.6.9 Summary

<b>Purpose</b>	An Item containing Text and Personal Status labels.	
<b>Functional Requirements</b>	A Summary is an abridged outline of the utterance(s) of one or more Users possibly including their Personal Statuses.	
<b>Metadata</b>	SummaryID	The ID of the Summary Item.
	UserID	The ID of the User “having Rights to Act on the Summary”.
	InRightsID	The ID of the Rights “to Act on the Summary”.
	OutRightsID	The ID of the Rights “a User may acquire on the Summary”.
	DescrMdata	Any description of the Summary.

## 8.7 Space-related Items

### 8.7.1 M-Location

<b>Purpose</b>	An Identified delimited space of an M-Environment.	
<b>Functional Requirements</b>	An M-Location: 1. Shall define the space of the M-Instance belonging to the M-Location. 2. May enable the creation of sub-spaces defining sub-M-Locations	
<b>Metadata</b>	M-LocationID	The ID of the M-Location Item.
	UserID	The ID of the User “having Rights to Act on the M-Location”.
	InRightsID	The ID of the Rights “to Act on the M-Location.
	OutRightsID	The ID of the Rights a User may acquire on the M-Location.
	DescrMdata	Any description of the M-Location.

### 8.7.2 U-Location

<b>Purpose</b>	An identifiable delimited portion of the Universe.	
<b>Functional Requirements</b>	A U-Location shall: 1. Shall define the space in the Universe belonging to the U-Location. 2. May enable the definition of sub-spaces defining sub-U-Locations comprised in the U-Location. The enforcement of Rights to a U-Location is not part of this document.	
<b>Metadata</b>	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.

## 9 Functional Requirements of Actions

### 9.1 General Actions in an M-Instance

#### 9.1.1 Register

<b>Purpose</b>	The Action of a human requesting that an M-Instance grant selected human’s Users the Rights to perform Actions in the M-Instance.		
<b>Request-Action</b>	Time		
	Source	humanID	
	Destination	ServiceID	
	Requested Action	<i>Register</i>	
	InItem	UserData v UserDataID	
	InLocation	Address	
	OutLocation	ServiceID	
	OutRights	Rights v RightsID	
<b>Response-Action</b>	Success	OutItem	Account v AccountID
	Error	FaultyReq	The Request is Faulty
		Wallet	Insufficient Value

### 9.1.2 Change

<b>Purpose</b>	The Action of requesting that a Service modify the Rights of a User and provide OutRights, e.g., to further Change the Rights.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Change</i>	
	InItems	UserID $\wedge$ (Rights $\vee$ RightsID)	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		M-Location	Out of range

### 9.1.3 Hide

<b>Purpose</b>	The Action of requesting that a Service make the ID of an Item unavailable and provide OutRights, e.g., to make the ID available again.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Requested Action	<i>Hide</i>	
	InItem	Item $\vee$ ItemID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.1.4 Authenticate

<b>Purpose</b>	The Action of requesting that a Service confirm that an Entity is what it claims to be.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Authenticate</i>	
	InItems	AuthenticateIn $\vee$ AuthenticateInID	
	InLocation	M-LocationID $\vee$ UserID	
	OutLocation	UserID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	AuthenticateOut $\vee$ AuthenticateOutID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		M-Location	Out of range
		U-Location	Out of range

### 9.1.5 Identify

<b>Purpose</b>	The Action of requesting that a Service produce an Item from Data & Metadata.		
<b>Request-Action</b>	Time		
	Source	Process ID	
	Destination	ServiceID	
	Action	<i>Identify</i>	
	InItems	DataMdata	
	InLocation	UserID	
	OutLocation	ServiceID	
<b>Response-Action</b>	Success	OutItem	Item $\vee$ ItemID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.1.6 Modify

<b>Purpose</b>	The Action of requesting that a Service produce a new Item from an existing Item by providing new Data and Metadata with the OutRights to further Act on the new Item.		
<b>Request-Action</b>	Time		
	Source	Process ID	
	Destination	ServiceID	
	Action	<i>Modify</i>	
	InItems	DataMdata $\wedge$ Item	
	InLocation	UserID	
	OutLocation	ServiceID	
	OutRight	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	Item $\vee$ ItemID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.1.7 Validate

<b>Purpose</b>	The Action of requesting that a Service verify that a Process has the Rights to perform or request a Process to perform an Action on an Item.		
<b>Request-Action</b>	Time		
	Source	ProcessID	
	Destination	ProcessID	
	Action	<i>Validate</i>	
	InItem	Request-Action $\vee$ Request-ActionID	
	InLocation	ProcessID	
	OutLocation	ProcessID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	Item $\vee$ ItemID
	Error	Request	Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		U-Location	Out of range



### 9.1.8 Execute

<b>Purpose</b>	The Action of requesting that a Process execute a Contract.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ProcessID	
	Action	<i>Execute</i>	
	InItem	Item ∨ ItemID ∨ DataMdata	
	OutRights	Rights ∨ RightsID	
<b>Response-Action</b>	Success	OutItem	Item ∨ ItemID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

## 9.2 Call a Service

### 9.2.1 Author

<b>Purpose</b>	The Action of Calling a Service to obtain an Entity with associated OutRights to Act on the Entity.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Author</i>	
	InItems	Item ∨ ItemID ∨ DataMdata	
	InLocation	UserID ∨ Address	
	OutLocation	UserID ∨ ServiceID	
	OutRights	Rights ∨ RightsID	
<b>Response-Action</b>	Success	OutItem	Entity ∨ EntityID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		Wallet error	Insufficient Value

### 9.2.2 Discover

<b>Purpose</b>	The Action of requesting that a Service provide a DiscoverOut Item containing: 1. The IDs of the Items relevant to the User's request to Discover or recommended expressed in the DiscoverIn Item 2. The OutRights to Act on the DiscoverOut Item.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Discover</i>	
	InItem	DiscoverIn ∨ DiscoverInID	
	InLocation	UserID ∨ ServiceID	
	OutLocation	UserID	
	OutRights	Rights ∨ RightsID	
<b>Response-Action</b>	Success	OutItem	DiscoverOut ∨ DiscoverOutID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect

		Rights	Missing or incomplete	
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### 9.2.3 Inform

<b>Purpose</b>	The Action of requesting that a Service provide an InformOut Item containing information about an InItem, such as the Metadata of the InItem, with the OutRights to Act on the InformOut Item.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Inform</i>	
	InItem	InformIn v InformInID	
	InLocation	M-LocationID	
	OutLocation	UserID	
	OutRights	Rights v RightsID	
<b>Response-Action</b>	Success	OutItem	InformOut v InformOutID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.2.4 Interpret

<b>Purpose</b>	The Action of requesting that a Service provide an InterpretOut Item containing interpretation of an InItem, such as translation or extraction of Personal Status, with the OutRights to Act on the InterpretOut Item.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Interpret</i>	
	InItem	InterpretIn v InterpretInID	
	InLocation	M-LocationID	
	OutLocation	UserID	
	OutRights	Rights v RightsID	
<b>Re-sponse-Action</b>	Success	OutItem	InterpretOut v InterpretOutID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.2.5 Post

<b>Purpose</b>	The Action of requesting that a Marketplace include an Asset to its repertory of Assets.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>Post</i>	
	InItem	Asset v AssetID	
	InLocation	UserID v ServiceID	
	OutLocation	ServiceID	
	OutRights	Rights v RightsID	

<b>Response-Action</b>	Success	OutItem		
	Error	FaultyReq	The Request is Faulty	
		IDs	Incorrect	
		Rights	Missing or incomplete	
		Wallet	Insufficient Value	

### 9.2.6 Transact

<b>Purpose</b>	The Action of a User <sub>1</sub> (“seller”) requesting that a Service: 1. Assign Rights on an Asset to User <sub>2</sub> (“buyer”). 2. Cause: 2.1. Wallet <sub>1</sub> of User <sub>1</sub> (“seller”) to be increased by Value <sub>1</sub> . 2.2. Wallet <sub>2</sub> of User <sub>2</sub> to be decreased by Value <sub>2</sub> . 2.3. Wallet <sub>3</sub> of the Service enabling/facilitating the Transaction to be increased by Value <sub>3</sub> (optionally).		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	Transact	
	InItem	Transaction ∨ TransactionID	
	InLocation	M-LocationID ∨ ServiceID	
	OutLocation	UserID ∨ ServiceID	
	OutRights	Rights ∨ RightsID	
<b>Response-Action</b>	Success	OutItems	AssetID ∧ WalletID <sub>1</sub> ∧ WalletID <sub>2</sub> ∧ WalletID <sub>3</sub>
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		Wallet	Wallet <sub>2</sub> has insufficient Value

### 9.2.7 Convert

Purpose	The Action of requesting that a Service change the Format of the Data of an Item into a Format specified by a FormatID.				
Request-Action	Time				
	Source		UserID		
	Destination		ServiceID		
	Action		Convert		
	InItem		(Item $\vee$ ItemID) $\wedge$ FormatID		
	InLocation		ServiceID $\vee$ M-LocationID		
	OutLocation		ServiceID		
	OutRights		Rights $\vee$ RightsID		
Response-Action	Success	OutItem	Item $\vee$ ItemID		
	Error	FaultyReq	The Request is Faulty		
		IDs	Incorrect		
		Rights	Missing or incomplete		

### 9.2.8 Resolve

<b>Purpose</b>	The Action of requesting that a Service in an M-Instance forward a Request-Resolve Item or a Response-Resolve Item to a Resolution Service of another M-Instance.			
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<b>Request-Action</b>	Time		
	Source		ProcessID
	Destination		ServiceID
	Requested Action		<i>Resolve</i>
	InItem		Request-Action $\vee$ Response-Action $\vee$ Request-ActionID $\vee$ Response-ActionID $\vee$ Item $\vee$ ItemID
	InLocation		ProcessID
	OutLocation		ProcessID
	OutRights		Rights $\vee$ RightsID
<b>Response-Action</b>	Success	OutItem	Request-Action $\vee$ Response-Action $\vee$ Item $\vee$ ItemID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

### 9.3 Manage Entities, Media, scenes and Data/Metadata (Metaverse to Metaverse)

#### 9.3.1 MM-Add

<b>Purpose</b>	The Action of requesting that a Service add an Entity at an M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Added Entity.		
<b>Request-Action</b>	Time		
	Source		UserID
	Destination		ServiceID
	Action		<i>MM-Add</i>
	InItem		(Entity $\vee$ EntityID) $\wedge$ Spatial Attitude
	InLocation		UserID $\vee$ ServiceID $\vee$ M-LocationID
	OutLocation		M-LocationID
	OutRights		Rights $\vee$ RightsID
<b>Response-Action</b>	Success	OutItem	Entity $\vee$ EntityID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		Clash	Entity clashes with another Entity
		M-Location	Out of range

#### 9.3.2 MM-Animate

<b>Purpose</b>	The Action of requesting that a Service change the features of a Model MM-Embedded at an M-Location with a Process and provide the OutRights to Act on the MM-Added Entity.		
<b>Request-Action</b>	Time		
	Source		UserID
	Destination		ProcessID
	Action		<i>MM-Animate</i>
	InItem		(Model $\vee$ ModelID) $\wedge$ Spatial Attitude
	InLocation		ServiceID
	OutLocation		M-LocationID
	OutRights		Rights $\vee$ RightsID
<b>Response-Action</b>	Success	OutItem	
	Error	FaultyReq	The Request is Faulty

		IDs	Incorrect
		Rights	Missing or incomplete
		Item mismatch	Entity Data Type and Animation Stream Data Type.

### 9.3.3 MM-Disable

<b>Purpose</b>	The Action of requesting that a Service stop MM-Enabling selected Entities Embedded at an M-Location and provide OutRights to Act on the MM-Disabled Entities.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>MM-Disable</i>	
	InItem	List of EntityIDs	
	InLocation	M-LocationID	
	OutLocation	M-LocationID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	
	Error	FaultyReq	
		IDs	
		Rights	
		M-Location	

### 9.3.4 MM-Embed

<b>Purpose</b>	The Composite Action of requesting that a Service MM-Add and MM-Enable an Entity either located at a Service or at an M-Location at a destination M-Location with a Spatial Attitude and provide OutRights to Act on the MM-Embedded Entity.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>MM-Embed</i>	
	InItem	(Entity $\vee$ EntityID) $\wedge$ Spatial Attitude	
	InLocation	ServiceID $\vee$ M-LocationID	
	OutLocation	M-LocationID	
	OutRights	Rights $\vee$ RightsID	
<b>Re-sponse-Action</b>	Success	OutItem	
	Error	FaultyReq	
		IDs	
		Rights	
		Clash	
		M-Location	

### 9.3.5 MM-Enable

<b>Purpose</b>	The Action of requesting that a Service accept requests to MM-Send selected Entities MM-Added at an M-Location or to MM-Embed those selected Entities at a destination M-Location and provide OutRights to act on the M-Entities.		
<b>Request-Action</b>	Time		
	Source	UserID	

	Destination		ServiceID		
	Action		<i>MM-Enable</i>		
	InItem		Entity ∨ EntityID		
	InLocation		M-LocationID		
	OutLocation		M-LocationID		
	OutRights		Rights ∨ RightsID		
<b>Re- sponse- Action</b>	Success	OutItem			
	Error	FaultyReq	The Request is Faulty		
		IDs	Incorrect		
		Rights	Missing or incomplete		
		M-Location	Out of range		

### 9.3.6 MM-Send

Purpose	The Action of requesting that a Service forward to a Process an Item, or Data/Metadata with OutRights to Act on the Item.		
Request-Action	Time		
	Source	ProcessID	
	Destination	ServiceID	
	Action	Send	
	InItem	Item v ItemID v DataMdata	
	InLocation	ProcessID v M-Location	
	OutLocation	ProcessID v M-Location	
	OutRights	Rights v RightsID	
Response-Action	Success	OutItem	Item v ItemID v DataMdata
	Error	Request	Faulty
		IDs	Incorrect
		Rights	Missing or incomplete

## 9.4 Manage Entities, Media, scenes and Data/Metadata (Metaverse to Universe)

### 9.4.1 MU-Actuate

Purpose	The Action of requesting that a Device present an Entity available at a Device to a U-Location as Media with a Spatial Attitude.		
Request-Action	Time		
	Source	UserID	
	Destination	DeviceID	
	Action	MU-Actuate	
	InItem	(Entity $\vee$ EntityID) $\wedge$ Spatial Attitude	
	InLocation	DeviceID	
	OutLocation	U-LocationID	
	OutRights	Metadata	
Response-Action	Success	OutItem	Media
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		U-Location	Out of range

#### 9.4.2 MU-Render

<b>Purpose</b>	The Composite Action of requesting that: <ol style="list-style-type: none"> <li>1. A Service MM-Send selected Entities Embedded at an M-Location to a Device.</li> <li>2. The Device MU-Actuate the Entity received at a U-Location with a Spatial Attitude.</li> </ol>		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	ServiceID	
	Action	<i>MM-Render</i>	
	InItem	List of Entities $\wedge$ Spatial Attitude	
	InLocation	M-LocationID	
	OutLocation	U-Location	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	Action result	Media
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		M-Location	Out of range

#### 9.4.3 MU-Send

<b>Purpose</b>	The Action of requesting that a Process transmit an Item to a Device or store an Item at an Address.		
<b>Request-Action</b>	Time		
	Source	ProcessID	
	Destination	ServiceID	
	Action	<i>MU-Send</i>	
	InItem	Item $\vee$ ItemID	
	InLocation	M-LocationID $\vee$ ProcessID	
	OutLocation	Address	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		Address	Incorrect

#### 9.4.4 Track

<b>Purpose</b>	The Composite Action of requesting that a Service: <ol style="list-style-type: none"> <li>1. MM-Embed a Model at an M-Location with a Spatial Attitude.</li> <li>2. UM-Animate the Model MM-Embedded at an M-Location.</li> <li>3. MU-Render specified Entities at the M-Location to a U-Location.</li> </ol>	
<b>Request-Action</b>	Time	
	Source	UserID
	Destination	ServiceID
	Action	Track
	InItem	(Model $\vee$ ModelID) $\wedge$ Spatial Attitude $\wedge$ M-LocationID
	InLocation	ServiceID

	OutLocation	U-LocationID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	Media
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		M-LocationID	Out of range
		U-LocationID	Out of range

## 9.5 Manage Entities, Media, scenes and Data/Metadata (Universe to Metaverse)

### 9.5.1 UM-Animate

<b>Purpose</b>	The Composite Action of a User requesting: <ol style="list-style-type: none"> <li>1. A Device to             <ol style="list-style-type: none"> <li>1.1. UM-Capture an animation stream extracted from a scene at a U-Location.</li> <li>1.2. UM-Send the animation stream and Metadata to a User.</li> </ol> </li> <li>2. A Service to Identify the Animation Stream.</li> <li>3. A Service to MM-Animate the Model MM-Embedded at the M-Location using the Animation Stream.</li> </ol>		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	DeviceID	
	Action	<i>UM-Animate</i>	
	InItem	scene $\wedge$ (Model $\vee$ ModelID)	
	InLocation	U-LocationID	
	OutLocation	M-LocationID	
	OutRights	Metadata	
<b>Response-Action</b>	Success	OutItem	Entity $\vee$ EntityID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		U-Location	Out of range
		M-Location	Out of range

### 9.5.2 UM-Capture

<b>Purpose</b>	The Action of requesting that a Device capture Media from a scene at a U-Location.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	DeviceID	
	Action	<i>UM-Capture</i>	
	InItem	scene	
	InLocation	U-LocationID	
	OutLocation	DeviceID	
<b>Response-Action</b>	Success	OutItem	Media
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect



		Rights	Missing or incomplete	
		U-Location	Out of range	

### 9.5.3 UM-Render

<b>Purpose</b>	The Composite Action of a User requesting: 1. A Device to: 1.1. UM-Capture a scene at U-Location. 1.2. MM-Send Data and Device-provided Metadata to a User. 2. A Service to: 2.1. Identify an Entity from UM-Sent Data and Metadata. 2.2. MM-Embed the Entity at an M-Location with a Spatial Attitude.		
<b>Request-Action</b>	Time		
	Source	UserID	
	Destination	DeviceID	
	Action	<i>UM-Render</i>	
	InItem	scene $\wedge$ Spatial Attitude	
	InLocation	U-LocationID	
	OutLocation	M-LocationID	
	OutRights	Rights $\vee$ RightsID	
<b>Response-Action</b>	Success	OutItem	Entity $\vee$ EntityID
	Error	FaultyReq	The Request is Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		Clash	Entity clashes with another Entity
		M-Location	Out of range
		U-Location	Out of range

### 9.5.4 UM-Send

<b>Purpose</b>	The Action of a Device transmitting Item or Data & Metadata to a Process.		
<b>Request-Action</b>	Time		
	Source	DeviceID	
	Destination	ProcessID	
	Action	<i>UM-Send</i>	
	InItem	Item $\vee$ ItemID $\vee$ DataMdata	
	InLocation	DeviceID $\vee$ Address	
	OutLocation	ProcessID	
	OutRights	Metadata	
<b>Response-Action</b>	Success	OutItem	DataMdata
	Error	Request	Faulty
		IDs	Incorrect
		Rights	Missing or incomplete
		U-Location	Out of range

## 10 Functional Requirements of Data Types

### 10.1 For location and time information

#### 10.1.1 Address

<b>Purpose</b>	The URL of a storage facility.
<b>Functional Requirements</b>	A URL

#### 10.1.2 Coordinates

<b>Purpose</b>	A set of numbers representing a Position in a Metaverse Environment using a coordinate system.
<b>Functional Requirements</b>	Coordinates shall be able to uniquely indicate a point in the space measured by a coordinate system.

#### 10.1.3 Orientation

<b>Purpose</b>	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° counterclockwise (right-to-left) with the x axis and its z axis (pointing up toward a User viewing from above).
<b>Functional Requirements</b>	Orientation is expressed as an array of 3 rows and 3 columns: $\alpha, \beta, \gamma$ (roll, pitch, and yaw) 1 <sup>st</sup> order time derivatives of $\alpha, \beta, \gamma$ 2 <sup>nd</sup> order time derivatives of $\alpha, \beta, \gamma$

#### 10.1.4 Point of View

<b>Purpose</b>	The Spatial Attitude of a Persona watching an Environment.
<b>Functional Requirements</b>	Point of View shall express the Position of a Persona with the Orientation of the Persona watching an Environment.

#### 10.1.5 Position

<b>Purpose</b>	The Coordinates of a point in a Metaverse Environment using a Coordinate system.
<b>Functional Requirements</b>	Position is expressed as an array of 3 rows and 3 columns: $x, y, z$ 1 <sup>st</sup> order time derivatives of $x, y, z$ 2 <sup>nd</sup> order time derivatives of $x, y, z$

#### 10.1.6 Spatial Attitude

<b>Purpose</b>	The Position and Orientation of an Entity, and their velocities and accelerations.
<b>Functional Requirements</b>	Spatial Attitude is expressed as an array of 6 rows and 3 columns: $x, y, z$ 1 <sup>st</sup> order time derivatives of $x, y, z$ 2 <sup>nd</sup> order time derivatives of $x, y, z$ $\alpha, \beta, \gamma$ (roll, pitch, and roll)

	1 <sup>st</sup> order time derivatives of $\alpha, \beta, \gamma$ 2 <sup>nd</sup> order time derivatives of $\alpha, \beta, \gamma$
--	--

### 10.1.7 Time

<b>Purpose</b>	The representation of the measure of time.
<b>Functional Requirements</b>	Time shall be able to express any value of time on the time axis.

## 10.2 For Transactions

### 10.2.1 Amount

<b>Purpose</b>	A number expressing a Value in a Currency.
<b>Functional Requirements</b>	The ability to express an Amount, e.g., a decimal number.

### 10.2.2 Currency

<b>Purpose</b>	A medium of exchange enabling Transactions in a Metaverse Environment.
<b>Functional Requirements</b>	Currency shall express an entry in a standard list of Currencies.

## 10.3 For internal state information

### 10.3.1 Cognitive State

<b>Purpose</b>	The representation of a User's Personal Status that reflects the way they understand the Environment, such as "Confused", "Dubious", "Convinced".
<b>Functional Requirements</b>	The ability to express a particular Cognitive State, e.g., with a label from a dictionary of Cognitive States.

### 10.3.2 Emotion

<b>Purpose</b>	The representation of a User's Personal Status that results from their interaction with an Environment, such as "Angry", "Sad", "Determined".
<b>Functional Requirements</b>	The ability to express a particular Emotion, e.g., with a label from a dictionary of Emotions.

### 10.3.3 Social Attitude

<b>Purpose</b>	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".
<b>Functional</b>	A particular Social Attitude is expressed by a label from a dictionary of Social Attitudes.

<b>Require-ments</b>	
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#### 10.3.4 Personal Status

<b>Purpose</b>	The representation of the information internal to a User characterising their behaviour.
<b>Functional Requirements</b>	Personal Status may include any of Cognitive State, Emotion, and Social Attitude or none at all.

## 11 Use Cases (Informative)

### 11.1 Introduction

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

### 11.2 Use Case Description Language

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

1. Processes (e.g., Users) are sequentially identified by one subscript.
2. Items Acted on by a Process are identified by the subscript of the Process performing an Action on the Item followed by a sequential number.
3. The Locations where the Actions take place are similarly identified by the subscript of the Process performing an Action at the Location followed by a sequential number.
4. If the Actions are performed at different M-Instances, all Processes, Items, and Locations are prefixed by a sequential capital letter.

For instance:

1. User<sub>i</sub> MM-Embeds Persona<sub>i,j</sub> at M-Location<sub>i,k</sub>.
2. User<sub>i</sub> MU-Renders Entity<sub>i,j</sub> at U-Location<sub>i,k</sub>.
3. User<sub>A,i</sub> MM-Sends Object<sub>A,i,j</sub> to User<sub>B,k</sub>.

All Use Cases assume that Actions are performed in an M-Instance. When they are performed in the Universe, this is specifically mentioned.

The following abbreviations are used throughout:

MLoc: M-Locations

SA: Spatial Attitude

ULoc: U-Locations

Note: Persona(AV) is a Persona that can be audio-visually perceived.

Object(AVH) is an Object that can be audio-visual-haptically perceived.

## 11.3 Virtual Lecture

### 11.3.1 Description

A student attends a lecture held by a teacher in a classroom created by a school manager:

1. School Manager
  - 1.1. Authors and embeds a virtual classroom.
  - 1.2. Pays the teacher.
2. Teacher
  - 2.1. Is at home.
  - 2.2. Embeds a persona of theirs from home at the classroom's desk.
  - 2.3. Embeds and animates a 3D model.
  - 2.4. Leaves the classroom.
3. Student
  - 3.1. Is at home.
  - 3.2. Pays to attend and to make a copy of their lecture Experience.
  - 3.3. Embeds a persona of theirs in the classroom.
  - 3.4. Approaches the teacher's desk to feel the 3D model with haptic gloves.
  - 3.5. Stores their lecture Experience.
  - 3.6. Leaves the classroom and returns home.

### 11.3.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	School Manager		
Object(V) <sub>1.1</sub>	Classroom	MLoc <sub>1.1</sub>	Location of classroom
Value <sub>1.1</sub>	Lecture consideration		
<b>User<sub>2</sub></b>	Teacher		
Persona(AV) <sub>2.1</sub>	Teacher's Persona	MLoc <sub>2.1</sub>	Teacher's home
		MLoc <sub>2.2</sub>	Desk in classroom
Model <sub>2.1</sub>	Model for experiment	MLoc <sub>2.3</sub>	Experiment place
<b>Process<sub>1</sub></b>	Animates Model <sub>2.1</sub>		
<b>User<sub>3</sub></b>	Student		
Persona(AV) <sub>3.1</sub>		MLoc <sub>2.1</sub>	Student's home
Value <sub>3.1</sub>	Lecture fees		
		MLoc <sub>3.1</sub>	Place in classroom
		MLoc <sub>3.3</sub>	Close to Experiment place
Experience <sub>3.1</sub>	Recorded Experience	Address <sub>3.1</sub>	Storing Experience

### 11.3.3 Detailed workflow

1. User<sub>1</sub> (Manager):
  - 1.1. Authors Object(V)<sub>1.1</sub>.
  - 1.2. MM-Embeds Object(V)<sub>1.1</sub> at MLoc<sub>1.1</sub>.
2. User<sub>2</sub> (Teacher):
  - 2.1. Tracks Persona(AV)<sub>2.1</sub> at MLoc<sub>2.1</sub> with SA.
  - 2.2. MM-Embeds Persona<sub>2.1</sub> at MLoc<sub>2.2</sub>.
  - 2.3. MM-Disables Persona<sub>2.1</sub> at MLoc<sub>2.1</sub>.
  - 2.4. MM-Embeds Model(AVH)<sub>2.1</sub> at MLoc<sub>2.3</sub> (Experiment place, close to MLoc<sub>2.2</sub>).
3. User<sub>3</sub> (Student):
  - 3.1. Tracks Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub> with SA.
  - 3.2. Transacts Value<sub>3.1</sub>.

- 3.3. MM-Embeds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.2</sub> with SA.
- 3.4. MM-Disables Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub>.
4. User<sub>2</sub> (Teacher):
  - 4.1. MM-Animates Model<sub>2.1</sub> with Process<sub>1</sub>.
5. User<sub>3</sub> (Student)
  - 5.1. MM-Adds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.3</sub> (Experiment place).
  - 5.2. MM-Sends Model<sub>2.1</sub> to User<sub>3</sub>.
  - 5.3. MU-Sends Experience<sub>3.1</sub> to Address<sub>3.1</sub>.
6. User<sub>1</sub> (Manager):
  - 6.1. Transacts Value<sub>1.1</sub> to User<sub>2</sub> (Teacher).
7. User<sub>2</sub> (Teacher):
  - 7.1. MM-Disables Persona<sub>2.1</sub> from MLoc<sub>2.2</sub>
  - 7.2. MM-Embeds Persona<sub>2.1</sub> at MLoc<sub>2.1</sub>.
8. User<sub>3</sub> (Student)
  - 8.1. MM-Disables Persona<sub>3.1</sub> from MLoc<sub>3.2</sub>
  - 8.2. MM-Embeds Persona<sub>3.1</sub> at MLoc<sub>3.1</sub>.

#### 11.3.4 Workflow and Actions

Table 5 – Virtual Lecture workflow and Actions.

User <sub>1</sub> (Manager)	Authors	Object(V) <sub>1.1</sub>	(Classroom).
	MM-Embeds	Object(V) <sub>1.1</sub>	MLoc <sub>1.1</sub> .
User <sub>3</sub> (Teacher)	Tracks	Persona (AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> w/ SA.
	MM-Embeds	Persona <sub>3.1</sub>	MLoc <sub>3.2</sub> (desk).
	MM-Disables	Persona <sub>3.1</sub>	MLoc <sub>3.1</sub>
	MM-Embeds	Model <sub>3.1</sub>	MLoc <sub>3.3</sub> (close to desk).
	MM-Animates	Model <sub>3.1</sub> .	
User <sub>2</sub> (Student)	Tracks	Persona (AV) <sub>2.1</sub>	MLoc <sub>2.1</sub> w/ SA.
	Transacts	Value <sub>2.1</sub>	(Lecture & Experience)
	MM-Embeds	Persona (AV) <sub>2.1</sub>	Location <sub>2.2</sub> with SA.
	MM-Disables	Persona <sub>2.1</sub>	MLoc <sub>2.1</sub> .
User <sub>3</sub> (Teacher)	MM-Embeds	Model (AVH) <sub>3.1</sub>	MLoc <sub>3.3</sub> (close to desk).
	MM-Animates	Model <sub>3.1</sub> .	
User <sub>2</sub> (Student)	MM-Adds	Persona (AV) <sub>2.1</sub>	MLoc <sub>2.3</sub> (close to desk).
	MM-Sends	Model (AVH) <sub>3.1</sub>	
	MU-Sends	Experience <sub>2.1</sub>	Address <sub>2.1</sub>
User <sub>1</sub> (Manager)	Transacts	Value <sub>1.1</sub>	User <sub>3</sub> (Lecture consideration).
User <sub>3</sub> (Teacher)	MM-Disables	Persona <sub>3.1</sub>	MLoc <sub>3.2</sub>
	MM-Embeds	Persona <sub>3.1</sub>	MLoc <sub>3.1</sub>
User <sub>2</sub> (Student)	MM-Disables	Persona <sub>2.1</sub>	MLoc <sub>2.2</sub>
	MM-Embeds	Persona <sub>2.1</sub>	MLoc <sub>2.1</sub>

#### 11.3.5 Actions, Items, and Data Types

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

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

Actions	Items	Data Types
Author	Object(V)	Amount
Identify	Experience	Coordinates
MM-Animate	M-Location	Currency
MM-Disable	Persona(AV)	Spatial Attitude
MM-Embed	U-Location	Value
MM-Send	Value	Orientation
MU-Render		Position
MU-Send		
UM-Capture		
UM-Send		
Track		
Transact		

## 11.4 Virtual Meeting

### 11.4.1 Description

A meeting manager

1. Authors a meeting room.
2. Deploys a Virtual Secretary tasked to produce a summary of the conversations, enriched by information about participants' Personal Statuses.

A participant

1. Attends a meeting held in the room.
2. Gets a translation of sentences uttered in languages other than their own.
3. Makes a presentation using a 3D model.

### 11.4.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	Meeting Manager		
Object(V) <sub>1.1</sub>	Classroom	MLoc <sub>1.1</sub>	Location of meeting room
Persona(AV) <sub>1.1</sub>	Virtual Secretary	MLoc <sub>1.2</sub>	Virtual Secretary's Location
Summary <sub>1.1</sub>	Meeting Summary	MLoc <sub>1.3</sub>	Location s Summary display.
<b>User<sub>2</sub></b>	Meeting participant #1		
Persona(AV) <sub>2.1</sub>	participant #1's Persona	MLoc <sub>2.1</sub>	Participant's home
		MLoc <sub>2.2</sub>	In the meeting room
Model <sub>2.1</sub>	Model for presentation	MLoc <sub>2.3</sub>	Location of presentation display.
Event <sub>2.1</sub>	Entire meeting		
<b>Process<sub>1</sub></b>	Animates Model <sub>2.1</sub>		
<b>User<sub>3</sub></b>	Meeting participant #2		
Persona(AV) <sub>3.1</sub>	participant #2's Persona	MLoc <sub>3.1</sub>	In the meeting room
Object(A) <sub>3.1</sub>	Speech segment		

### 11.4.3 Detailed workflow

1. User<sub>1</sub> (Meeting Manager)
  - 1.1. Authors Object(V)<sub>1.1</sub> (meeting room).
  - 1.2. MM-Embeds Object(V)<sub>1.1</sub> at MLoc<sub>1.1</sub>.
  - 1.3. MM-Embeds Persona(AV)<sub>1.1</sub> (a Virtual Secretary) at MLoc<sub>1.2</sub>.

- 1.4. MM-Animates Persona(AV)<sub>1,1</sub>.
2. User<sub>2</sub> (1<sup>st</sup> Meeting participant):
  - 2.1. Tracks Persona(AV)<sub>2,1</sub> at MLoc<sub>2,1</sub> (its home).
  - 2.2. MM-Embeds Persona(AV)<sub>2,1</sub> at MLoc<sub>2,2</sub> (enters meeting room.).
  - 2.3. MM-Disables Persona(AV)<sub>2,1</sub> from MLoc<sub>2,1</sub> (disappears from home).
3. User<sub>3</sub> (2<sup>nd</sup> meeting participant)
  - 3.1. MM-Embeds Persona(AV)<sub>3,1</sub> at MLoc<sub>2,1</sub>.
  - 3.2. MM-Sends Object(A)<sub>3,1</sub>.
4. User<sub>2</sub> (1<sup>st</sup> Meeting participant):
  - 4.1. Authenticates Object(A)<sub>3,1</sub>.
  - 4.2. Interprets (requests translation of Object(A)<sub>3,1</sub>).
  - 4.3. MM-Embeds Entity<sub>2,1</sub> (a 3D model) at MLoc<sub>2,3</sub> (in meeting room).
  - 4.4. MM-Animates Entity<sub>2,1</sub> with Process<sub>1</sub> (makes presentation with 3D model).
5. Virtual Secretary:
  - 5.1. Interprets Persona<sub>3,1</sub>'s Object(A)<sub>3,1</sub> (request speech recognition and extraction of Personal Status displayed by Persona<sub>3,1</sub>).
  - 5.2. Produces Summary<sub>1,1</sub> of Persona<sub>3,1</sub>'s Object(A)<sub>3,1</sub> (with added graphical signs expressing Persona<sub>3,1</sub>'s Personal Status).
  - 5.3. MM-Embeds Summary<sub>1,1</sub> at MLoc<sub>1,3</sub> (in meeting room for participants to comment).
  - 5.4. User<sub>1</sub> removes Persona<sub>1,1</sub>.
  - 5.5. User<sub>2</sub> removes Persona<sub>2,1</sub> and returns home.
  - 5.6. User<sub>1</sub> removes Persona<sub>3,1</sub> and returns home.

#### 11.4.4 Workflow and Actions

Table 7 – Virtual Meeting workflow and actions.

Who	Does	What	Where/comment
User <sub>1</sub> (Manager)	MM-Embeds	Object(V) <sub>1,1</sub>	(Meeting room) MLoc <sub>1,1</sub>
	MM-Embeds	Persona <sub>1,1</sub>	(Virtual Secretary) MLoc <sub>1,2</sub>
	MM-Animates	Persona <sub>1,1</sub>	Animates Virtual Secretary.
User <sub>2</sub> (Participant)	Tracks	Persona <sub>2,1</sub> (AV)	At MLoc <sub>2,1</sub> w/ SA
	MM-Embeds	Persona <sub>2,1</sub> (AV)	At MLoc <sub>2,2</sub> w/ SA
	MM-Disables	Persona <sub>2,1</sub> (AV)	From MLoc <sub>2,1</sub>
User <sub>3</sub> (Participant)	Tracks	Persona <sub>3,1</sub> (AV)	At MLoc <sub>3,1</sub> w/ SA
	MM-Embeds	Persona <sub>3,1</sub> (AV)	At MLoc <sub>3,2</sub> w/ SA
	MM-Disables	User <sub>3</sub>	From MLoc <sub>3,1</sub>
	MM-Sends	Object(A) <sub>3,1</sub>	(Speaks)
User <sub>2</sub> (Participant)	Authenticates	Object(A) <sub>3,1</sub>	
	Interprets	Object(A) <sub>3,1</sub>	(Requests translation)
	MM-Embeds	Model <sub>2,1</sub>	At MLoc <sub>2,2</sub> (3D presentation)
	MM-Animates	Model <sub>2,1</sub>	
Virtual Secretary	Interprets	Object(A) <sub>3,1</sub>	(With Personal Status)
	Produces	Summary <sub>1,1</sub>	
	MM-Embeds	Summary <sub>1,1</sub>	At MLoc <sub>1,3</sub> (Meeting room)
User <sub>1</sub> (Manager)	MM-Disables	Persona <sub>1,1</sub>	At MLoc <sub>1,2</sub>
User <sub>2</sub> (Participant)	MU-Sends	Event <sub>2,1</sub>	To Address <sub>2,1</sub>
	MM-Embeds	Persona <sub>2,1</sub> (AV)	At MLoc <sub>2,1</sub> (home)
	MM-Disables	Persona <sub>2,1</sub> (AV)	From MLoc <sub>2,2</sub>
User <sub>3</sub> (Participant)	MM-Embeds	Persona <sub>3,1</sub> (AV)	At MLoc <sub>2,1</sub> (home)



	MM-Disables	Persona <sub>3,1</sub> (AV)	From MLoc <sub>3,2</sub>
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#### 11.4.5 Actions, Items, and Data Types

Table 8 gives the list of Actions, Items, and Data Types used by the Virtual Meeting Use Case. For simplicity, the Actions implied by the Track Action have not been added to the Table.

*Table 8 – Virtual Meeting Actions, Items, and Data Types.*

Actions	Items	Data Types
Authenticate	Event	Coordinates
Interpret	Object(AV)	Orientation
MM-Animate	Object(V)	Position
MM-Disable	Persona(AV)	Spatial Attitude
MM-Embed	Summary	
MM-Send		
Track		

### 11.5 Hybrid working

#### 11.5.1 Description

A company applies mixed in-presence and remote working policy.

1. Some Workers (R-Workers) attend Company physically.
2. Some Workers (V-Workers) attend Company virtually.
3. All Workers
  - 3.1. Are Authenticated.
  - 3.2. Are present in the Virtual office.
  - 3.3. Communicate by sharing AV messages (Communication of R-Workers' Personae is also mapped to the M-Environment).
  - 3.4. Participate in Virtual meetings.

#### 11.5.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	Company Manager		
Object(V) <sub>1,1</sub>	Office space	MLoc <sub>1,1</sub>	(Location of company office).
Persona(AV) <sub>1,1</sub>	Gatekeeper	MLoc <sub>1,2</sub>	(Location of company gateway).
<b>Process<sub>1</sub></b>	Animates Persona(AV) <sub>1,1</sub>		
<b>User<sub>2</sub></b>	R-Worker #1		
Persona(AV) <sub>2,1</sub>	R-Worker #1's Persona	MLoc <sub>2,1</sub>	(Participant's home)
		MLoc <sub>2,2</sub>	(Office desk)
Model(AVH) <sub>2,1</sub>	Whiteboard	MLoc <sub>2,3</sub>	(Location at Meeting room)
<b>Process<sub>2</sub></b>	Animates whiteboard		
<b>User<sub>3</sub></b>	V-Worker #1		
Persona(AV) <sub>3,1</sub>	V-Worker #1's Persona	MLoc <sub>3,1</sub>	(Participant's home).
		MLoc <sub>3,2</sub>	(Office desk).
Object(A) <sub>3,1</sub>	Speech segment		

#### 11.5.3 Detailed workflow

1. User<sub>1</sub> (Manager):
  - 1.1. Authors Object(V)<sub>1,1</sub> (Virtual office).

- 1.2. Embeds Object(V)<sub>1.1</sub> at MLoc<sub>1.1</sub>.
- 1.3. Embeds Persona(AV)<sub>1.1</sub> at MLoc<sub>1.2</sub> (Office gateway)
- 1.4. MM-Animates Persona<sub>1.1</sub> with Process<sub>1</sub> to act as gatekeeper.
2. User<sub>2</sub> (R-Worker #1):
  - 2.1. MM-Adds Persona(AV)<sub>2.1</sub> at MLoc<sub>2.1</sub>.
3. R-Worker #1:
  - 3.1. Comes to real office.
4. Process<sub>1</sub> (Manager):
  - 4.1. Authenticates R-Worker #1.
5. User<sub>2</sub> (R-worker):
  - 5.1. MM-Embeds Persona(AV)<sub>2.1</sub> at MLoc<sub>2.1</sub> (Office desk).
6. User<sub>3</sub> (V-worker):
  - 6.1. Tracks Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub>
7. Process<sub>1</sub> Authenticates:
  - 7.1. User<sub>3</sub> (V-worker).
8. User<sub>3</sub> (V-worker):
  - 8.1. MM-Embeds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.2</sub> (Office desk).
  - 8.2. MM-Disables Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub>
  - 8.3. MM-Sends Object<sub>3.1</sub> (A) to User<sub>2</sub> (R-worker).
  - 8.4. MM-Embeds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.3</sub> (close to R-worker's desk).
  - 8.5. MM-Disables Persona(AV)<sub>3.1</sub> at MLoc<sub>3.2</sub> (own office desk).
  - 8.6. MM-Embeds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.4</sub> (Meeting room).
  - 8.7. MM-Disables Persona(AV)<sub>3.1</sub> at MLoc<sub>3.3</sub>
9. User<sub>2</sub> (R-worker)
  - 9.1. MM-Embeds Model(AVH)<sub>2.1</sub> (Whiteboard) at MLoc<sub>2.2</sub> (Meeting room).
  - 9.2. MM-Animates Whiteboard with Process<sub>2</sub>.
  - 9.3. MM-Disables Persona(AV)<sub>2.1</sub> at MLoc<sub>2.2</sub> (Meeting room).
10. User<sub>3</sub> (V-worker):
  - 10.1. MM-Embeds Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub> (Home).
  - 10.2. MM-Disables Persona(AV)<sub>3.1</sub> at MLoc<sub>3.1</sub> (Meeting room).

#### 11.5.4 Workflow and Actions

Table 9 – Hybrid Working workflow and actions.

Who	Does	What	Where/comment
User <sub>1</sub> (Manager)	MM-Embeds	Object(V) <sub>1.1</sub>	MLoc <sub>1.1</sub> (Company Office)
	MM-Embed	Persona(AV) <sub>1.1</sub>	MLoc <sub>1.2</sub> (Gatekeeper)
	MM-Animates	Persona(AV) <sub>1.1</sub>	MLoc <sub>1.2</sub>
human <sub>2</sub>			(Enters company)
User <sub>2</sub> (R-Worker)	Tracks	Persona(AV) <sub>2.1</sub>	MLoc <sub>2.1</sub> (Office desk)
User <sub>1</sub> (Gatekeeper)	Authenticates	Object(AV) <sub>1.1</sub>	(AV of R-Worker #1)
User <sub>3</sub> (V-Worker)	Tracks	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> (home)
	MM-Embeds	Persona <sub>3.1</sub>	MLoc <sub>3.2</sub> w/ SA (Office desk)
	MM-Sends	Objects(A) <sub>3.1</sub>	To Persona(AV) <sub>2.1</sub>
	MM-Embeds	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.3</sub> (talk “in person”)
	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.2</sub>
	MM-Embeds	Persona <sub>3.1</sub>	MLoc <sub>3.4</sub> (Meeting room)
	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.3</sub>
User <sub>2</sub> (R-Worker)	MM-Embeds	Persona(AV) <sub>2.1</sub>	MLoc <sub>3.4</sub> (Meeting room)

	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>2.2</sub> (Meeting room)
	MM-Embeds	Object(AVH) <sub>2.1</sub>	MLoc <sub>2.3</sub> (Whiteboard)
	MM-Animates	Object(AVH) <sub>2.1</sub>	Operates Whiteboard
	MM-Disables	Persona(AV) <sub>2.1</sub>	From MLoc <sub>3.4</sub>
User <sub>3</sub> (V-Worker)	MM-Embeds	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> (back home)
	MM-Disables	Persona(AV) <sub>3.1</sub>	From MLoc <sub>3.4</sub>

### 11.5.5 Actions, Items, and Data Types

Table 10 – Hybrid Working Actions, Items, and Data Types

Actions	Items	Data Types
Authenticate	Object(V)	Coordinates
MM-Animate	M-Location	Orientation
MM-Disable	Object(A)	Position
MM-Embed	Object(AVH)	Spatial Attitude
MM-Send	Persona(AV)	
Track		

## 11.6 eSports Tournament

### 11.6.1 Description

1. A site manager
  - a. Develops a game landscape.
  - b. Makes it available to a game manager.
2. The game manager
  - a. Deploys autonomous characters.
  - b. Places virtual cameras and microphones in the landscape.
3. Captured AV from game landscape is displayed onto a dome screen and streamed online.

### 11.6.2 Processes, Items, and Locations

User <sub>1</sub>	Site Manager		
Object(AVH) <sub>1.1</sub>	Game landscape	MLoc <sub>1.1</sub>	(Location of Game landscape).
User <sub>2</sub>	Game manager		
Personae <sub>2.i</sub>	Autonomous characters	M-Loc <sub>2.i</sub>	Location in Game landscape
Scene <sub>2.1</sub>	Game's Scene		
User <sub>j</sub>	Players		
Personae <sub>j.1</sub>	Players' characters	M-Loc <sub>j.1</sub>	Location in Game landscape
Process <sub>2.i</sub>	Autonomous char. animation		
Service <sub>1</sub>	Camera/microphone control		
Device <sub>1</sub>	Dome screen		
Device <sub>k</sub>	Device of online human.		

### 11.6.3 Detailed workflow

1. User<sub>1</sub> (Site Manager)
  - 1.1. Authors Object(AVH)<sub>1.1</sub> (game landscape).
  - 1.2. MM-Embeds Object(AVH)<sub>1.1</sub> (game landscape) at M-Loc<sub>1.1</sub>.
2. User<sub>2</sub> (Game Manager)
  - 2.1. MM-Animates Object(AV)<sub>1.1</sub> with Process<sub>1</sub>.

- 2.2. MM-Embeds Personae<sub>2,i</sub> (Autonomous characters) with SA at M-Loc<sub>2,i</sub>.
- 2.3. Calls Process<sub>2,i</sub> to provide role-specific:
  - 2.3.1. Costumes (e.g., magician, warrior).
  - 2.3.2. Forms, physical features, and abilities (e.g., cast spells, shoot, fly, jump).
- 2.4. Calls Service<sub>1</sub> (virtual camera/microphone control).
3. User<sub>j</sub> (Player<sub>j</sub>) Tracks Persona<sub>j,1</sub> (AVH) at MLoc<sub>j,1</sub> with SA.
4. User<sub>2</sub> (Game Manager):
  - 4.1. MU-Sends Scene<sub>2,1</sub> composed of
    - 4.1.1. Animated Object<sub>1,1</sub> (game landscape).
    - 4.1.2. Personae<sub>2,i</sub> (Autonomous characters).
    - 4.1.3. Personae<sub>2,j</sub> (Players).
  - 4.2. To
    - 4.2.1. Device<sub>1</sub> (Dome screen)
    - 4.2.2. Device<sub>k</sub> (Viewers online via streaming).
5. Device<sub>1</sub> MU-Renders Scene<sub>2,1</sub>.
6. Device<sub>k</sub> MU-Renders Scene<sub>2,1</sub>.

#### 11.6.4 Workflow

*Table 11 – eSports Tournament workflow and actions.*

User <sub>1</sub> (Site Manager)	Authors	Object(AVH) <sub>1,1</sub>	(Game landscape)
	MM-Embeds	Object(AVH) <sub>1,1</sub>	(Landscape) at M-Loc <sub>1,1</sub>
User <sub>2</sub> (Game Manager)	Transacts	Value <sub>2,1</sub>	To User <sub>1</sub>
	MM-Embeds	Personae <sub>2,i</sub> (AC)	At M-Loc <sub>2,i</sub> w/SA
	MM-Animates	Personae <sub>2,i</sub> (AC)	At M-Loc <sub>2,i</sub>
User <sub>j</sub> (Player)	Tracks	Persona <sub>j,1</sub>	At MLoc <sub>j,1</sub> w/ SA
Service <sub>1</sub>	Controls	Camera/microphone	
User <sub>2</sub> (Game Manager)	MU-Renders	Scene(AVH) <sub>2,1</sub>	U-Loc <sub>1,1</sub> (via screen). U-Loc <sub>k,1</sub> (via streaming).

#### 11.6.5 Actions, Items, and Data Types

*Table 12 – eSports Tournament Actions, Items, and Data Types.*

Actions	Items	Data Types
Author	Object(AVH)	Amount
MM-Animate	Persona (AVH)	Coordinates
MM-Embed	Scene(AVH)	Currency
MU-Render	M-Location	Orientation
Track	U-Location	Position
Transact	Value	Spatial Attitude

### 11.7 Virtual performance

#### 11.7.1 Description

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

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

### 11.7.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	Impresario		
Value <sub>1.1</sub>	Payment for MLoc <sub>1.1</sub>	MLoc <sub>1.1</sub>	(Location of Auditorium).
Value <sub>1.2</sub>	Payment for Object <sub>1.1</sub>		
Value <sub>1.3</sub>	Consideration for Performance		
Object(V) <sub>1.1</sub>	Auditorium		
Object(A) <sub>1.1</sub>	SFX		
<b>Serrvice<sub>1</sub></b>	Collects Preferences		
<b>User<sub>2</sub></b>	Performer		
Persona <sub>2</sub>	Performer's Persona	M-Loc <sub>2.1</sub>	(Home)
		M-Loc <sub>2.2</sub>	(Stage in Auditorium)
<b>User<sub>3</sub></b>	Participant #1		
Persona <sub>3</sub>	User <sub>3</sub> Persona	M-Loc <sub>3.1</sub>	(Home)
		M-Loc <sub>3.2</sub>	(Seat in Auditorium)
		M-Loc <sub>3.3</sub>	
Object <sub>3.1</sub> (A)	Message to Participant #4		
Value <sub>3.1</sub>	Ticket		
<b>User<sub>4</sub></b>	Participant #2		
Persona <sub>4</sub>	User <sub>4</sub> Persona	M-Loc <sub>4.1</sub>	(Home)
		M-Loc <sub>4.2</sub>	(Seat in Auditorium)
Value <sub>4.1</sub>	Ticket		

### 11.7.3 Detailed workflow

1. User<sub>1</sub> (Organiser)
  - 1.1. Transacts Value<sub>1.1</sub> (to get Rights to MLoc<sub>1.1</sub> (Parcel)).
  - 1.2. Authors Object<sub>1.1</sub> (Auditorium).
  - 1.3. Transacts Value<sub>1.2</sub> (to get Rights to Object<sub>1.1</sub> (Auditorium)).
  - 1.4. MM-Embeds Object<sub>1.1</sub> at MLoc<sub>1.1</sub>.
  - 1.5. Calls Service<sub>1</sub> (to collect Users' Preferences).
2. User<sub>2</sub> (Performer)
  - 2.1. Tracks Persona<sub>2.1</sub> at MLoc<sub>2.1</sub> (Home)
  - 2.2. Embeds Persona<sub>2.1</sub> (AV) at MLoc<sub>2.2</sub> (in Auditorium) w/ SA.
  - 2.3. MM-Disables Persona<sub>2.1</sub> from MLoc<sub>2.1</sub>.
3. User<sub>3</sub> (Participant #1)
  - 3.1. Tracks Persona<sub>3.1</sub> at MLoc<sub>3.1</sub> (at home).
  - 3.2. Transacts Value<sub>3.1</sub> (buys ticket).
  - 3.3. Embeds Persona<sub>3.1</sub> (AV) w/ SA at MLoc<sub>3.2</sub> (in Auditorium).
  - 3.4. MM-Disables Persona<sub>3.1</sub> (AV) from MLoc<sub>3.1</sub>.
4. User<sub>4</sub> (Participant #2)
  - 4.1. Tracks Persona<sub>4.1</sub> at MLoc<sub>4.1</sub> (at home).

- 4.2. Transacts Value<sub>4.1</sub> (buys ticket).
- 4.3. Embeds Persona<sub>4.1</sub> (AV) w/ SA at MLoc<sub>4.2</sub> (in Auditorium).
- 4.4. MM-Disables Persona<sub>3.1</sub> (AV) from MLoc<sub>4.1</sub>.
5. User<sub>3</sub> (Participant #1)
  - 5.1. MM-Sends Object<sub>3.1</sub>(A) to Persona<sub>4.1</sub> (Participant #2).
  - 5.2. Calls Service<sub>1</sub> (expresses preferences).
  - 5.3. MM-Adds Persona<sub>3.1</sub> at MLoc<sub>3.3</sub> (close to stage for 5 minutes).
6. User<sub>1</sub> (Organiser)
  - 6.1. MM-Disables Persona<sub>3.1</sub> from MLoc<sub>3.3</sub> (5 minutes passed).
  - 6.2. Interprets Participants Status (of all participants).
  - 6.3. MM-Embeds Object(A)<sub>1.1</sub> (SFX).
  - 6.4. Transacts Value<sub>1.3</sub> to User<sub>2</sub> (performance fees).
7. User<sub>2</sub> (Performer)
  - 7.1. MM-Embeds Persona<sub>2.1</sub> (AV) to MLoc<sub>2.1</sub>.
  - 7.2. MM-Disables Persona<sub>2.1</sub> from MLoc<sub>2.2</sub>.
8. User<sub>3</sub> (Participant #1)
  - 8.1. MM-Embeds Persona<sub>3.1</sub> (AV) to MLoc<sub>3.1</sub>.
  - 8.2. MM-Disables Persona<sub>3.1</sub> from MLoc<sub>3.2</sub>.
9. User<sub>3</sub> (Participant #2)
  - 9.1. MM-Embeds Persona<sub>3.1</sub> (AV) to MLoc<sub>4.1</sub>.
  - 9.2. MM-Disables Persona<sub>3.1</sub> from MLoc<sub>4.2</sub>.

#### 11.7.4 Workflow and Actions

*Table 13 – Virtual Event workflow and actions.*

User <sub>1</sub> (Impresario)	Transacts	Value <sub>1.1</sub>	(Parcel of MLoc <sub>1.1</sub> )
	Authors	Object(AV) <sub>1.1</sub>	(Auditorium)
	Transacts	Value <sub>1.2</sub>	(Auditorium)
	MM-Embeds	Object(V) <sub>1.1</sub>	M-MLoc <sub>1.1</sub>
	Calls	Service <sub>1</sub>	(Collect Users' Preferences)
User <sub>2</sub> (Performer)	Tracks	Persona(AV) <sub>2.1</sub>	MLoc <sub>2.1</sub>
	Embeds	Persona(AV) <sub>2.1</sub>	MMLoc <sub>2.2</sub> (Auditorium) w/ SA.
	MM-Disables	Persona(AV) <sub>2.1</sub>	At MLoc <sub>2.1</sub> .
	MM-Sends	Object(A) <sub>2.1</sub>	(Performs)
User <sub>3</sub> (Participant)	Tracks	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> (at home).
	Transacts	Value <sub>2.1</sub>	(Buys ticket).
	Embeds	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.2</sub> (in Auditorium) w/ SA.
	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> .
User <sub>4</sub> (Participant)	Tracks	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> (at home).
	Transacts	Value <sub>2.1</sub>	(Buys ticket).
	Embeds	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.2</sub> (in Auditorium) w/ SA.
	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.1</sub> .
User <sub>3</sub> (Participant)	MM-Sends	Object(A) <sub>3.1</sub>	Persona <sub>4.1</sub> (Participant).
	Calls	Service <sub>1.1</sub>	(Expresses preferences).
	MM-Adds	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.2</sub> (close to stage).
User <sub>1</sub> (Impresario)	MM-Disables	Persona(AV) <sub>3.1</sub>	MLoc <sub>3.2</sub> (after 5 min).
	Calls	Service <sub>1.1</sub>	(Collects preferences).
	Interprets	Participants Status <sub>1.1</sub>	
	MM-Embeds	Entities <sub>1.i</sub>	(SFX)

	Transacts	Value <sub>1,2</sub>	User <sub>2</sub> (performance fees).
User <sub>2</sub> (Performer)	MM-Embeds	Persona(AV) <sub>2,1</sub>	MLoc <sub>2,1</sub> .
	MM-Disables	Persona <sub>2,1</sub>	MLoc <sub>2,2</sub> .
User <sub>3</sub> (Participant)	MM-Embeds	Persona(AV) <sub>3,1</sub>	MLoc <sub>3,1</sub> .
	MM-Disables	Persona <sub>3,1</sub>	MLoc <sub>3,2</sub> .
User <sub>4</sub> (Participant)	MM-Embeds	Persona(AV) <sub>4,1</sub>	MLoc <sub>4,1</sub> .
	MM-Disables	Persona <sub>4,1</sub>	MLoc <sub>4,2</sub> .

### 11.7.5 Actions, Items, and Data Types

Table 14 – Virtual Event Actions, Items, and Data Types.

Actions	Items	Data Types
Author	Object (A)	Amount
Interpret	Object (AV)	Coordinates
MM-Disable	Persona (AV)	Currency
MM-Embed	M-Location	Orientation
MM-Send	Value	Participants Status
Track		Position
Transact		Spatial Attitude

## 11.8 AR Tourist Guide

### 11.8.1 Description

In his Use Case human<sub>3</sub> engages the following humans:

1. human<sub>1</sub> to cause their User<sub>1</sub> to buy a virtual parcel and develop a virtual landscape suitable for a tourist application.
2. human<sub>2</sub> to cause their User<sub>2</sub> to develop scenes and autonomous agents for the different places of the landscape.
3. human<sub>4</sub> to create an app that alerts the holder of a smart phone where the app is installed.
4. human<sub>5</sub> holding a smart phone with the app to perceive Entities and interact with Personae MM-Embedded at M-Locations and MM-Animated by autonomous agents (AA).

### 11.8.2 Processes, Items, and Locations

User <sub>1</sub>	Land developer		
Object(V) <sub>1,1</sub>	Landscape	MLoc <sub>1,1</sub>	parcel
Value <sub>1,1</sub>	Payment for MLoc <sub>1,1</sub>	MLoc <sub>1,1</sub>	
User <sub>2</sub>	Object developer		
Objects(AV) <sub>2,i</sub>	Objects for landscape	MLoc <sub>2,i</sub>	Key ULoc twin
Value <sub>2,1</sub>	For Objects(AV) <sub>2,i</sub> -Object(AV) <sub>1,1</sub> -Objects(AV) <sub>2,i</sub>		
User <sub>3</sub>	Tourist application developer		
Persona <sub>3,k</sub>	Persona to be MM-Animated	MLoc <sub>3,k</sub>	Key ULoc twin
human <sub>4</sub>	Software developer		
Map			
Value <sub>4,1</sub>	For Map and App		
human <sub>5</sub>	human holding Device with App		
Device <sub>1</sub>	Held by human <sub>5</sub>	ULoc <sub>5,1</sub>	
App <sub>1</sub>	Installed in Device <sub>1</sub>		

Message <sub>5.1</sub>	From App <sub>5</sub> to Device <sub>5</sub>		
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### 11.8.3 Detailed workflow

1. User<sub>1</sub>
  - 1.1. Buys MLoc<sub>1.1</sub> (parcel) in an M-Environment.
  - 1.2. Authors Object(V)<sub>1.1</sub> (landscape suitable for a virtual path through n sub-MLocs).
  - 1.3. Embeds Object(V)<sub>1.1</sub> (landscape) at MLoc<sub>1.1</sub> (parcel).
  - 1.4. Sells Object(V)<sub>1.1</sub> (landscape) and MLoc<sub>1.1</sub> (parcel) to a User<sub>2</sub>.
2. User<sub>2</sub>
  - 2.1. Authors n Object(AV)<sub>2.i</sub> for the MLocs.
  - 2.2. MM-Embeds Object(AV)<sub>2.i</sub> at MLoc<sub>2.i</sub> (n places)
  - 2.3. Sells parcel + landscape + n Object(AV)<sub>2.i</sub>.
3. human<sub>4</sub>
  - 3.1. Develops
    - 3.1.1. Map recording the pairs MLoc<sub>2.i</sub> – U-Loc<sub>2.i</sub>
    - 3.1.2. App alerting human<sub>5</sub> that they have reached a key U-Loc.
  - 3.2. Sells Map and App to human<sub>3</sub>.
4. User<sub>3</sub> MM-Embeds Persona(AV)<sub>3.j</sub> at n MLoc<sub>3.j</sub> places.
5. human<sub>5</sub> reaches key U-Loc<sub>5.1</sub> corresponding to MLoc<sub>2.k</sub>.
6. App<sub>1</sub> MM-Sends Message<sub>5.1</sub> to Device<sub>1</sub>.
7. Device<sub>1</sub>
  - 7.1. MM-Sends Message<sub>5.1</sub> to User<sub>3</sub>.
8. User<sub>3</sub>
  - 8.1. MU-Renders Object(AV)<sub>2.k</sub> MM-Embedded at MLoc<sub>2.k</sub> at U-Loc<sub>5.1</sub>.
  - 8.2. MU-Animates Persona(AV)<sub>2.k</sub>.
  - 8.3. MU-Renders Persona(AV)<sub>2.k</sub> at U-Loc<sub>5.1</sub>.

### 11.8.4 Workflow

Table 15 – AR Tourist Guide workflow.

Who	Does	What	Where/comment
User <sub>1</sub>	Transacts	Value <sub>1.1</sub>	MLoc <sub>1.1</sub> 's parcel.
	Authors	Object(V) <sub>1.1</sub>	(landscape of MLocs).
	Embeds	Object(V) <sub>1.1</sub>	(Parcel).
	Transacts	Value <sub>1.1</sub>	User <sub>2</sub> (MLoc <sub>1.1</sub> & Object(V) <sub>1.1</sub> )
User <sub>2</sub>	Authors	Object(AV) <sub>2.1</sub> to Object(AV) <sub>2.n</sub>	(to be MM-Embedded)
	Embeds	Object(AV) <sub>2.1</sub> to Object(AV) <sub>2.n</sub>	MLoc <sub>2.1-2.n</sub>
	Transacts <sub>2.1</sub>	Value <sub>2.1</sub>	User <sub>3</sub> (all Object(AV) <sub>2.1-2.n</sub> )
human <sub>4</sub>	develops	Map	Of MLocs & ULocs
	develops	App	
	sells	Map and App	To human <sub>3</sub> .
User <sub>3</sub>	MM-Embeds	Personae	MLoc <sub>2.1-2.n</sub> .
	MM-Animates	Personae	MLoc <sub>2.1-2.n</sub> .
human <sub>5</sub>	comes to		key U-Loc <sub>2.i</sub> .
App <sub>5.1</sub>	MM-Sends	Message <sub>5.1</sub>	Device <sub>1</sub>
Device <sub>5.1</sub>	MM-Sends	Message <sub>5.1</sub>	User <sub>3</sub>
User <sub>3</sub>	MU-Renders	Entity <sub>5.1</sub> @MLoc <sub>5.1</sub>	At key U-Loc <sub>5.1</sub> .
	MM-Animates	Persona(AV) <sub>2.k</sub>	At key U-Loc <sub>5.1</sub> .
	MU-Renders	MM-Animated Persona <sub>5.2</sub>	At key U-Loc <sub>5.1</sub> .



### 11.8.5 Actions, Items, and Data Types

*Table 16 – AR Tourist Guide Actions, Items, and Data Types.*

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

## 11.9 Virtual Dance

### 11.9.1 Description

This Use Cases envisages that:

1. Dance teacher places in the dance school a virtual secretary animated by an autonomous agent.
2. Student #1:
  - 2.1. Shows up at school.
  - 2.2. Greets the secretary.
3. Virtual secretary reciprocates greetings.
4. Dance teacher:
  - 4.1. Places a haptic Persona of theirs in the dance school.
  - 4.2. Dances with student #1.
5. Student #2:
  - 5.1. Is at home.
  - 5.2. Shows up at school.
6. The teacher:
  - 6.1. Places the haptic Persona close to student #2.
  - 6.2. Places (replaces) another haptic Persona of theirs.
  - 6.3. Animates the new haptic Persona with autonomous agent dancing with student #1.
  - 6.4. Dances with student #2.

### 11.9.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	Dance teacher		
Persona(AVH) <sub>1.1</sub>	Dancing persona	MLoc <sub>1.1</sub>	Teacher's Office
Persona(AVH) <sub>1.2</sub>	Virtual Secretary	MLoc <sub>1.2</sub>	Dance School
Persona(AVH) <sub>1.3</sub>	Another dancing persona	MLoc <sub>1.3</sub>	Dance place
Object(A) <sub>1.1</sub>	Response to greetings	MLoc <sub>1.4</sub>	Another dance place
<b>User<sub>2</sub></b>	Dance student #1		
Persona(AVH) <sub>2.1</sub>	Student's Persona	MLoc <sub>2.1</sub>	Student's home
		MLoc <sub>2.1</sub>	Place in dance school
Object(A) <sub>2.1</sub>	Student's greetings		
<b>User<sub>3</sub></b>			

Persona(AVH) <sub>3.1</sub>	Student's Persona	MLoc <sub>3.1</sub>	Student's home
		MLoc <sub>3.1</sub>	Place in dance school

### 11.9.3 Detailed description

1. User<sub>1</sub> (dance teacher)
  - 1.1. Tracks Persona(AVH)<sub>1.1</sub> at MLoc<sub>1.1</sub>
  - 1.2. MM-Embeds Persona(AV)<sub>1.2</sub> (another of its Personae) at MLoc<sub>1.2</sub>.
  - 1.3. MM-Animates Persona(AV)<sub>1.2</sub> (as virtual secretary attending to students coming to school).
2. User<sub>2</sub> (dance student #1):
  - 2.1. MM-Embeds its Persona(AVH)<sub>2.1</sub> at MLoc<sub>2.1</sub> (its "home").
  - 2.2. MM-Embeds Persona(AVH)<sub>2.1</sub> at MLoc<sub>2.2</sub> (close to virtual secretary).
  - 2.3. MM-Sends Object(A)<sub>2.1</sub> to Persona<sub>1.2</sub> (greet virtual secretary).
  - 2.4. MM-Disables Persona(AVH)<sub>2.1</sub> from MLoc<sub>2.1</sub>.
3. User<sub>1</sub> (Persona(AVH)<sub>1.2</sub>):
  - 3.1. MM-Sends Object(A)<sub>1.1</sub> (to student #1 reciprocating greetings).
  - 3.2. MM-Send Object(A)<sub>1.2</sub> (calling teacher's Persona<sub>1.1</sub>).
4. Dance teacher (Persona(AVH)<sub>1.1</sub>):
  - 4.1. MM-Embeds Persona(AVH)<sub>1.1</sub> at MLoc<sub>1.3</sub> (classroom).
  - 4.2. UM-Animates Persona(AVH)<sub>1.1</sub> (dances with student #1).
5. While Persona(AVH)<sub>2.1</sub> (student #1) and Persona(AVH)<sub>1.1</sub> (teacher) dance, User<sub>3</sub> (dance student #2):
  - 5.1. MM-Embeds Persona(AVH)<sub>3.1</sub> at MLoc<sub>3.1</sub> (its "home").
  - 5.2. MM-Embeds Persona(AVH)<sub>3.1</sub> at MLoc<sub>3.2</sub> (place in classroom).
  - 5.3. MM-Disables Persona(AVH)<sub>3.1</sub> from MLoc<sub>3.1</sub>.
6. After a while, User<sub>1</sub> (dance teacher):
  - 6.1. MM-Embeds Persona(AVH)<sub>1.1</sub> at MLoc<sub>1.4</sub> (close to student #2's position).
  - 6.2. MM-Disables Persona(AVH)<sub>1.1</sub> (from where it was dancing with student #1).
  - 6.3. MM-Embeds Persona(AVH)<sub>1.3</sub> at MLoc<sub>1.3</sub>.
  - 6.4. MM-Animates Persona(AVH)<sub>1.3</sub> with autonomous agent (to dance with student #1).
  - 6.5. UM-Animates Persona(AVH)<sub>1.1</sub> at MLoc<sub>3.2</sub> (dances with student #2).

### 11.9.4 Workflow

Table 17 – Virtual Dance workflow.

User <sub>1</sub> (teacher)	Tracks	Persona(AVH) <sub>1.1</sub>	MLoc <sub>1.1</sub>
	MM-Embeds	Persona(AV) <sub>1.2</sub>	MLoc <sub>1.2</sub> .
	MM-Animates	Persona(AV) <sub>1.2</sub>	(As VS for students).
User <sub>2</sub> (student <sub>1</sub> )	Tracks	Persona(AVH) <sub>2.1</sub>	MLoc <sub>2.1</sub> (its "home").
	MM-Embeds	Persona(AVH) <sub>2.1</sub>	MLoc <sub>2.2</sub> (close to VS).
	MM-Sends	Object(A) <sub>2.1</sub>	Persona(AVH) <sub>1.2</sub> (greet VS).
	MM-Disables	Persona(AVH) <sub>2.1</sub>	from MLoc <sub>2.1</sub> .
User <sub>1</sub> (Persona <sub>1.1</sub> )	MM-Sends	Object(A) <sub>1.1</sub>	(Responds to student #1).
User <sub>1</sub> (Persona <sub>1.2</sub> )	MM-Embeds	Persona(AVH) <sub>1.2</sub>	MLoc <sub>2.3</sub> (classroom).
User <sub>1</sub> (Persona <sub>1.1</sub> )	UM-Animates	Persona(AVH) <sub>1.1</sub>	(Dances with student #1).
User <sub>3</sub> (student <sub>2</sub> )	Tracks	Persona(AVH) <sub>3.1</sub>	MLoc <sub>3.1</sub> (its "home").
	MM-Embeds	Persona(AVH) <sub>3.1</sub>	MLoc <sub>3.2</sub> (close to VS).
	MM-Disables	Persona(AVH) <sub>3.1</sub>	from MLoc <sub>3.1</sub> .
User <sub>1</sub> (teacher)	MM-Embeds	Persona(AVH) <sub>1.1</sub>	MLoc <sub>1.4</sub> (near student <sub>2</sub> ).

	MM-Disables	Persona(AVH) <sub>1.1</sub>	From MLoc <sub>2.2</sub> .
	MM-Embeds	Persona(AVH) <sub>1.3</sub>	At MLoc <sub>2.2</sub> .
	MM-Animates	Persona(AVH) <sub>1.3</sub>	(w/ AA with student #1).

### 11.9.5 Actions, Items, and Data Types

*Table 18 – Virtual Dance Actions, Items, and Data Types.*

Actions	Items	Data Types
MM-Animate	M-Location	Orientation
MM-Disable	Object (A)	Position
MM-Embed	Persona (AV)	Spatial Attitude
MM-Send	Persona (AVH)	
Track		

## 11.10 Virtual Car Showroom

### 11.10.1 Description

This Use Cases envisages that:

1. A car dealer MM-Embeds an MM-Animated Persona in the car showroom (as attendant).
2. A customer:
  - 2.1. MM-Embeds its Persona in the car showroom.
  - 2.2. Greets the showroom attendant.
3. The Showroom attendant reciprocates the greeting.
4. The dealer:
  - 4.1. UM-Animates the attendant.
  - 4.2. Converses with the customer.
  - 4.3. Embeds a 3D AVH model of a car.
5. The customer
  - 5.1. Has a virtual test drive.
  - 5.2. Buys the car.
  - 5.3. Returns home.

### 11.10.2 Processes, Items, and Locations

<b>User<sub>1</sub></b>	Car dealer		
Persona(AV) <sub>1.1</sub>	Car dealer	MLoc <sub>1.1</sub>	Car dealer's Office
Persona(AV) <sub>1.2</sub>	Attendant	MLoc <sub>1.2</sub>	
Object(A) <sub>1.1</sub>	Response to greetings	M-Loc <sub>1.3</sub>	Place in the showroom
<b>User<sub>2</sub></b>	Customer		
Persona(AV) <sub>2.1</sub>	Customer's Persona	M-Loc <sub>2.1</sub>	Customer's home
Object(A) <sub>2.1</sub>	Greetings	M-Loc <sub>2.2</sub>	Place in showroom
Persona(AVH) <sub>2.1</sub>	User <sub>2</sub> 's Persona in test driving	M-Loc <sub>2.3</sub>	Location of virtual car
Value <sub>2.1</sub>	Payment for car		

### 11.10.3 Detailed workflow

1. User<sub>1</sub> (car dealer):
  - 1.1. Tracks Persona(AV)<sub>1.1</sub> at M-Loc<sub>1.1</sub> ("office").
  - 1.2. MM-Embeds Persona(AV)<sub>1.2</sub> at M-Loc<sub>1.2</sub> ("showroom") with SA.

- 1.3. MM-Animates Persona(AV)<sub>1.2</sub>.
2. User<sub>2</sub> (customer):
  - 2.1. Tracks Persona(AV)<sub>2.1</sub> at M-Loc<sub>2.1</sub> (“home”).
  - 2.2. MM-Embeds Persona(AV)<sub>2.1</sub> at M-Loc<sub>2.2</sub> (“in the showroom”).
  - 2.3. MM-Sends Object(A)<sub>2.1</sub> to Persona<sub>1.2</sub> (greeted showroom attendant).
  - 2.4. MM-Disables Persona(AV)<sub>2.1</sub> at M-Loc<sub>2.1</sub> (“home”).
3. User<sub>1</sub> (Persona(AV)<sub>1.2</sub>):
  - 3.1. MM-Sends Object(A)<sub>1.1</sub> to Persona<sub>2.1</sub> (responds to greetings).
4. User<sub>1</sub> (Persona(AV)<sub>1.1</sub>)
  - 4.1. MM-Embeds Persona(AV)<sub>1.1</sub> at M-Loc<sub>1.3</sub> (“in the showroom”).
  - 4.2. MM-Sends Object(A)<sub>1.2</sub> to Persona<sub>2.1</sub> (engages in conversation).
  - 4.3. MM-Embeds Model(AVH)<sub>1.1</sub> at M-Loc<sub>1.4</sub> (model car “in the showroom”).
  - 4.4. MM-Animates Model(AVH)<sub>1.1</sub> (“animate model car”).
5. User<sub>2</sub> (customer)
  - 5.1. MM-Embeds Persona(AVH)<sub>2.1</sub> at M-Loc<sub>2.3</sub> (location of virtual car).
  - 5.2. UM-Animates Persona(AVH)<sub>2.1</sub>.
  - 5.3. Transacts Value<sub>2.1</sub> (buys car).
  - 5.4. MM-Disables Persona(AVH)<sub>2.1</sub> at M-Loc<sub>1.3</sub>.
  - 5.5. MM-Embeds Persona(AV)<sub>2.1</sub> at M-Loc<sub>2.1</sub> (“at home”).

#### 11.10.4 Workflow

Table 19 – Virtual Car Showroom workflow.

User <sub>1</sub> (car dealer)	Tracks	Persona(AV) <sub>1.1</sub>	M-Loc <sub>1.1</sub> (“office”).
	MM-Embeds	Persona(AV) <sub>1.2</sub>	M-Loc <sub>1.2</sub> (“showroom”) w/ SA <sub>1.1</sub>
	MM-Animates	Persona(AV) <sub>1.2</sub>	(Showroom attendant).
User <sub>2</sub> (customer)	Tracks	Persona(AV) <sub>2.1</sub>	M-Loc <sub>2.1</sub> (“home”).
	MM-Embeds	Persona(AV) <sub>2.1</sub>	M-Loc <sub>2.1</sub> (“showroom”).
	MM-Sends	Object(A) <sub>1.1</sub>	Persona <sub>1.2</sub> (greeted attendant).
	MM-Disables	Persona(AV) <sub>2.1</sub>	M-Loc <sub>2.1</sub> (“home”).
User <sub>1</sub> (Persona <sub>1.2</sub> )	MM-Sends	Object(A) <sub>1.1</sub>	Persona <sub>2.1</sub> (responds to greetings).
	MM-Sends	Object(A) <sub>1.2</sub>	Persona <sub>1.1</sub> (“attend customer”).
User <sub>1</sub> (Persona <sub>1.1</sub> )	MM-Embeds	Persona(AVH) <sub>1.1</sub>	M-Loc <sub>1.3</sub> (“showroom”).
	MM-Sends	Object(A) <sub>1.2</sub>	Persona <sub>2.1</sub> (converses).
	MM-Embeds	Model(AVH) <sub>1.1</sub>	M-Loc <sub>1.4</sub> (“in showroom”).
	MM-Animates	Model(AVH) <sub>1.1</sub>	(“Animate model car”).
User <sub>2</sub> (customer)	MM-Embeds	Persona(AVH) <sub>2.1</sub>	M-Loc <sub>2.3</sub> (in virtual car)
	UM-Animates	Persona(AVH) <sub>2.1</sub>	(Drives virtual car)
	Transacts	Value <sub>2.1</sub>	(Buys car).
	MM-Disables	Persona(AVH) <sub>2.1</sub>	M-Loc <sub>1.3</sub> .
	MM-Embeds	Persona(AV) <sub>2.1</sub>	M-Loc <sub>2.1</sub> (“at home”).

#### 11.10.5 Actions, Items, and Data Types

Table 20 – Virtual Car Showroom Actions, Items, and Data Types.

Actions	Items	Data Types
MM-Animate	Object (A)	Amount
MM-Disable	Persona(AV)	Currency
MM-Embed	Persona(AVH)	Orientation

MM-Send	Scene (AVH)	Position
Track	Value	Spatial Attitude
Transacts		
UM-Animate		

## 11.11 Drive a Connected Autonomous Vehicle

### 11.11.1 Description

This Use Case considers some of the steps made by a human having rights to an implementation of Technical Specification: Connected Autonomous Vehicle (MPAI-CAV) – Architecture [6]. Chapter 7 of Annex 1 - MPAI Basic provides a high-level summary of the specification.

A CAV rights holder *Registers* with the CAV to access the CAV-created M-Instance by providing:

1. The requested subset of their Personal profile.
2. Two User Processes required to operate a CAV:
  - 2.1. User<sub>1</sub> to operate the Human-CAV Interaction Subsystem.
  - 2.2. User<sub>2</sub> to operate the Autonomous Motion Subsystem.
3. User<sub>1</sub>'s Personae.
4. WalletIDs.

For simplicity, the Use Case assumes that there are two CAVs: CAV<sub>A</sub> and CAV<sub>B</sub> and that the CAV<sub>A</sub> rights holder (User<sub>A,1</sub>) wants to see the CAV<sub>B</sub> Environment in the CAV<sub>B</sub> M-Instance:

1. User<sub>A,1</sub>
  - 1.1. Authenticates the human's voice.
  - 1.2. Interprets driving instructions from human.
  - 1.3. Communicates driving instructions to User<sub>A,2</sub>.
2. User<sub>A,2</sub>
  - 2.1. Gets information about CAV<sub>A</sub> position.
  - 2.2. Gets travel options from Route Planner.
  - 2.3. Communicates travel options to User<sub>A,1</sub>.
3. User<sub>A,1</sub>
  - 3.1. Produces Speech Object with travel options.
4. human utters selected option to User<sub>A,1</sub>.
5. User<sub>A,1</sub>
  - 5.1. Interprets driving instructions from human.
  - 5.2. Communicates driving instructions to User<sub>A,2</sub>.
6. User<sub>A,2</sub>
  - 6.1. Gets the Basic Environment Representation from its ESS.
  - 6.2. Authenticates its peer User<sub>B,2</sub>.
  - 6.3. Gets elements of the Basic Environment Representation from User<sub>B,2</sub>.
  - 6.4. Produces Full Environment Representation.
  - 6.5. Sends a command to the Ego CAV's Motion Actuation Subsystem.
7. User<sub>A,1</sub>
  - 7.1. Authenticates its peer User<sub>A,2</sub>.
  - 7.2. Watches CAV<sub>B</sub>'s Environment.

### 11.11.2 Processes, Items, and Locations

User <sub>A,1</sub>	CAV <sub>A</sub> 's HCI		
human <sub>A</sub>	CAV <sub>A</sub> 's rights holder	MLoc <sub>A,1,1</sub>	Corresponding to MLoc <sub>A,1,1</sub>

Object(A) <sub>A.1.1</sub>	human utterance #1	ULoc <sub>A.1.1</sub>	Close to CAV <sub>A</sub>
Object(A) <sub>A.1.2</sub>	User <sub>A.1</sub> 's utterance #1	MLoc <sub>A.1.2</sub>	Inside CAV <sub>A</sub>
HCI-AMSCCommand <sub>A.1.1</sub>	Travel request		
Object(A) <sub>A.1.3</sub>	User <sub>A.1</sub> 's utterance #2		
Object(A) <sub>A.1.4</sub>	human utterance #2		
HCI-AMSCCommand <sub>A.1.2</sub>	Travel selection		
Request-Authenticate <sub>A.1.1</sub>	User <sub>B.1</sub> Authentication		
Response-Authenticate <sub>A.1.1</sub>	User <sub>B.1</sub> Authentication		
User <sub>A.2</sub>	CAV <sub>A</sub> 's AMS		
AMS-HCIResponse <sub>A.2.1</sub>	Route selection	Scene <sub>A.2.1</sub>	CAV <sub>A</sub> 's Environment
Request-Authenticate <sub>A.2.1</sub>	User <sub>B.2</sub> Authentication		
Response-Authenticate <sub>A.2.1</sub>	User <sub>B.2</sub> Authentication		
User <sub>B.2</sub>	CAV <sub>B</sub> 's AMS	Scene <sub>B.2.1</sub>	CAV <sub>B</sub> 's Environment
User <sub>B.1</sub>	CAV <sub>B</sub> 's HCI		

### 11.11.3 Detailed workflow

1. human<sub>A</sub> Registers with CAV<sub>A</sub>.
2. User<sub>A.1</sub>
  - 2.1. Tracks Persona<sub>A.1.1</sub> at M-Loc<sub>A.1.1</sub> (connects CAV<sub>A</sub>'s M-Loc<sub>A.1.1</sub> with U-Loc<sub>A.1.1</sub>).
  - 2.2. Authenticates Object(A)<sub>A.1.1</sub> (human<sub>A</sub>'s request to travel).
  - 2.3. Interprets Object(A)<sub>A.1.1</sub>.
  - 2.4. MM-Sends HCI-AMSCCommand<sub>A.1.1</sub> to User<sub>A.2</sub>.
3. User<sub>A.2</sub>
  - 3.1. MM-Sends ESS's Scene<sub>A.2.1</sub> to RoutePlanner.
  - 3.2. MM-Sends Route<sub>A.2.1</sub> to User<sub>A.1</sub>.
4. User<sub>A.1</sub>
  - 4.1. MU-Renders Object(A)<sub>A.1.2</sub> (to human<sub>A</sub>).
  - 4.2. UM-Renders Object(A)<sub>A.1.3</sub> (human<sub>A</sub>'s Route selection).
  - 4.3. Interprets Object(A)<sub>A.1.3</sub> (understand Route).
  - 4.4. MM-Sends HCI-AMSCCommand<sub>A.1.2</sub> to User<sub>A.2</sub>.
5. User<sub>A.2</sub>
  - 5.1. Authenticates User<sub>B.2</sub>.
  - 5.2. MM-Sends
    - 5.2.1. ESS's Scene<sub>A.2.2</sub> to Environment Representation Fusion (ERF).
    - 5.2.2. Scene<sub>A.2.3</sub> at M-Loc<sub>A.2.1</sub> (in CAV<sub>B</sub>'s M-Instance) to ERF.
    - 5.2.3. Path<sub>A.2.1</sub> to Motion Planner.
    - 5.2.4. Trajectory<sub>A.2.1</sub> to Obstacle Avoider.
    - 5.2.5. Trajectory<sub>A.2.1</sub> to Command Issuer.
    - 5.2.6. AMS-MASCommand<sub>A.2.1</sub> to Motion Actuation Subsystem.
    - 5.2.7. MAS-AMSResponse<sub>A.2.1</sub>.
6. User<sub>A.1</sub>
  - 6.1. Authenticates User<sub>A.2</sub>.
  - 6.2. MM-Sends Scene(AV)<sub>A.1.4</sub> (CAV<sub>B</sub>'s Environment) to User<sub>A.1</sub>.

### 11.11.4 Workflow

Table 21 – Drive a Connected Autonomous Vehicle workflow.

Who	Does	What	Where/(comment)
human <sub>A</sub>	Registers		(With CAV <sub>A</sub> ).
User <sub>A.1</sub>	Authenticates	Object <sub>A.1.1</sub> (AV)	(Recognises human <sub>A</sub> 's voice).

	Interprets	Object <sub>A.1.1</sub> (A)	(human <sub>A</sub> 's request to go).
	MM-Sends	HCI-AMSCmd <sub>A.1.1</sub>	User <sub>A.2</sub> .
User <sub>A.2</sub>	MM-Sends	ESS's Scene <sub>A.2.1</sub>	Route Planner.
	MM-Sends	AMS-HCIResp <sub>A.2.1</sub>	Route <sub>A.2.1</sub> to User <sub>A.1</sub>
User <sub>A.1</sub>	MU-Renders	Object <sub>A.1.2</sub> (A)	(To human <sub>A</sub> ).
	UM-Renders	Object <sub>A.1.3</sub> (A)	(Route selection).
	Interprets	Object <sub>A.1.3</sub> (A)	(Understand Route).
	MM-Sends	HCI-AMSCmd <sub>A.1.2</sub>	User <sub>A.2</sub>
User <sub>A.2</sub>	Authenticates	User <sub>B.2</sub>	
	MM-Sends	ESS's Scene <sub>A.2.2</sub>	(To ERF).
		Path <sub>A.2.1</sub>	Motion Planner.
		Trajectory <sub>A.2.1</sub>	Obstacle Avoider.
		Trajectory <sub>A.2.1</sub>	Command Issuer.
		AMS-MASCmd <sub>A.2.1</sub>	MAS.
		MAS-AMS Resp <sub>A.2.1</sub> .	From MAS.
User <sub>A.1</sub>	Authenticates	User <sub>A.2</sub> .	
	MM-Sends	Scene <sub>A.1.1</sub>	CAV <sub>B</sub> 's Environment.

### 11.11.5 Actions, Items, and Data Types

Note: The MPAl-CAV specific Items are included.

*Table 22 – Drive a Connected Autonomous Vehicle Actions, Items, and Data Types.*

Action	Item	Data Types
Authenticate	AMS-HCIResponse	Spatial Attitude
Interpret	AMS-MASCommand	Coordinates
MM-Embed	Environment Representation	Orientation
MM-Send	HCI-AMSCCommand	Position
MU-Render	MAS-AMSResponse	
Register	M-Location	
Request	Object (A)	
Track	Path	
UM-Render	Persona	
	Route	
	Scene	
	Trajectory	

## 12 Functionality Profiles

In the following Functionality Profile is shortened to Profile.

### 12.1 Profile elements

Table 23 lists the currently identified Actions, Items and Data Types. Cells with text in *italic* indicate the beginning of an Item-Action-Data Type classification.

Table 23 – Metaverse Actions, Items, and Data Types

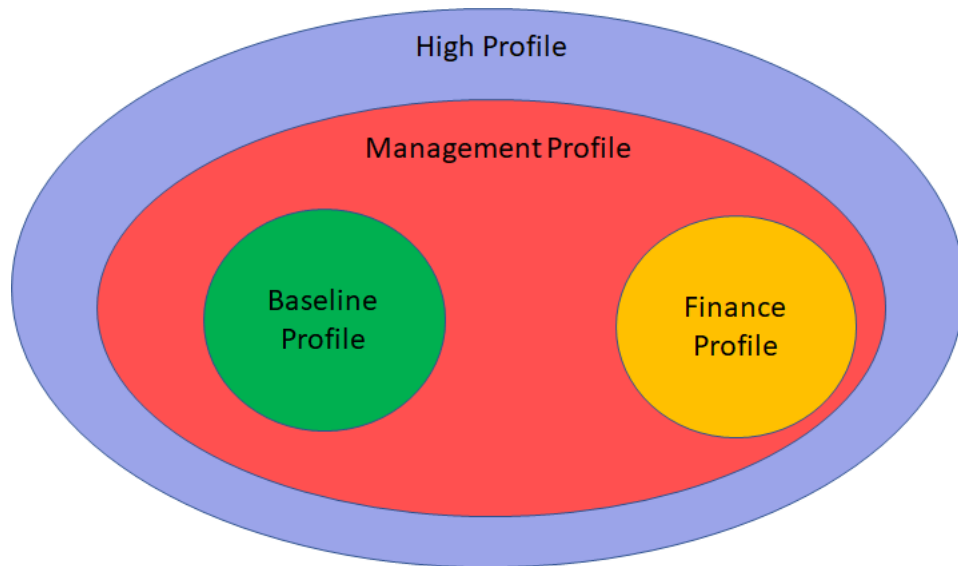
Items	Actions	Data Types
<i>General Items</i>	<i>General Actions</i>	<i>For location and time</i>
M-Instance	Register	Address
M-Capabilities	Change	Coordinates
M-Environment	Hide	Map
Identifier	Authenticate	Orientation
Rules	Identify	Point of View
Rights	Modify	Position
Program	Validate	Spatial Attitude
Contract	Request	Time
<i>Human and User-related Items</i>	Respond	<i>For Transactions</i>
Account	Execute	Amount
Activity Data	<i>Call a Service</i>	Currency
Personal Profile	Author	<i>For internal state</i>
Social Graph	Discover	Cognitive State
User Data	Inform	Emotion
<i>Items for Process Interaction</i>	Interpret	Social Attitude
Message	Post	Personal Status
P-Capabilities	Transact	
Items for Service access	Convert	
AuthenticateIn	Resolve	
AuthenticateOut	<i>Manage Entities (MM)</i>	
DiscoverIn	MM-Add	
DiscoverOut	MM-Animate	
InformIn	MM-Disable	
InformOut	MM-Embed	
InterpretIn	MM-Enable	
InterpretOut	MM-Send	
<i>Finance-related Items</i>	<i>Manage Entities (MU)</i>	
Asset	MU-Actuate	
Ledger	MU-Render	
Provenance	MU-Send	
Transaction	Track	
Value	<i>Manage Entities (UM)</i>	
Wallet	UM-Animate	
<i>Perception-related Items</i>	UM-Capture	
Event	UM-Render	
Experience	UM-Send	
Interaction		
Map		
Model		
Object		
Scene		
Stream		
Summary		



<i>Space-related Items</i>		
M-Location		
U-Location		

## 12.2 Profile structure

The currently identified Profiles are Baseline, Management, Finance, and High. The High Profile includes the Management Profile, and this includes the Baseline and Finance Profiles. The Profile structure includes hierarchical Profiles and one independent Profile. The Baseline, Management, and High Profiles have Levels, currently identified as: Audio only, Audio-Visual, and Audio-Visual-Haptic. The Finance Profile does not have Levels. This is depicted in Figure 3. The next Sections provide additional details.



*Figure 3 - The currently identified Functionality Profiles*

Actions, Items, and Data Types are allocated for the Baseline, Finance, and Management Profiles. The identified four Profiles serve well the needs conveyed by the identified Functionalities. As more Functionalities are added, the number of Profiles and potentially Levels, is likely to increase.

## 12.3 Baseline Functionality Profile

The Baseline Profile enables a human equipped with a Device supporting the Baseline Profile to allow their Users to perform the functions of Table 24. This Profile supports basic forms of lecture, meeting, and hang-out. Currently, this Profile has the following Levels: Audio only; Audio-Visual; and Audio-Visual-Haptic.

*Table 24 - Actions and Items of the Baseline Functionality Profile*

<b>Functions</b>	<b>Action</b>	<b>Items</b>
Read Items and Data	UM-Send	Item
Identify Item	Identify	Item, Identifier
Author Entity	Author	Item
Place Entity at an MLoc without perception	MM-Add	Entity, MLoc
Make an MM-Added Entity perceptible	MM-Enable	Entity
Place an Entity at MLoc, with perception	MM-Embed	Entity, MLoc
Stop perception of Scene	MM-Disable	Entity, MLoc
Make available an Object to a User	MM-Send	Entity

Render at ULoc an Entity at MLoc	MU-Render	Entity, MLoc, ULoc
Make scene at ULoc available to a Device	UM-Capture	ULoc
Make Data of a Device available to a Process	UM-Send	Device, Process
Transfer Data between Processes	MM-Send	Message
Animate Model @MLoc w/ Data from ULoc	UM-Animate	Model, ULoc
Place Entity @ MLoc	UM-Render	Entity, MLoc, ULoc
Send an Entity at an MLoc to a Device	MM-Send	Entity, Device, MLoc
Place, Animate, and Render Model at MLoc	Track	Model, Stream
Store Item	MU-Send	Item

Table 25 lists the Actions, Entities, and Data Types of the Baseline Functionality Profile.

*Table 25 – Actions, Entities, and Data Types of the Baseline Functionality Profile*

<b>Actions</b>	Author	Identify	MM-Add	MM-Embed
	MM-Disable	MM-Enable	MM-Send	MU-Actuate
	MU-Render	MU-Send	Track	UM-Animate
	UM-Capture	UM-Render	UM-Send	
<b>Items</b>	Identifier	Message	M-Instance	M-Location
	Model	Object	Scene	Stream
	U-Location			
<b>Data Types</b>	Address	Coordinates	Orientation	Position
	Spatial Attitude			

## 12.4 Finance Functionality Profile

The Finance Profile enables a human equipped with a Device supporting the Baseline Profile to allow their Users to perform the functions of Table 26. The Finance Profile enables a User to Post Assets and make Transactions. As depicted in *Figure 4*, this Profile is independent of the Basic and Management Functionality Profiles. Both Profiles share some technologies but the Finance Profile introduces technologies not used by the Baseline Profile. Currently, this Profile does not have Levels.

*Table 26 – Functions, Actions, and Items of the Finance Functionality Profile*

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

Table 27 lists the Actions, Entities, and Data Types of the Finance Profile.

Table 27 – Actions, Entities, and Data Types of the Finance Profile

<b>Actions</b>	Authenticate	Author	Change	Discover
	Hide	Identify	Inform	MM-Add
	MM-Disable	MM-Embed	MM-Enable	MM-Send
	Modify	MU-Actuate	MU-Render	MU-Send
	Post	Register	Transact	UM-Capture
	UM-Render	UM-Send		
<b>Items</b>	Account	Activity Data	Asset	Identifier
	Ledger	Map	M-Environment	Message
	M-Instance	M-Location	Model	Object
	Personal Profile	Provenance	AuthenticateIn	AuthenticateOut
	DiscoverIn	DiscoverOut	InformIn	InformOut
	Rights	Rules	Scene	Social Graph
	Stream	Transaction	U-Location	User Data
	Value	Wallet		
<b>Data Types</b>	Address	Amount	Coordinates	Currency
	Orientation	Position	Spatial Attitude	Time

## 12.5 Management Functionality Profile

The Management Profile enables a controlled ecosystem by supporting all Actions, Items, and Data Types of the Baseline Profile and the Finance Profile in addition to some others of its own. It enables a human equipped with a Device supporting the Management Profile to allow their Users to perform the functions of Table 28. As depicted in *Figure 4* the Management Profile is a superset of the Baseline and Finance Profiles. Currently, this Profile has the following Levels: Audio; Audio-Visual; and Audio-Visual-Haptic.

Table 28 – Functions, Actions, and Items of the Management Functionality Profile

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

Table 29 lists the Actions, Entities, and Data Types required by the Management Profile.

Table 29 – Actions, Item, and Data Types of Management Profile

<b>Actions</b>	Authenticate	Author	Change	Discover
	Hide	Identify	Inform	Interpret
	MM-Add	MM-Animate	MM-Disable	MM-Embed
	MM-Enable	MM-Send	Modify	MU-Actuate
	MU-Render	MU-Send	Post	Register
	Track	Transact	UM-Animate	UM-Capture

	UM-Render	UM-Send		
<b>Items</b>	Account	Activity Data	Asset	AuthenticateIn
	AuthenticateOut	DiscoverIn	DiscoverOut	Event
	Experience	Identifier	InformIn	InformOut
	Interaction	InterpretIn	InterpretOut	Ledger
	Map	M-Environment	Message	M-Instance
	M-Location	Model	Object	Personal Profile
	Provenance	Rights	Rules	Scene
	Social Graph	Stream	Summary	Transaction
	U-Location	Value	Wallet	
<b>Data Types</b>	Address	Amount	Cognitive State	Coordinates
	Currency	Emotion	Map	Orientation
	Personal Status	Point of View	Position	Social Attitude
	Spatial Attitude	Time		

## 12.6 High Functionality Profile

This Profile includes all other Profiles. Table 23 gives the full list of Actions, Items and Data Types of the High Profile. Table 30 gives the Actions and Items non present in the Management Profile. Currently, this Profile has the following Levels: Audio; Audio-Visual; and Audio-Visual-Haptic.

*Table 30 - Actions, Items, and Data Types of High Profile not in the Management Profile*

<b>Actions</b>	Convert	Execute	Resolve	Validate
<b>Item</b>	Contract	M-Capabilities	P-Capabilities	Program
<b>Data Types</b>				

## Annex 1 - MPAI Basics

### 1 General

In recent years, Artificial Intelligence (AI) and related technologies have been introduced in a broad range of applications affecting the life of millions of people and are expected to do so much 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. In addition, some AI technologies may carry inherent risks, e.g., in terms of bias toward some classes of users making the need for standardisation more important and urgent than ever.

The above considerations have prompted the establishment of the international, unaffiliated, not-for-profit Moving Picture, Audio and Data Coding by Artificial Intelligence (MPAI) organisation with the mission to develop *AI-enabled data coding standards* to 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 – and new in standardisation – type of Specification includes standard operating procedures that 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.

### 2 Governance of the MPAI Ecosystem

The technical foundations of the MPAI Ecosystem are currently provided by the following documents developed and maintained by MPAI:

1. Technical Specification.
2. Reference Software Specification.
3. Conformance Testing.
4. Performance Assessment.
5. Technical Report

An MPAI Standard is a collection of a variable number of the 5 document types.

Figure 4 depicts the MPAI ecosystem operation for conforming MPAI implementations.

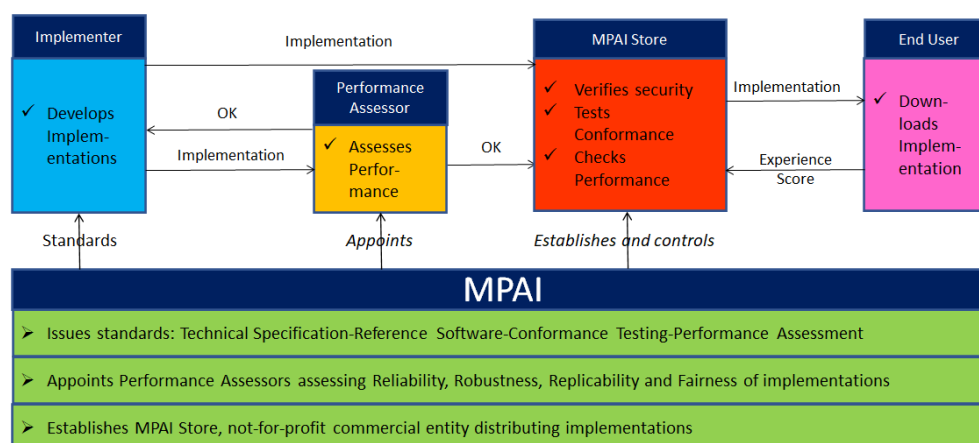


Figure 4 – The MPAI ecosystem operation

Technical Specification: Governance of the MPAI Ecosystem [1] identifies the following roles in the MPAI Ecosystem:

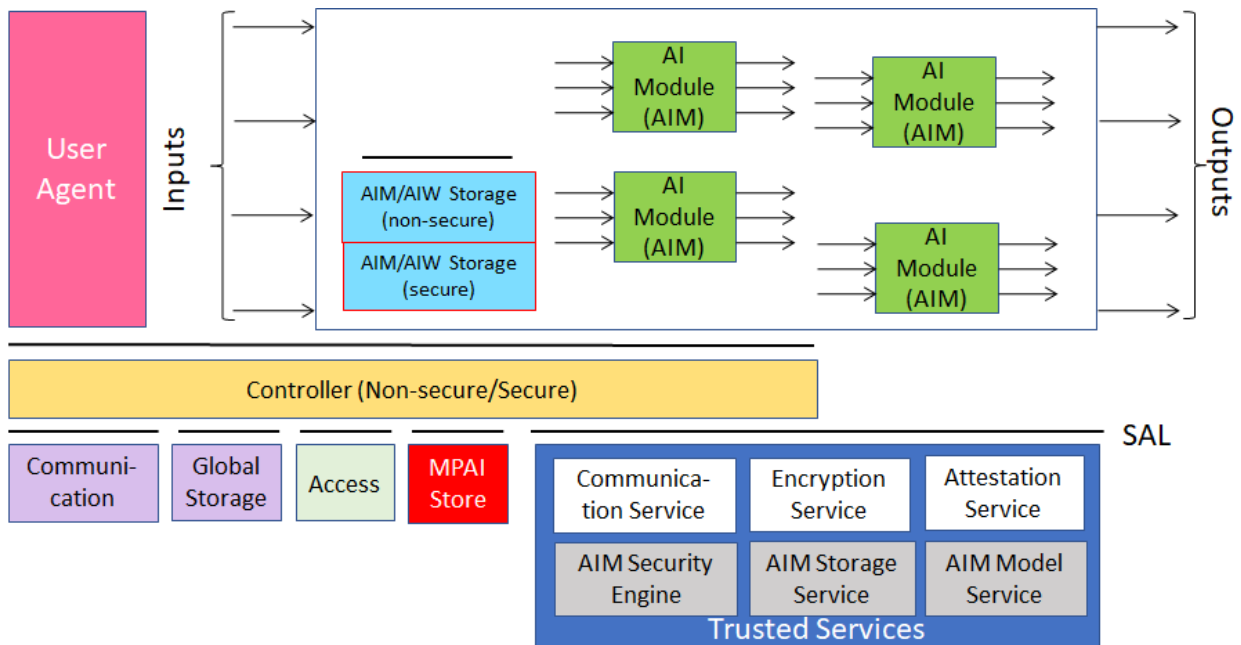
*Table 31 - Roles in the MPAI Ecosystem*

MPAI	Publishes Standards. Establishes the not-for-profit MPAI Store. Appoints Performance Assessors.
Implementers	Submit Implementations to Performance Assessors.
Performance Assessors	Inform Implementation submitters and the MPAI Store if Implementation Performance is acceptable.
Implementers	Submit Implementations to the MPAI Store.
MPAI Store	Assign unique ImplementerIDs (IID) to Implementers in its capacity as ImplementerID Registration Authority (IIDRA) <sup>2</sup> . Verifies security and Tests Implementation Conformance.
Users	Download Implementations and report their experience to MPAI.

### 3 AI Framework

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.

Figure 5 depicts the MPAI-AIF Reference Model under which Implementations of MPAI Application Standards and user-defined MPAI-AIF Conforming applications operate [5].



*Figure 5 – The AI Framework (AIF) Reference Model*

<sup>2</sup> At the time of publication of this Technical Report, the MPAI Store was assigned as the IIDRA.

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.

An AIW is defined by its Function and input/output Data and by its AIM topology. Likewise, an AIM is defined by its Function and input/output Data. MPAI standard are silent on the technology used to implement the AIM which may be based on AI or data processing, and implemented in software, hardware or hybrid software and hardware technologies.

MPAI also defines 3 Interoperability Levels of an AIF that executes an AIW. The AIW and its AIMs may have 3 Levels:

*Table 32 - MPAI Interoperability Levels*

<i>Level</i>	<i>AIW</i>	<i>AIMs</i>
<i>1</i>	An implementation of a use case	Implementations able to call the MPAI-AIF APIs.
<i>2</i>	An Implementation of an MPAI Use Case	Implementations of the MPAI Use Case
<i>3</i>	An Implementation of an MPAI Use Case certified by a Performance Assessor	Implementations of the MPAI Use Case certified by Performance Assessors

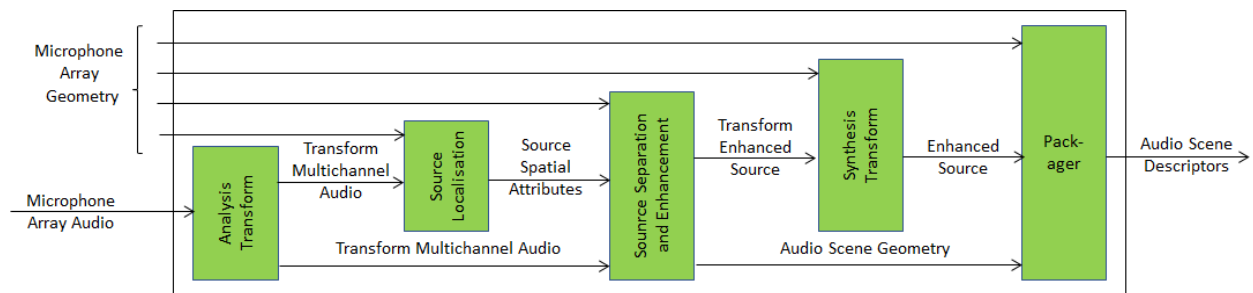
## 4 Audio-Visual Scene Description

The ability to describe (i.e., digitally represent) an audio-visual scene is a key requirement of several MPAI Technical Specifications and Use Cases. MPAI has developed Technical Specification: Context-based Audio Enhancement (MPAI-CAE) [6] that includes Audio Scene Descriptors and uses a subset of Graphics Language Transmission Format (glTF) [12] to describe a visual scene.

### 4.1 Audio Scene Descriptors

Audio Scene Description is a Composite AI Module (AIM) specified by Technical Specification: Context-based Audio Enhancement (MPAI-CAE) [6]. The position of an Audio Object is defined by Azimuth, Elevation, Distance, and Distance Flag.

The Audio Scene Description Composite AIM and its AIMs are depicted in Figure 12.



*Figure 6 - The Audio Scene Description Composite AIM*

## 5 Personal Status

### 5.1 General

*Personal Status* is the set of internal characteristics of a human and a machine making a conversation. Technical Specification: Multimodal Conversation (MPAI-MMC) [8] identifies three Factors of the internal state:

1. *Cognitive State* is a typically rational result from the interaction of a human/avatar with the Environment (e.g., “Confused”, “Dubious”, “Convinced”).
2. *Emotion* is typically a less rational result from the interaction of a human/avatar with the Environment (e.g., “Angry”, “Sad”, “Determined”).
3. *Social Attitude* is the stance taken by a human/avatar who has an Emotional and a Cognitive State (e.g., “Respectful”, “Confrontational”, “Soothing”).

The Personal Status of a human can be displayed in one of the following Modalities: *Text*, *Speech*, *Face*, or *Gesture*. More Modalities are possible, e.g., the body itself as in body language, dance, song, etc. The Personal Status may be shown only by one of the four Modalities or by two, three or all four simultaneously.

### 5.2 Personal Status Extraction

Personal Status Extraction (PSE) is a composite AIM that analyses the Personal Status conveyed by Text, Speech, Face, and Gesture – of a human or an avatar – and provides an estimate of the Personal Status in three steps:

1. *Data Capture* (e.g., characters and words, a digitised speech segment, the digital video containing the hand of a person, etc.).
2. *Descriptor Extraction* (e.g., pitch and intonation of the speech segment, thumb of the hand raised, the right eye winking, etc.).
3. *Personal Status Interpretation* (i.e., at least one of Emotion, Cognitive State, and Attitude).

Figure 7 depicts the Personal Status estimation process:

1. Descriptors are extracted from Text, Speech, Face Object, and Body Object. Depending on the value of Selection, Descriptors can be provided by an AIM upstream.
2. Descriptors are interpreted and the specific indicators of the Personal Status in the Text, Speech, Face, and Gesture Modalities are derived.
3. Personal Status is obtained by combining the estimates of different Modalities of the Personal Status.

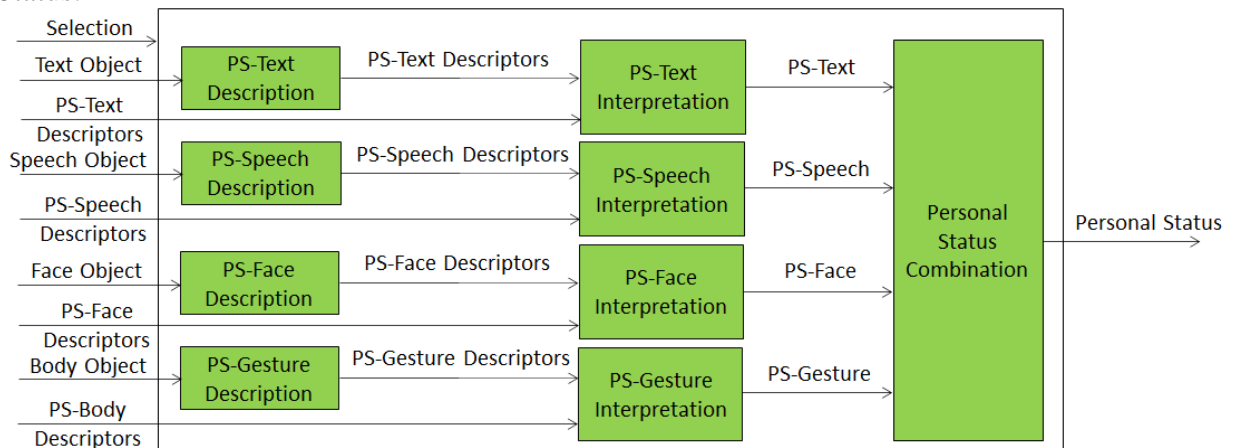


Figure 7 – Reference Model of Personal Status Extraction

An implementation can combine, e.g., the PS-Gesture Description and PS-Gesture Interpretation AIMs into one AIM, and directly provide PS-Gesture from a Body Object without exposing PS-Gesture Descriptors.



### 5.3 Personal Status Display

A Personal Status Display (PSD) is a Composite AIM receiving Text and Personal Status and generating an avatar producing Text and uttering Speech with the intended Personal Status while the avatar's Face and Gesture show the intended Personal Status. Instead of a ready-to-render avatar, the output can be provided as Compressed Avatar Descriptors. The Personal Status driving the avatar can be extracted from a human or can be synthetically generated by a machine as a result of its conversation with a human or another avatar. Reference Architecture.

Figure 8 represents the AIMs required to implement Personal Status Display.

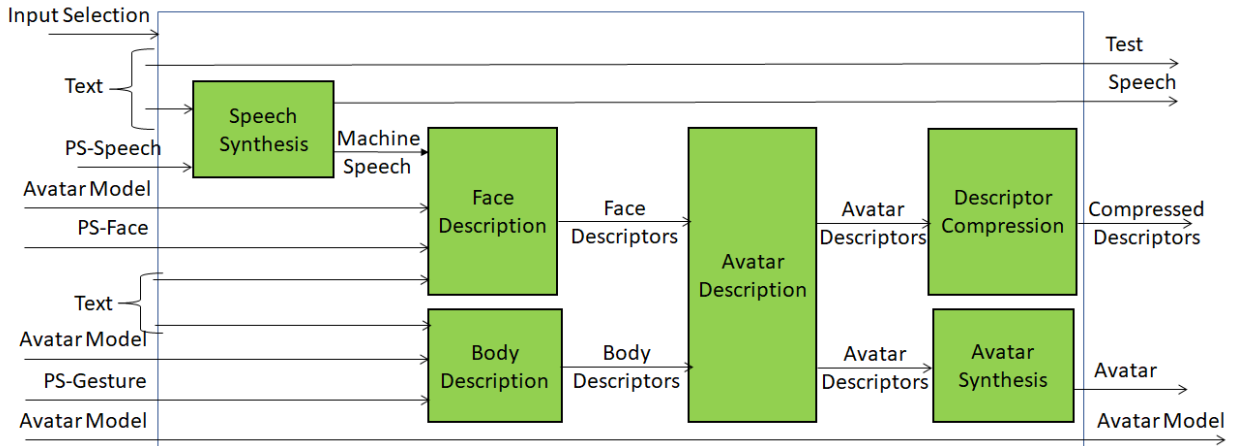


Figure 8 – Reference Model of Personal Status Display

The Personal Status Display operates as follows:

1. Selection determines the type of avatar output – ready-to-render avatar or compressed avatar descriptors.
2. Text is passed as output and synthesised as Speech using the Personal Status provided by PS (Speech).
3. Machine Speech and PS (Face) are used to produce the Face Descriptors.
4. PS (Gesture) and Text are used for Body Descriptors using the Avatar Model.
5. Avatar Description produces a complete set of Avatar Descriptors.
6. Descriptor Compression produces Compressed Avatar Descriptors.
7. Avatar Synthesis produces a ready-to-render Avatar.

## 6 Human-Machine dialogue

Figure 9 depicts the model of the MPAI Personal-Status-based human-machine dialogue.

Audio Scene Description and Visual Scene Description are two front-end AIMs. The former produces 1) Physical Objects, Face and Body Descriptors of the humans, and Visual Scene Geometry; the latter produces Audio Objects and Audio Scene Geometry.

Body Descriptors, Physical Objects and Visual Scene Geometry are used by the Spatial Object Identification AIM. This provides the identifier of the Physical Object the human body is indicating by using the Body Descriptors and the Scene Geometry. The Speech extracted from the Audio Scene Descriptor is recognised and passed to the Language Understanding AIM together with the Physical Object ID. The AIM provided a refined text (Text (Language Understanding)) and Meaning (semantic, syntactic, and structural information extracted from input data).

Face and Body Descriptors, Meaning and Speech are used by Personal Status Extraction to extract the Personal Status of the human. Dialogue Processing produces a textual response with an associated machine Personal Status that is congruent with the input Text (Language Understanding)

and human Personal Status. The Personal Status Display AIM produces a synthetic Speech and an avatar representing the machine.

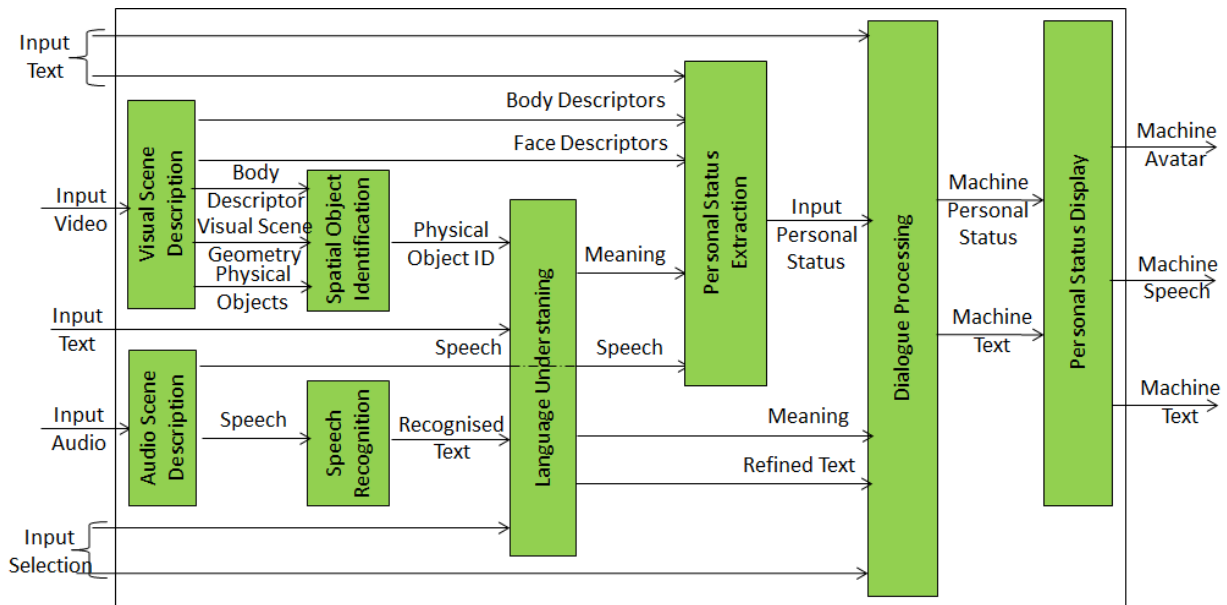


Figure 9 - Personal Status-based Human-Machine dialogue

## 7 Connected Autonomous Vehicles

MPAI defines a Connected Autonomous Vehicle (CAV), as a physical system that:

1. Converses with humans by understanding their utterances, e.g., a request to be taken to a destination.
2. Acquires information with a variety of sensors on the physical environment where it is located or traverses like the one depicted in *Figure 10*.
3. Plans a Route enabling the CAV to reach the requested destination.
4. Autonomously reaches the destination by:
  - 4.1. Moving in the physical environment.
  - 4.2. Building Digital Representations of the Environment.
  - 4.3. Exchanging elements of such Representations with other CAVs and CAV-aware entities.
  - 4.4. Making decisions about how to execute the Route.
  - 4.5. Acting on the CAV motion actuation to implement the decisions.

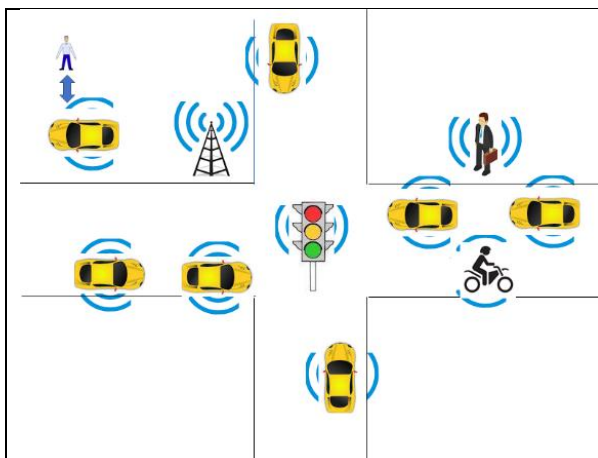


Figure 10 - An environment of CAV operation

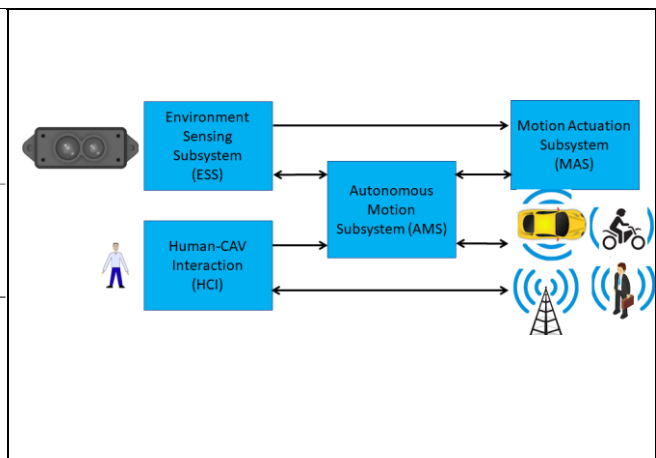
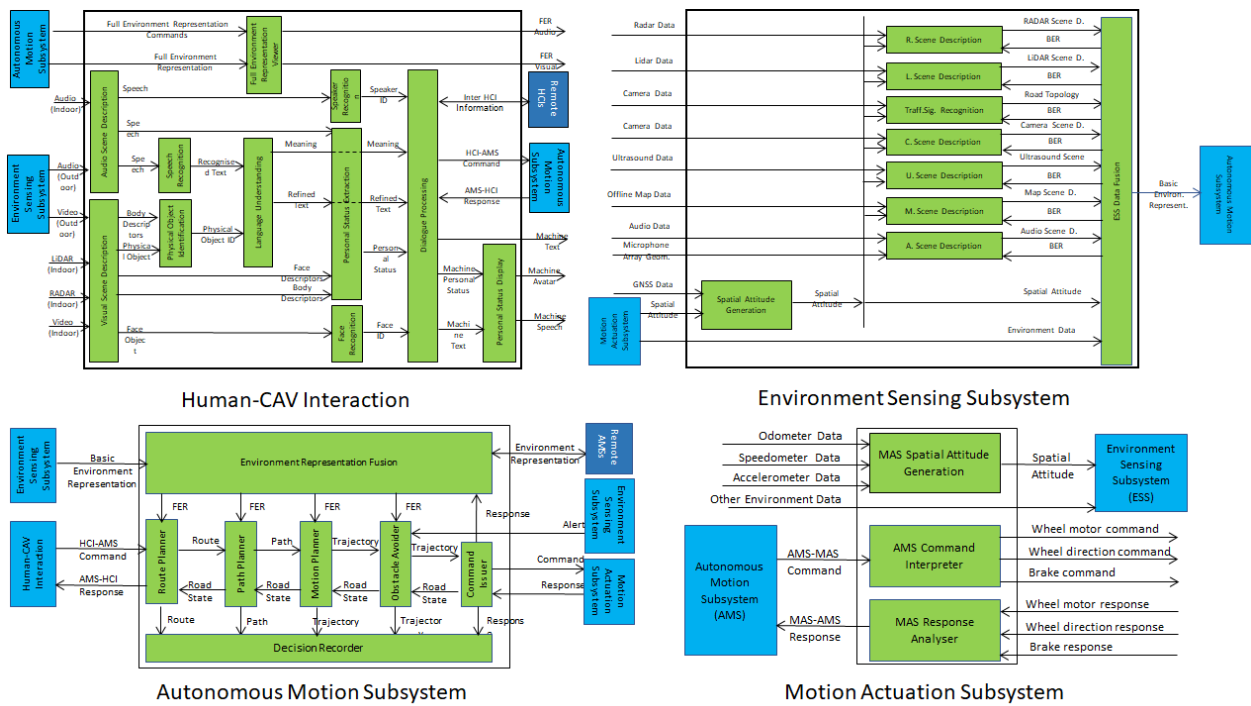


Figure 11 – The MPAI-CAV subsystems

MPAI believes in the capability of standards to accelerate the creation of a global competitive CAV market and has published Technical Specification: Connected Autonomous Vehicle (MPAI-CAV) – Architecture that includes (see *Figure 11*):

1. A CAV Reference Model broken down into four Subsystems.
2. The Functions of each Subsystem.
3. The Data exchanged between Subsystems.
4. A breakdown of each Subsystem in Components of which the following is specified:
  - 4.1. The Functions of the Components.
  - 4.2. The Data exchanged between Components.
  - 4.3. The Topology of Components and their Connections.
5. Subsequently, Functional Requirements of the Data exchanged.
6. Eventually, standard technologies for the Data exchanged.



*Figure 12 - The MPAI-CAV Subsystems with their Components*

Subsystems are implemented as AI Workflows and Components as AI Modules according to Technical Specification: AI Framework (MPAI-AIF) [5].

The Processes of a CAV generate a persistent M-Instance resulting from the integration of:

1. The Environment Representation generated by the Environment Sensing Subsystem by *UM-Capturing* the U-Location being traversed by the CAV.
2. The M-Locations of the M-Instances produced by other CAVs in range CAV that reproduce the U-Locations being traversed by such CAVs to improve the accuracy of the Ego CAV's M-Locations.
3. Relevant Experiences of the Autonomous Motion Subsystem at the M-Location.

Some operations of an implementation of MPAI-CAV can be represented according to the MPAI-MMM – Architecture [9] as shown in Section 11.11 Drive a Connected Autonomous Vehicle.

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

The notices and legal disclaimers given below shall be borne in mind when [downloading](#) and using approved MPAI Standards.

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

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## Annex 3 - General MPAI Terminology

The Terms used in this standard whose first letter is capital and are not already included in *Table 1* are defined in *Table 33*.

*Table 33 – MPAI-wide Terms*

<b>Term</b>	<b>Definition</b>
Access	Static or slowly changing data that are required by an application such as domain knowledge data, data models, etc.
AI Framework (AIF)	The environment where AIWs are executed.
AI Module (AIM)	A processing element receiving AIM-specific Inputs and producing AIM-specific Outputs according to its Function. An AIM may be an aggregation of AIMs.
AI Workflow (AIW)	A structured aggregation of AIMs implementing a Use Case receiving AIM-specific inputs and producing AIM-specific outputs according to its Function.
AIF Metadata	The data set describing the capabilities of an AIF set by the AIF Implementer.
AIM Metadata	The data set describing the capabilities of an AIM set by the AIM Implementer.
Application Programming Interface (API)	A software interface that allows two applications to talk to each other
Application Standard	An MPAI Standard specifying AIWs, AIMs, Topologies and Formats suitable for a particular application domain.
Channel	A physical or logical connection between an output Port of an AIM and an input Port of an AIM. The term “connection” is also used as a synonym.
Communication	The infrastructure that implements message passing between AIMs.
Component	One of the 9 AIF elements: Access, AI Module, AI Workflow, Communication, Controller, Internal Storage, Global Storage, MPAI Store, and User Agent.
Conformance	The attribute of an Implementation of being a correct technical Implementation of a Technical Specification.
Conformance Tester	An entity authorised by MPAI to Test the Conformance of an Implementation.
Conformance Testing	The normative document specifying the Means to Test the Conformance of an Implementation.
Conformance Testing Means	Procedures, tools, data sets and/or data set characteristics to Test the Conformance of an Implementation.
Connection	A channel connecting an output port of an AIM and an input port of an AIM.
Controller	A Component that manages and controls the AIMs in the AIF, so that they execute in the correct order and at the time when they are needed.
Data	Information in digital form.
Data Format	The standard digital representation of Data.
Data Semantics	The meaning of Data.

Device	A hardware and/or software entity running at least one instance of an AIF.
Ecosystem	The ensemble of the following actors: MPAI, MPAI Store, Implementers, Conformance Testers, Performance Testers and Users of MPAI-AIF Implementations as needed to enable an Interoperability Level.
Event	An occurrence acted on by an Implementation.
Explainability	The ability to trace the output of an Implementation back to the inputs that have produced it.
Fairness	The attribute of an Implementation whose extent of applicability can be assessed by making the training set and/or network open to testing for bias and unanticipated results.
Function	The operations effected by an AIW or an AIM on input data.
Global Storage	A Component to store data shared by AIMs.
Identifier	A name that uniquely identifies an Implementation.
Implementation	1. An embodiment of the MPAI-AIF Technical Specification, or 2. An AIW or AIM of a particular Level (1-2-3).
Internal Storage	A Component to store data of the individual AIMs.
Interoperability	The ability to functionally replace an AIM/AIW with another AIM/AIW having the same Interoperability Level
Interoperability Level	The attribute of an AIW and its AIMs to be executable in an AIF Implementation and to be: 1. Implementer-specific and satisfying the MPAI-AIF Standard ( <i>Level 1</i> ). 2. Specified by an MPAI Application Standard ( <i>Level 2</i> ). 3. Specified by an MPAI Application Standard and certified by a Performance Assessor ( <i>Level 3</i> ).
Knowledge Base	Structured and/or unstructured information made accessible to AIMs via MPAI-specified interfaces
Message	A sequence of Records.
Normativity	The set of attributes of a technology or a set of technologies specified by the applicable parts of an MPAI standard.
Performance	The attribute of an Implementation of being Reliable, Robust, Fair and Replicable.
Performance Assessment	The normative document specifying the procedures, the tools, the data sets and/or the data set characteristics to Assess the Grade of Performance of an Implementation.
Performance Assessment Means	Procedures, tools, data sets and/or data set characteristics to Assess the Performance of an Implementation.
Performance Assessor	An entity authorised by MPAI to Assess the Performance of an Implementation in a given Application domain
Port	A physical or logical communication interface of an AIM.
Profile	A particular subset of the technologies used in MPAI-AIF or an AIW of an Application Standard and, where applicable, the classes, other subsets, options and parameters relevant to that subset.
Record	Data with a specified structure.
Reference Model	The AIMs and theirs Connections in an AIW.
Reference Software	A technically correct software implementation of a Technical Specification containing source code, or source and compiled code.

Reliability	The attribute of an Implementation that performs as specified by the Application Standard, profile and version the Implementation refers to, e.g., within the application scope, stated limitations, and for the period of time specified by the Implementer.
Replicability	The attribute of an Implementation whose Performance, as Assessed by a Performance Assessor, can be replicated, within an agreed level, by another Performance Assessor.
Robustness	The attribute of an Implementation that copes with data outside of the stated application scope with an estimated degree of confidence.
Scope	The domain of applicability of an MPAI Application Standard
Service Provider	An entrepreneur who offers an Implementation as a service (e.g., a recommendation service) to Users.
Specification	A collection of normative clauses.
Standard	The ensemble of Technical Specification, Reference Software, Conformance Testing and Performance Assessment of an MPAI application Standard.
Technical Specification	<p>(Framework) the normative specification of the AIF.</p> <p>(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:</p> <ol style="list-style-type: none"> <li>1. The formats of the Input/Output data of the AIWs implementing the AIWs.</li> <li>2. The Connections of the AIMs of the AIW.</li> <li>3. The formats of the Input/Output data of the AIMs belonging to the AIW.</li> </ol>
Testing Laboratory	A laboratory accredited by MPAI to Assess the Grade of Performance of Implementations.
Time Base	The protocol specifying how Components can access timing information
Topology	The set of AIM Connections of an AIW.
Use Case	A particular instance of the Application domain target of an Application Standard.
User	A user of an Implementation.
User Agent	The Component interfacing the user with an AIF through the Controller
Version	A revision or extension of a Standard or of one of its elements.
Zero Trust	A cybersecurity model primarily focused on data and service protection that assumes no implicit trust.



## **Annex 4 - Patent declarations (Informative)**

Technical Specification: MPAI Metaverse Model (MPAI-MM) – Architecture has been developed according to the process outlined in the MPAI Statutes [1] and the MPAI Patent Policy [2].

The following entities have agreed to licence their standard essential patents reading on the Technical Specification: Metaverse Model (MPAI-MM) – Architecture according to Framework: Metaverse Model (MPAI-MMM) – Architecture [3] (to be published after patent declarations have been received):

*Table 34 - Companies having submitted a patent declaration (MPAI-MMC V1)*

<b>Entity</b>	<b>Name</b>	<b>Email address</b>