

Connecting physical and virtual worlds with digital twins

Requirements, reference model and architecture

Ask the Expert session, 22nd Jan. 2026

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What is the Metaverse



Definition of Metaverse

A collective virtual environment where physical and virtual worlds converge, that enables users to interact with shared digital spaces, objects, and services.

NOTE – A metaverse can be virtual, augmented, representative of, or associated with the physical world.

- ITU-T Y.4238, Requirements for integrating virtual and physical worlds through digital twins in the metaverse

Virtual Metaverse

A metaverse where users can interact with virtual objects
within virtual worlds

Augmented Metaverse

A metaverse where users can interact with virtual objects that are overlaid or augmented onto physical world

Integrated Metaverse

A virtual or augmented metaverse where users can interact with physical object via virtual objects

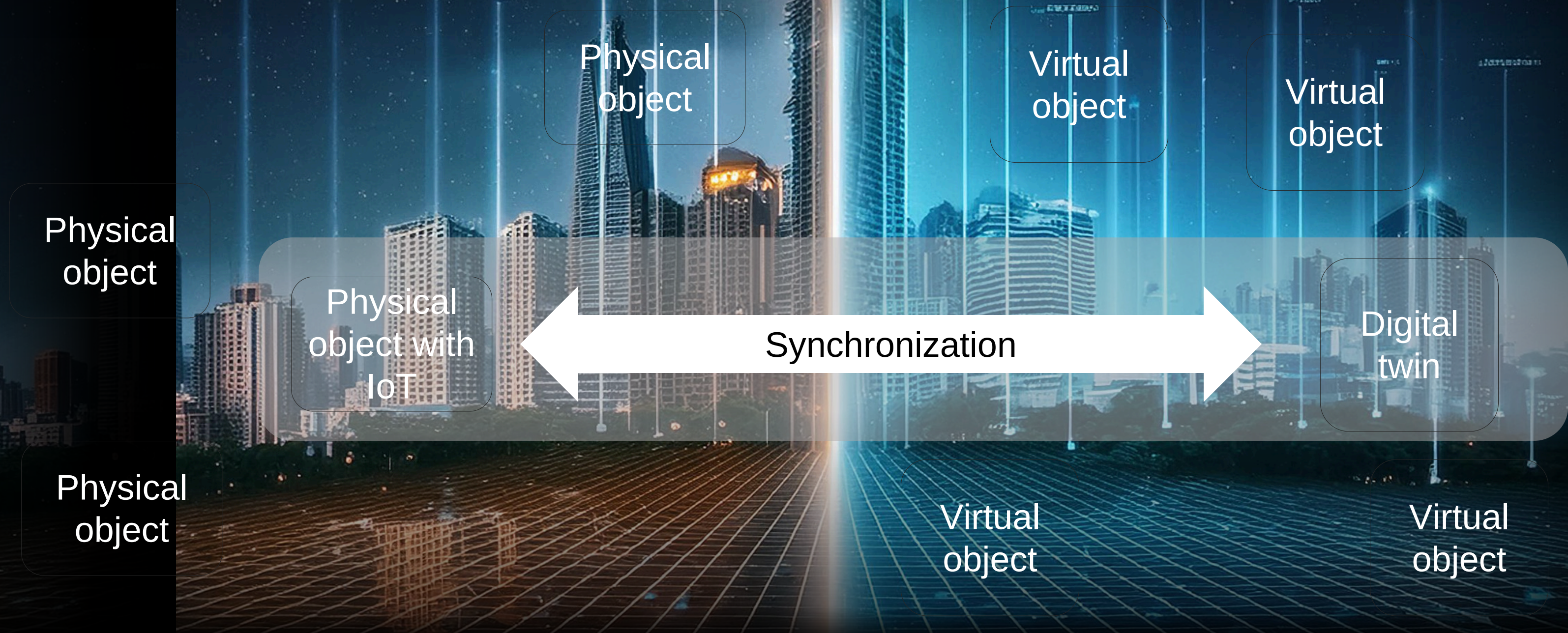
The enabler of Integrated Metaverse are



The background is a composite image. The top half shows a dark sky with the Milky Way galaxy and a complex network of glowing blue lines and dots, representing a digital or IoT network. The bottom half shows a city skyline at night, with several tall buildings illuminated. In the center of the city, there is a glowing blue rectangular area with three human figures standing inside it, suggesting a digital twin or metaverse environment.

The enabler of Integrated
Metaverse are
IoT and Digital Twin

IoT and Digital twins for Integrated Metaverse





SG20 - Internet of Things, digital twins and smart sustainable cities and communities

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LAST MEETING

SG20 meeting
Geneva, 15-25 September 2025

- ▶ Announcement
- ▶ Draft Agenda
- ▶ Draft timetable
- ▶ Meeting Room Allocation I Mobile friendly version
- ▶ Remote participation (registered delegates only) I Guides: delegates | moderator]
- ▶ Executive Summary
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- ▶ [2025-09] [2025-01]

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- ▶ 31st JC
- ▶ ITU-T S
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ITU-T SG20 Internet of Things, digital twins and smart sustainable cities and communities

- Q1/20 (WP2/20):Interworking between smart city platforms including digital twins

ITU Publications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T Y.4238 (11/2025)


SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet of things and smart cities and communities – Requirements and use cases

Requirements for integrating virtual and physical worlds through digital twins in the metaverse

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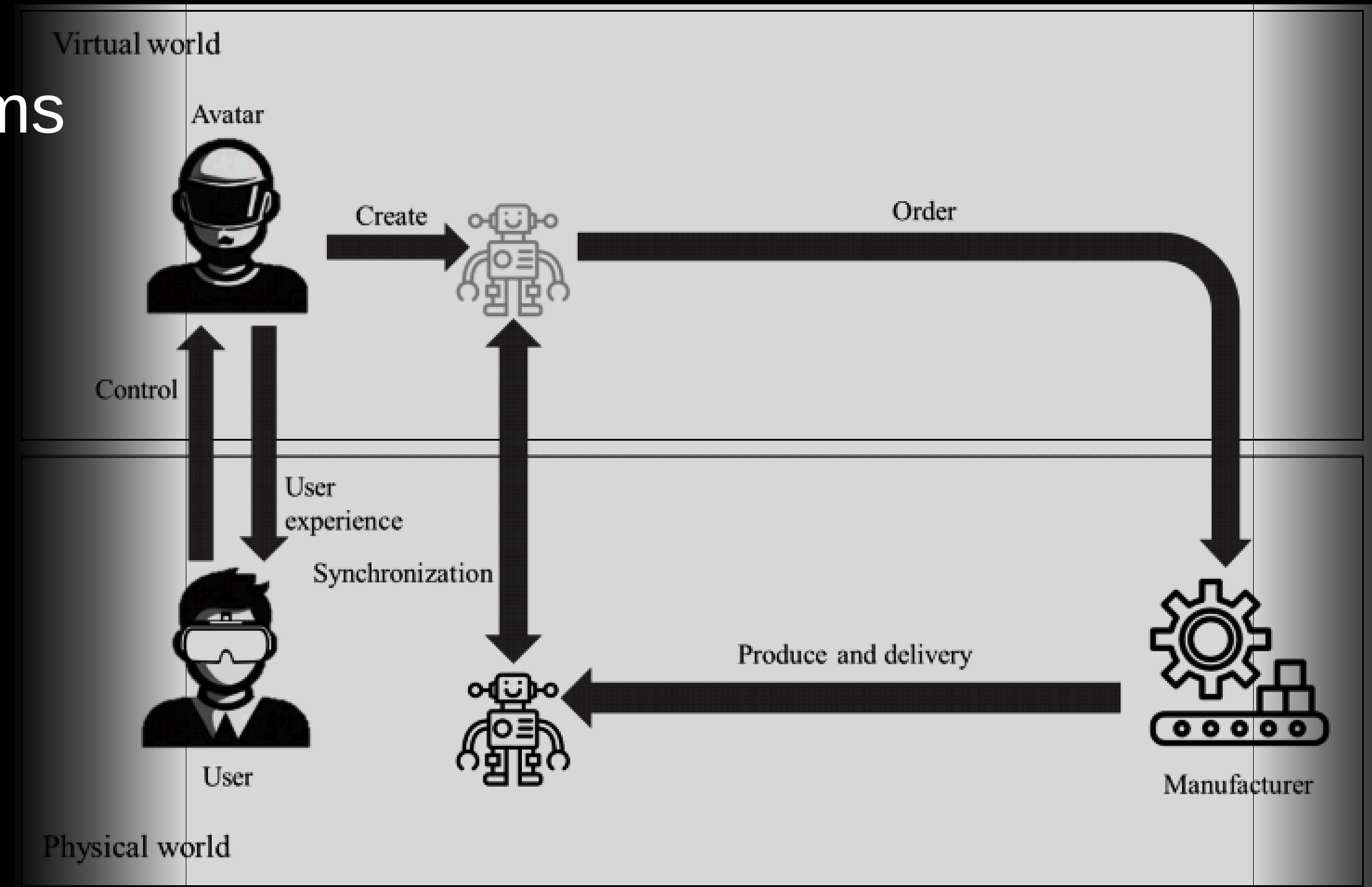
Requirements for integrating virtual and physical worlds through digital twins in the metaverse

Introduces six service scenarios and defines requirements for integrating virtual and physical worlds through digital twins in the metaverse.

Service scenario 1

Synchronizing produced items with virtual creations

A potential scenario where a user creates a virtual object in a virtual world and places an order for its production. After the product is delivered, the user synchronizes it with the virtual object in the virtual world.

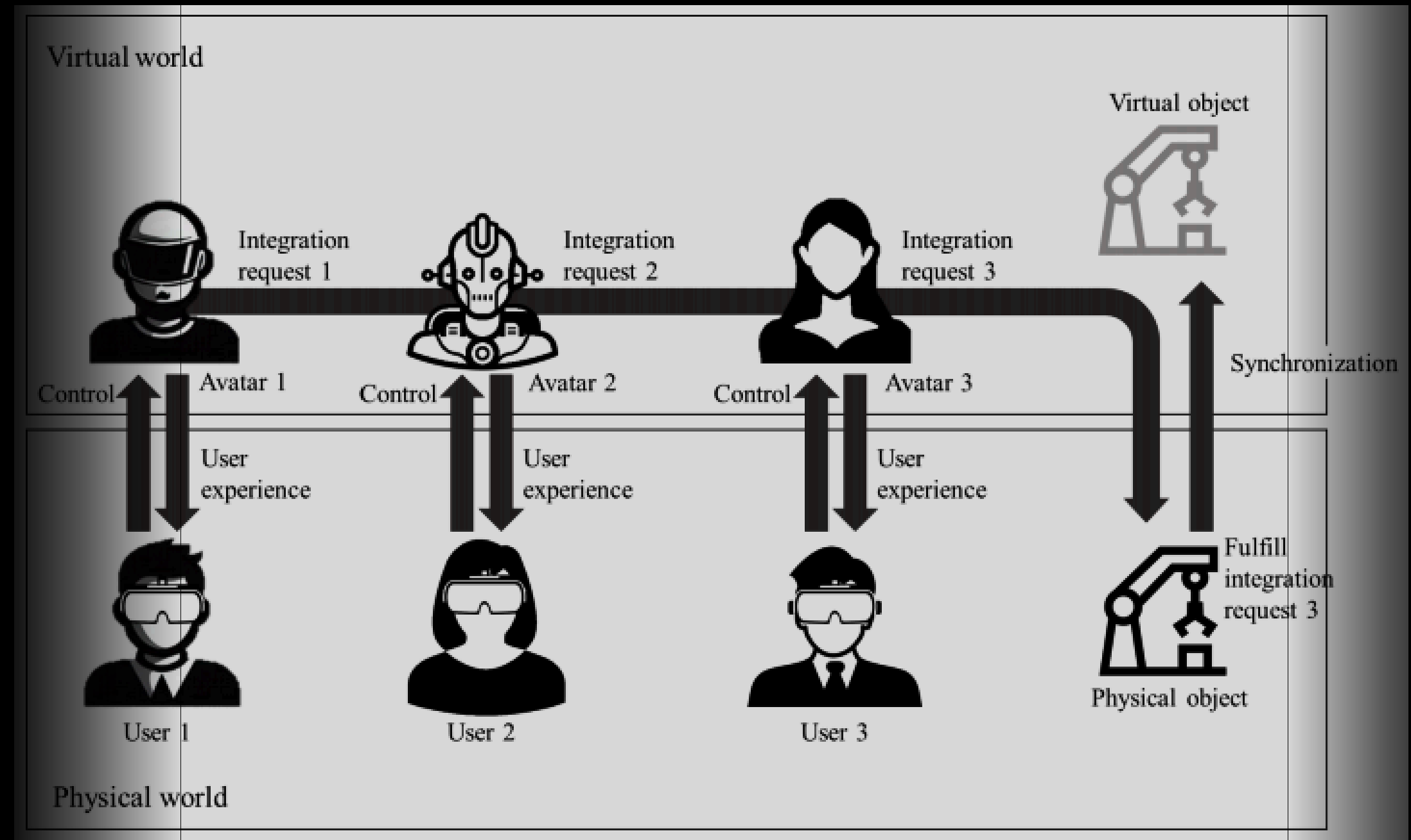


Service scenario 2

Scheduling integration process

A potential scenario where multiple users tries the integration to the same physical object.

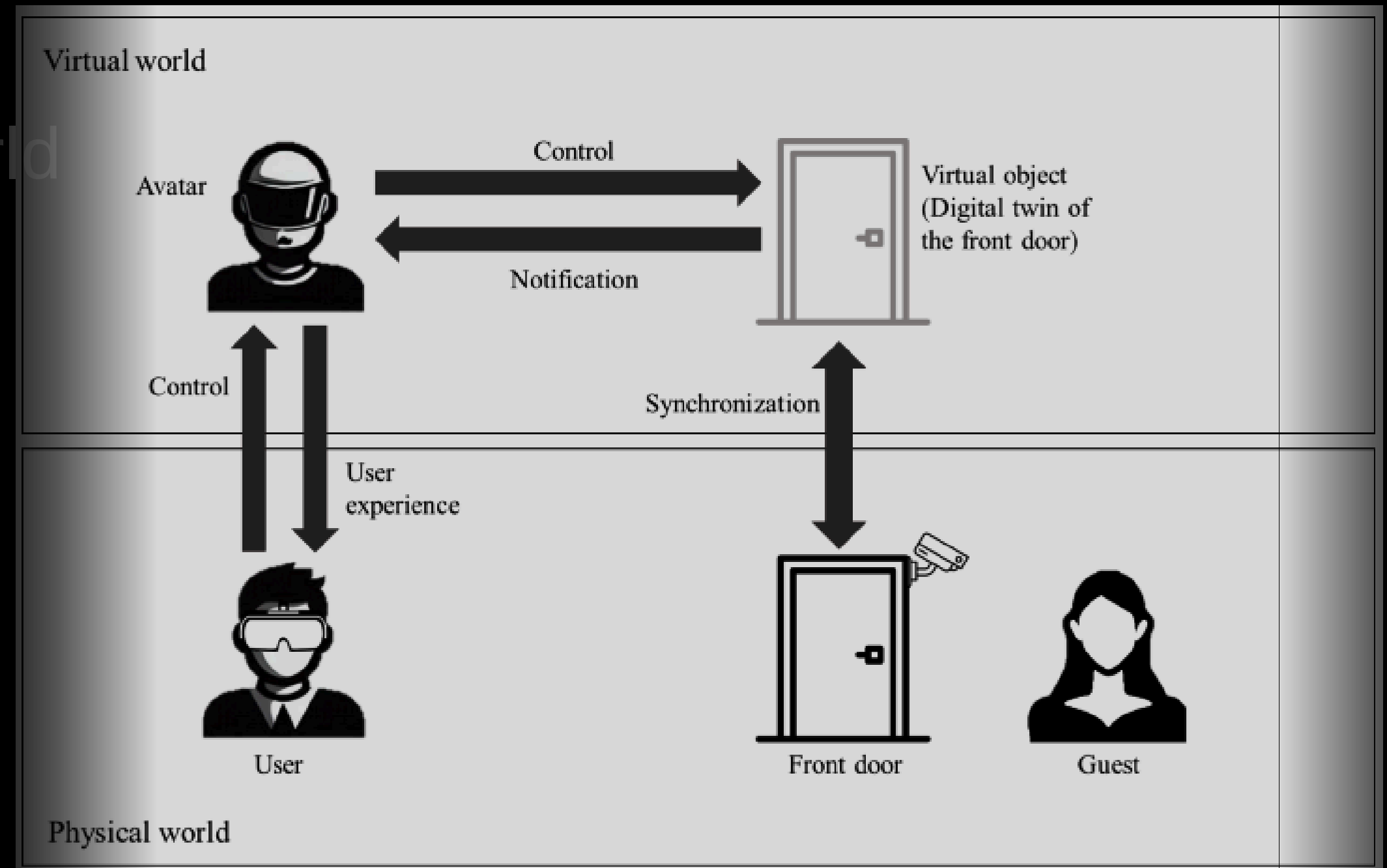
The integration of the digital twin with the same physical object in the physical world needs to be scheduled as only one digital twin can be integrated once at a time.



Service scenario 3

Notifying a guest in a physical world to a virtual world

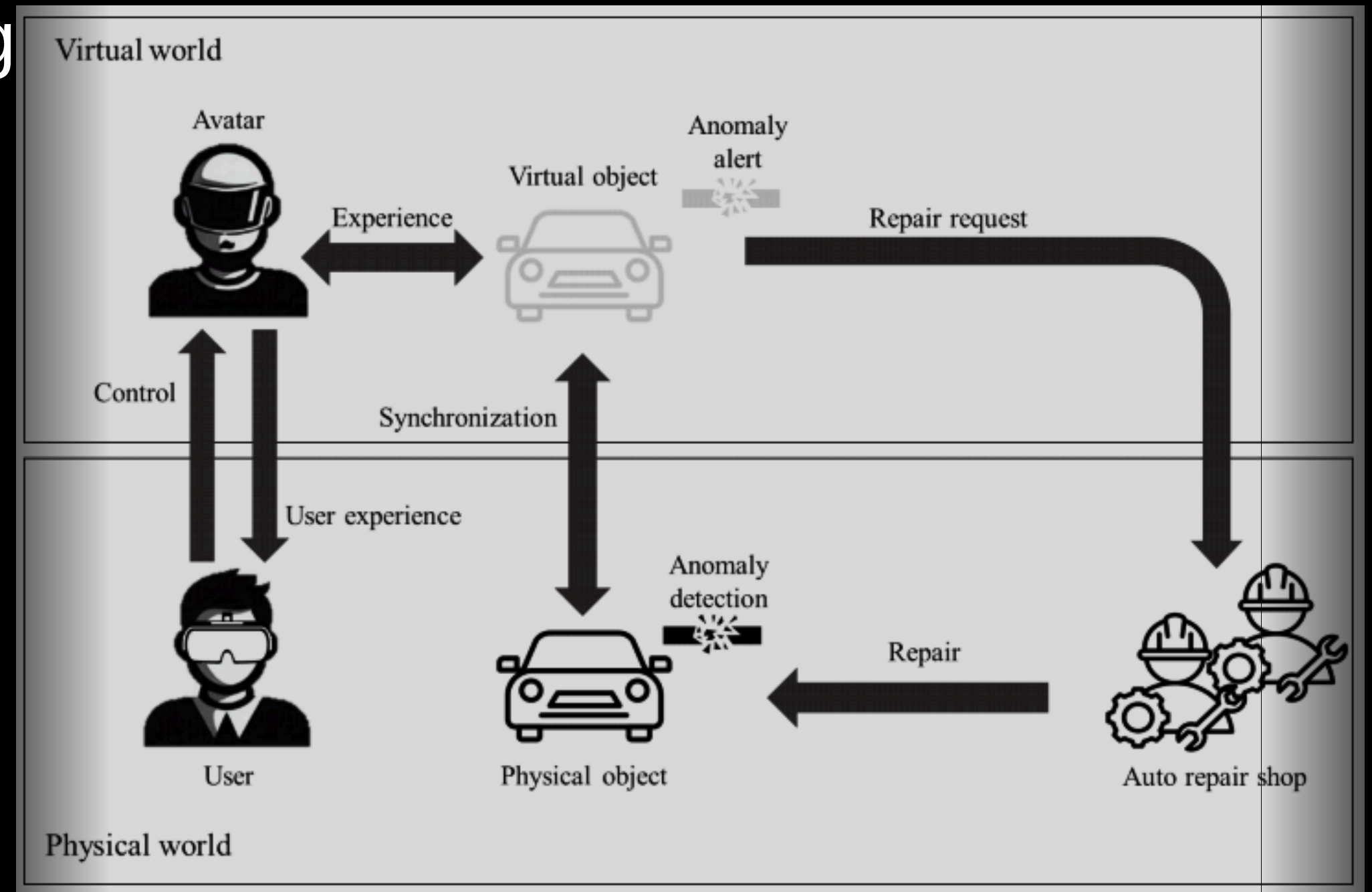
A potential scenario in where a user in a virtual world is notified of a guest's arrival and can control the front door for the guest



Service scenario 4

Service integration for repairing a physical object

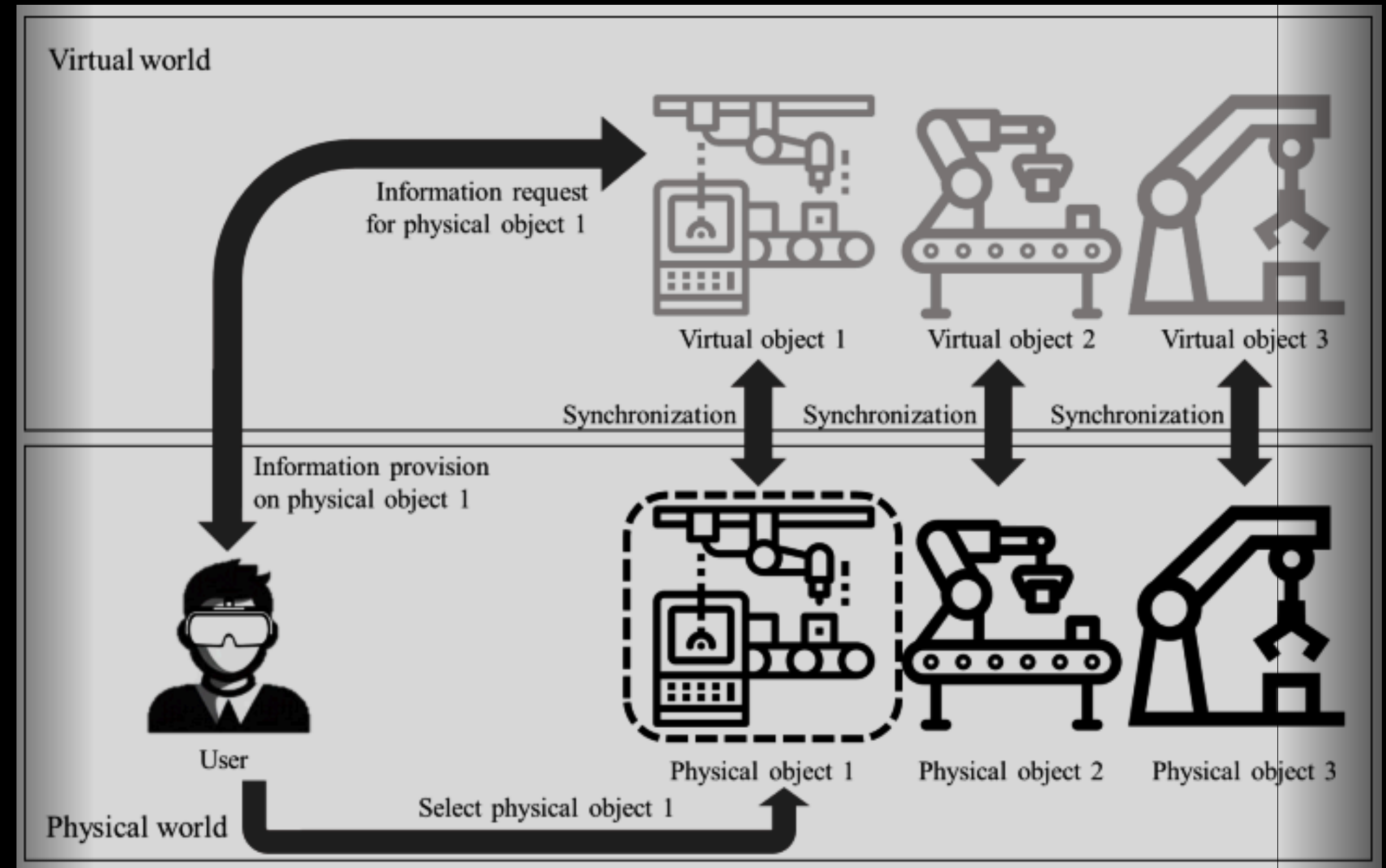
A potential scenario in which a physical object is repaired through an external service, triggered by an anomaly alert sent to virtual world for the physical object.



Service scenario 5

Additional information provision for physical objects

A potential scenario in which additional information of a specific physical object is provided, triggered by a user's selection.

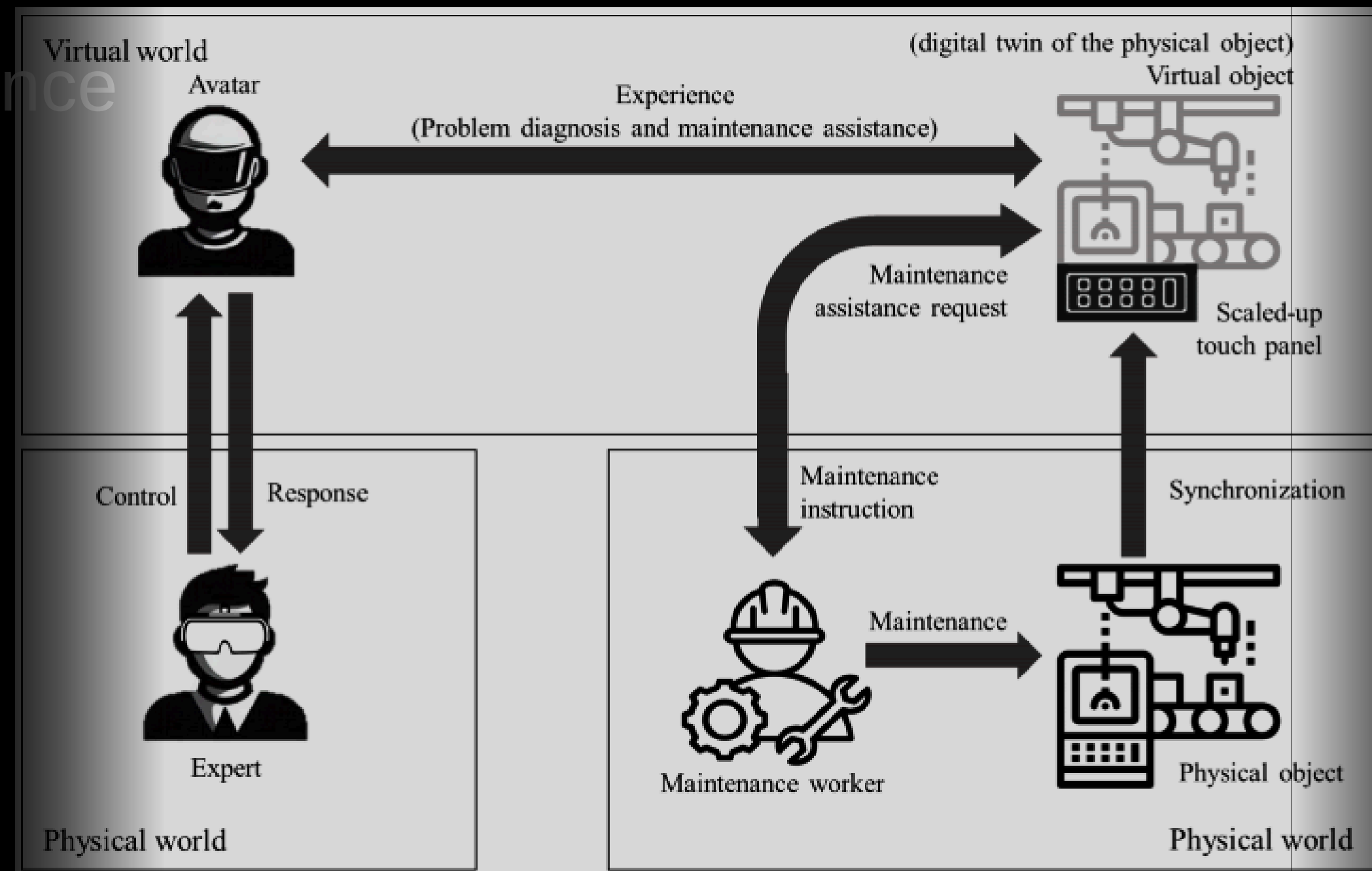


Service scenario 6

Remote maintenance assistance via virtual collaboration

A potential scenario in which a remotely located expert collaborates with a maintenance worker who is physically present beside complex industrial equipment.

The collaboration takes place through a virtual world to support effective and efficient maintenance activities. A virtual object representing the equipment, synchronized through a digital twin system, enables the expert to guide the maintenance worker in real time through virtual interactions.



Requirements related to digital twins

- REQ-DT-01 A digital twin is required to be uniquely identifiable within the metaverse;
- REQ-DT-02 A digital twin is required to be maintained by a digital system that can interact with the metaverse system;
- REQ-DT-03 The digital system is required to be searchable in order to use the digital twin in metaverse;
- REQ-DT-04 The digital twin system is required to support functionality for discovering digital twins to be used within the metaverse;
- REQ-DT-05 The digital twin system is required to support functionality for managing information about the access rights for each digital twin;
- REQ-DT-06 A digital twin is required to be capable of interacting with entities within the metaverse, including user avatars and other digital twins;
- REQ-DT-07 A digital twin is required to be capable of synchronizing with its corresponding physical object in the physical world, either periodically or upon user request;
- REQ-DT-08 A digital twin used within the metaverse is recommended to synchronize with its corresponding physical object based on user priority;
- REQ-DT-09 A digital twin is required to include metadata enabling intentional adjustments of its geometrical and structural models for enhanced visibility, accessibility, and interaction within the metaverse environment.

Requirements related to digital twins

- REQ-DT-10 The digital twin system is required to provide metadata to the metaverse system for intentional adjustments of digital twin representations;
- REQ-DT-11 If the metaverse system adjusts digital twin representations for better visualization or interaction, it is recommended to have the capability to communicate these adjustments back to the digital twin system when necessary.

Requirements related to virtual worlds

- REQ-MV-01 The virtual world is required to be capable of providing information about the digital twins that users request;
- REQ-MV-02 A metaverse system is required to construct and manage the virtual world;
- REQ-MV-03 The metaverse system is required to support interaction with the digital twin system that maintains the digital twins selected by users via their devices;
- REQ-MV-04 The metaverse system is required to support interaction with the digital twin system to enable the registration of virtual objects created by users via their devices as digital twins;
- REQ-MV-05 The virtual world is required to be capable of providing users with experiences of using digital twins they have selected;
- REQ-MV-06 The metaverse system is required to support interaction with the digital twin system to synchronize virtual objects with their corresponding physical objects;
- REQ-MV-07 The virtual world is recommended to be capable of providing information about third-party services that users can access within the virtual world;
- REQ-MV-08 The virtual world is recommended to be capable of providing services offered by third-party service provider selected by users;

Requirements related to virtual worlds

- REQ-MV-09 The metaverse system is recommended to support interaction with thirdparty service systems that offer services selected by users;
- REQ-MV-10 The metaverse system is required to support utilization and manipulation of adjustment metadata to dynamically render digital twins, enabling intentional modifications to their geometric and structural models.

Requirements related to interaction interfaces

- REQ-SI-01 An interaction interface is required to be provided between the digital system and the metaverse system;
- REQ-SI-02 An interaction interface is recommended to be provided between the digital twin system and third-party system;
- REQ-SI-03 An interaction interface is recommended to be provided between the metaverse system and third-party system.

Recommendation

ITU-T Y.4239 (11/2025)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet of things and smart cities and communities – Requirements and use cases

Reference model for integrating virtual and physical worlds through digital twins in the metaverse

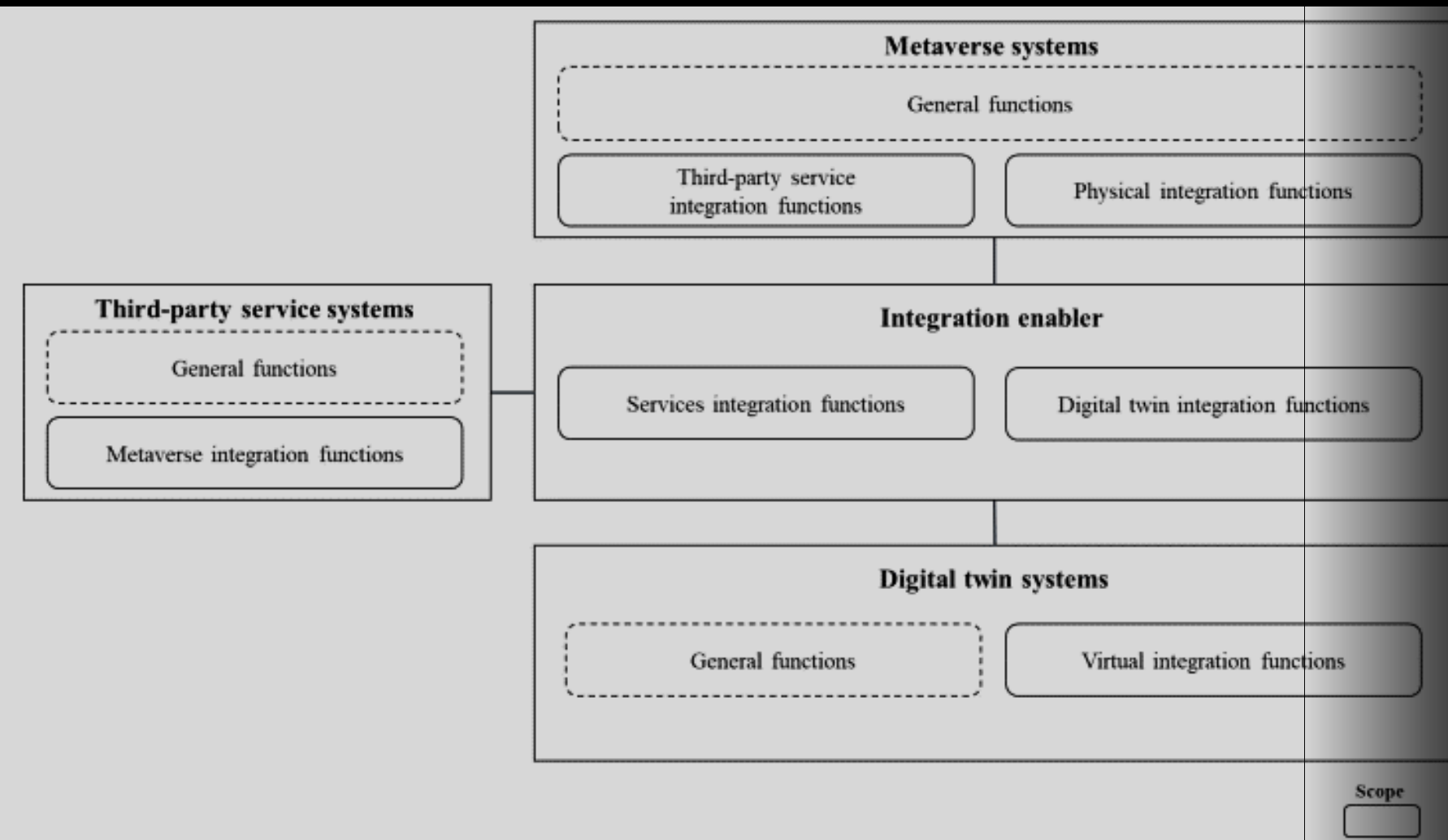
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Reference model for integrating virtual and physical worlds through digital twins in the metaverse

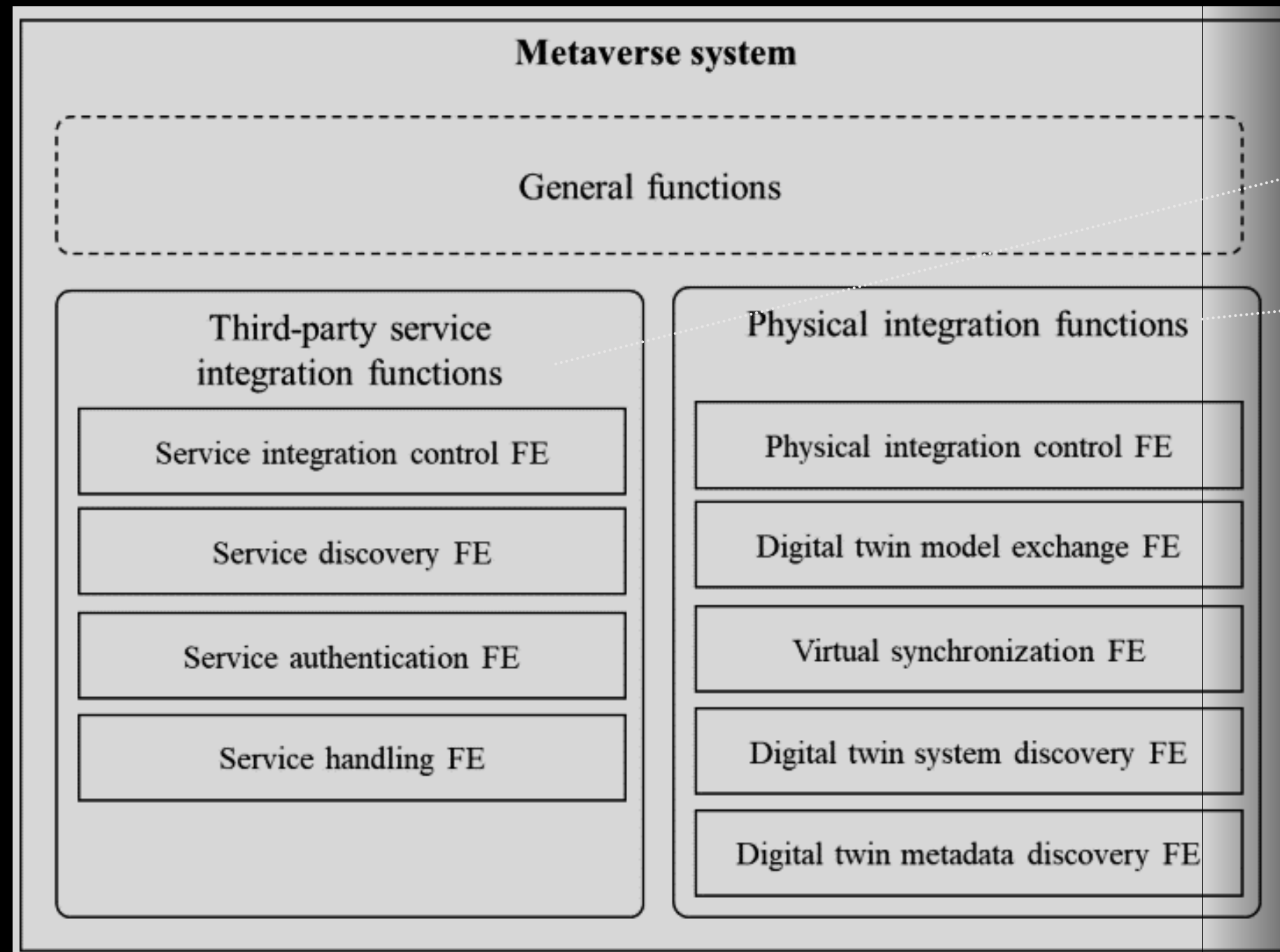
Defines a reference model including an essential component called the integration enabler

Reference model for integrating virtual and physical worlds through digital twins in the metaverse



This reference model defines the integration enabler to facilitate seamless integration among third party service systems, digital twin systems and metaverse systems, enabling integration between the virtual and physical worlds. The integration enabler serves as a core management framework that facilitates the seamless integration of digital twin systems, third-party service systems, and metaverse systems.

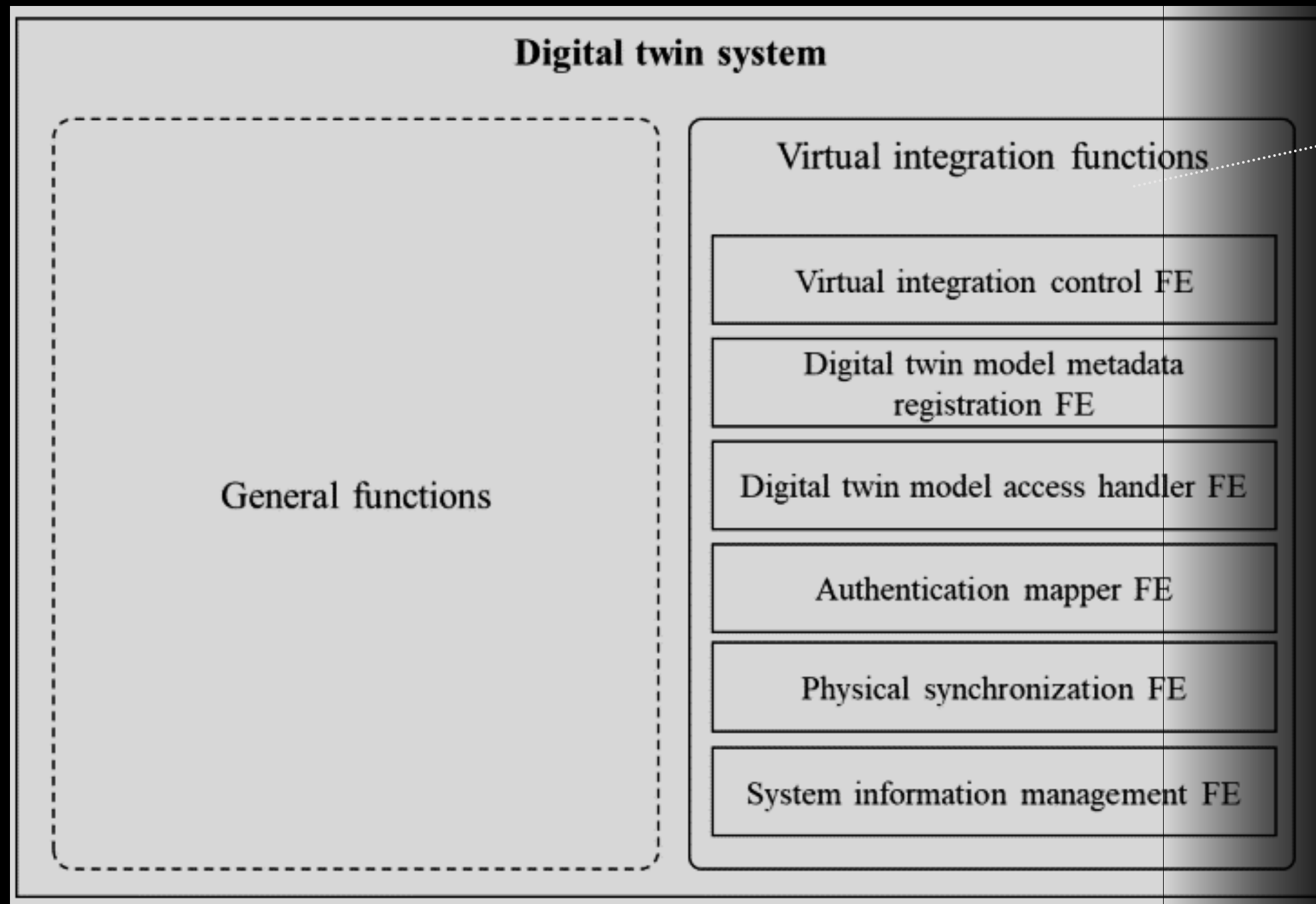
Functions of metaverse system



The third-party service integration functions (TSIF) supports integration with the third-party service system.

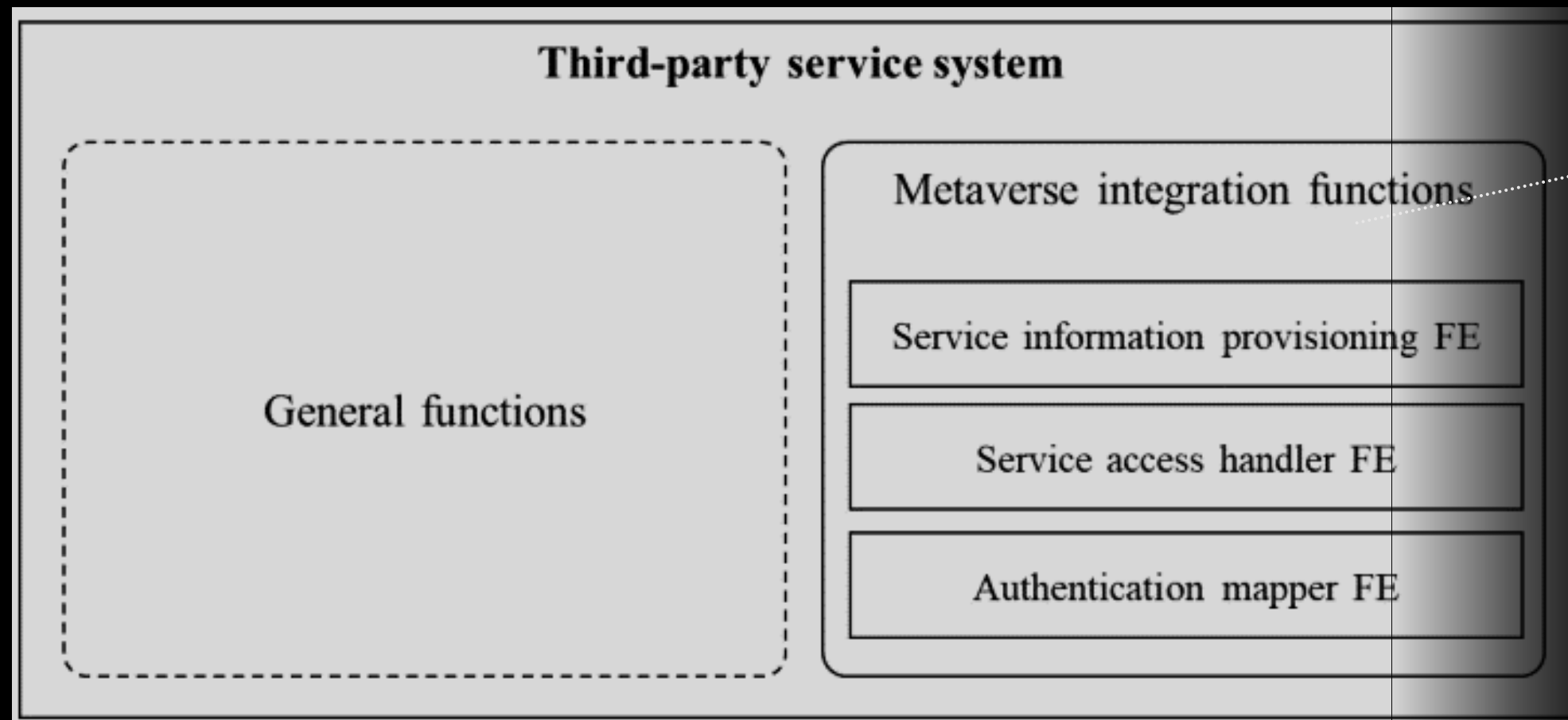
The physical integration functions (PIF) supports integration with the digital twin system

Functions of digital twin system



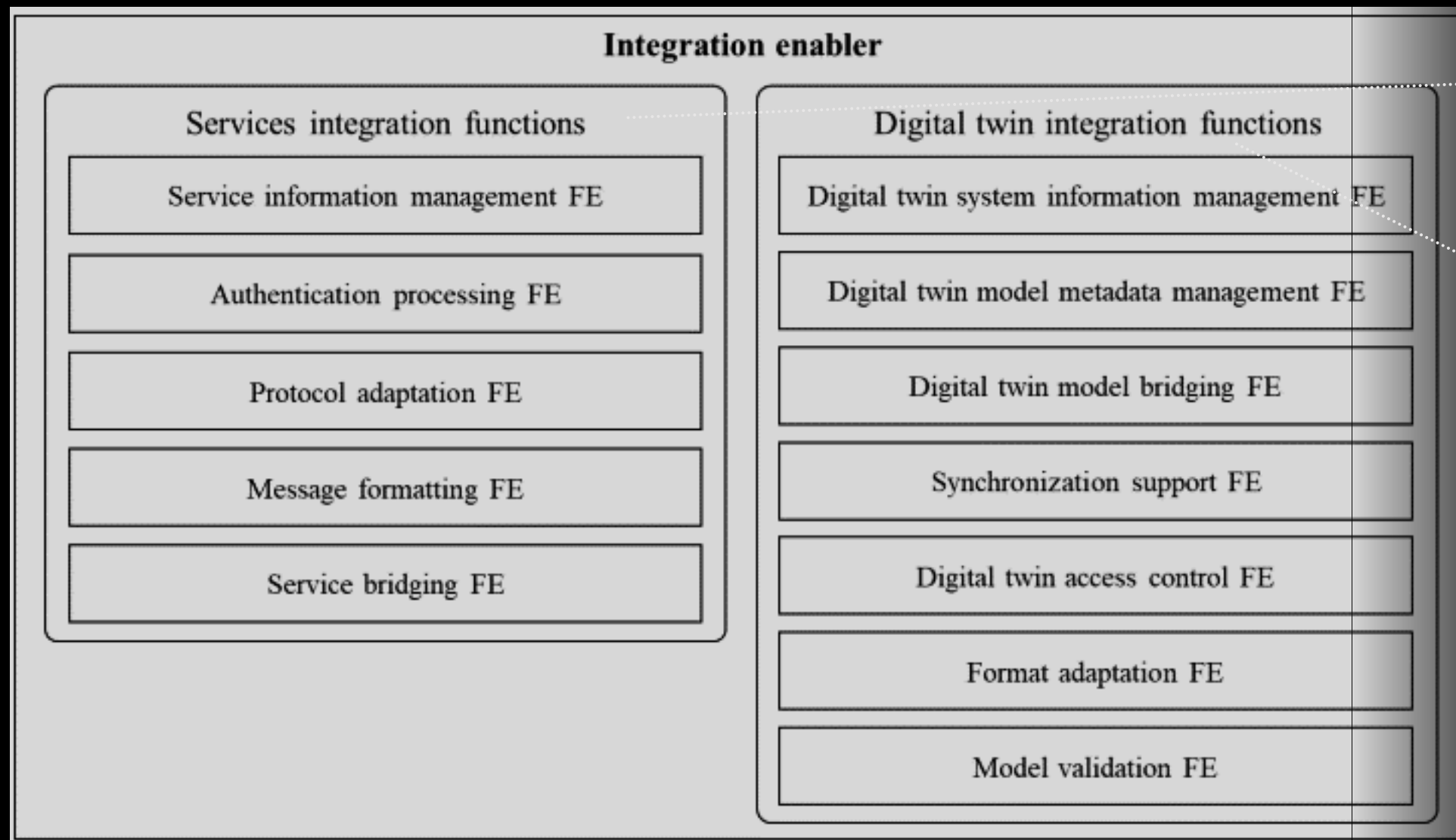
The virtual integration functions (VIF) supports integration with the metaverse system.

Functions of third-party service system



The metaverse integration functions (MIF) supports service integration with the metaverse system.

Functional entities of integration enabler



The services integration functions (SIF) supports integration between the metaverse system and the third-party service system.

The digital twin integration functions (DTIF) supports integration between the metaverse system and the digital twin system.

Recommendation

ITU-T Y.4240 (11/2025)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Internet of things and smart cities and communities – Requirements and use cases

Interoperability for integrating virtual and physical worlds through digital twins in the metaverse

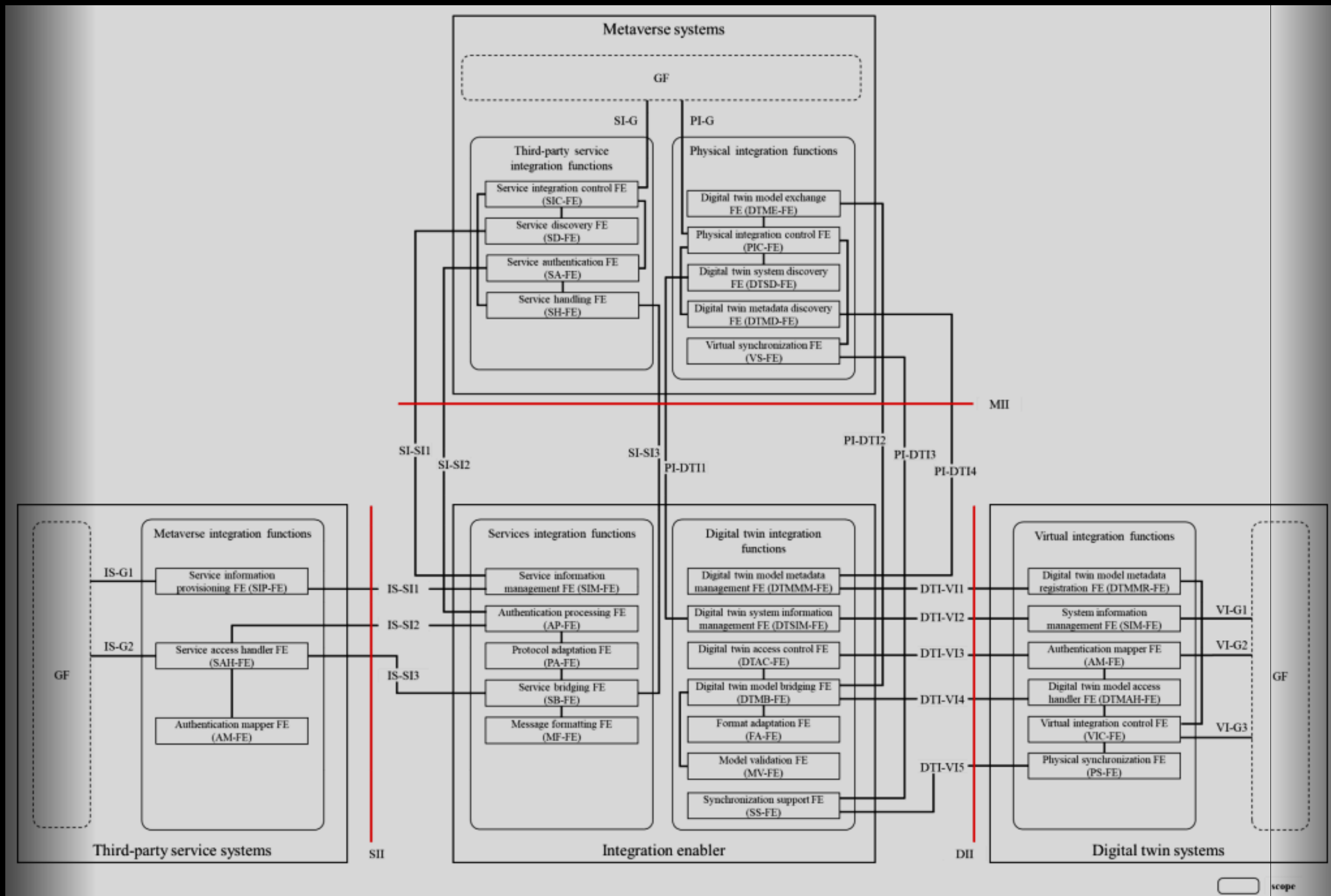
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Interoperability for integrating virtual and physical worlds through digital twins in the metaverse

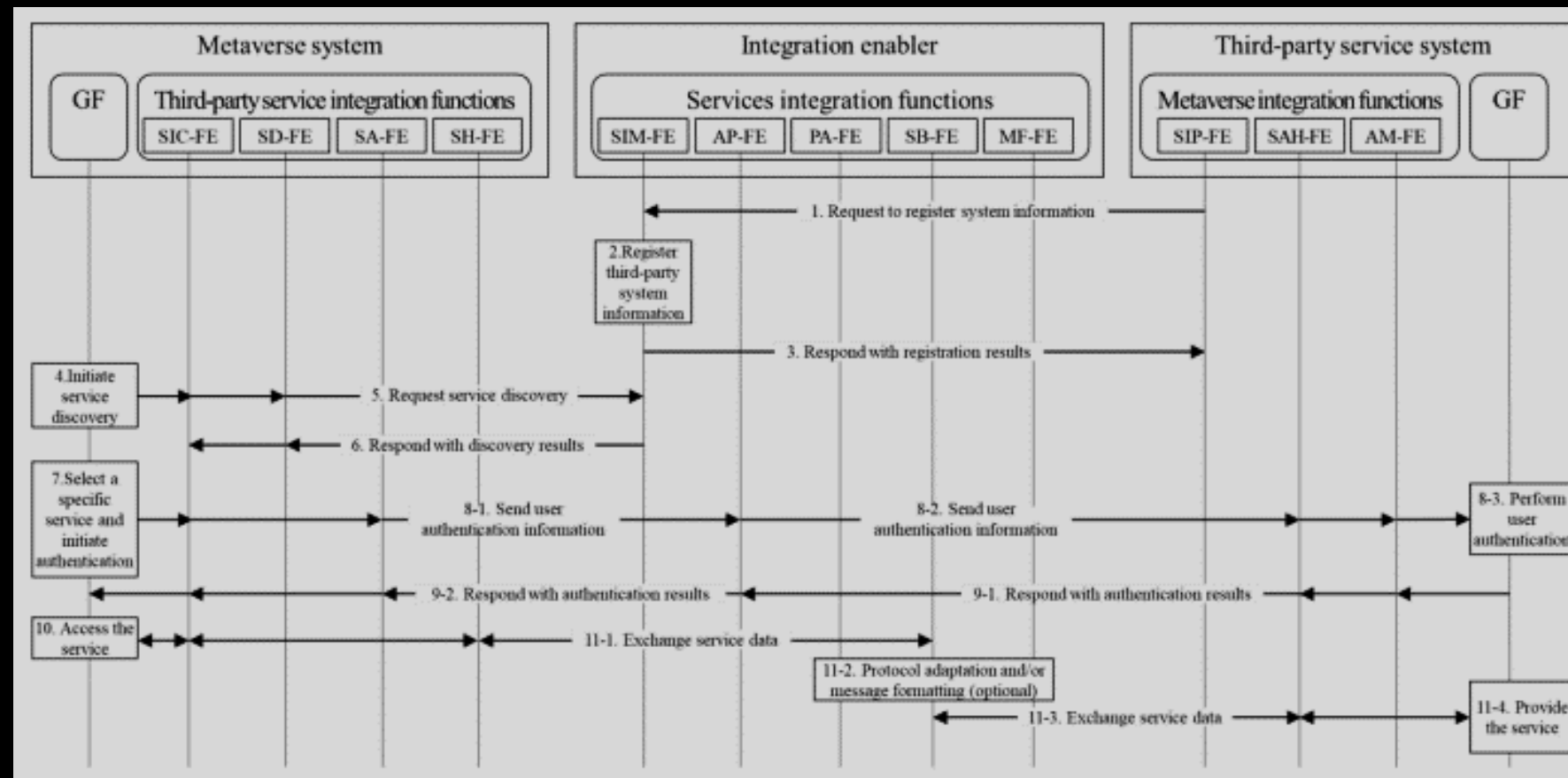
Defines three foundational interfaces and their specific reference points for integrating virtual and physical worlds through digital twins in the metaverse

Reference architecture including interfaces and reference points

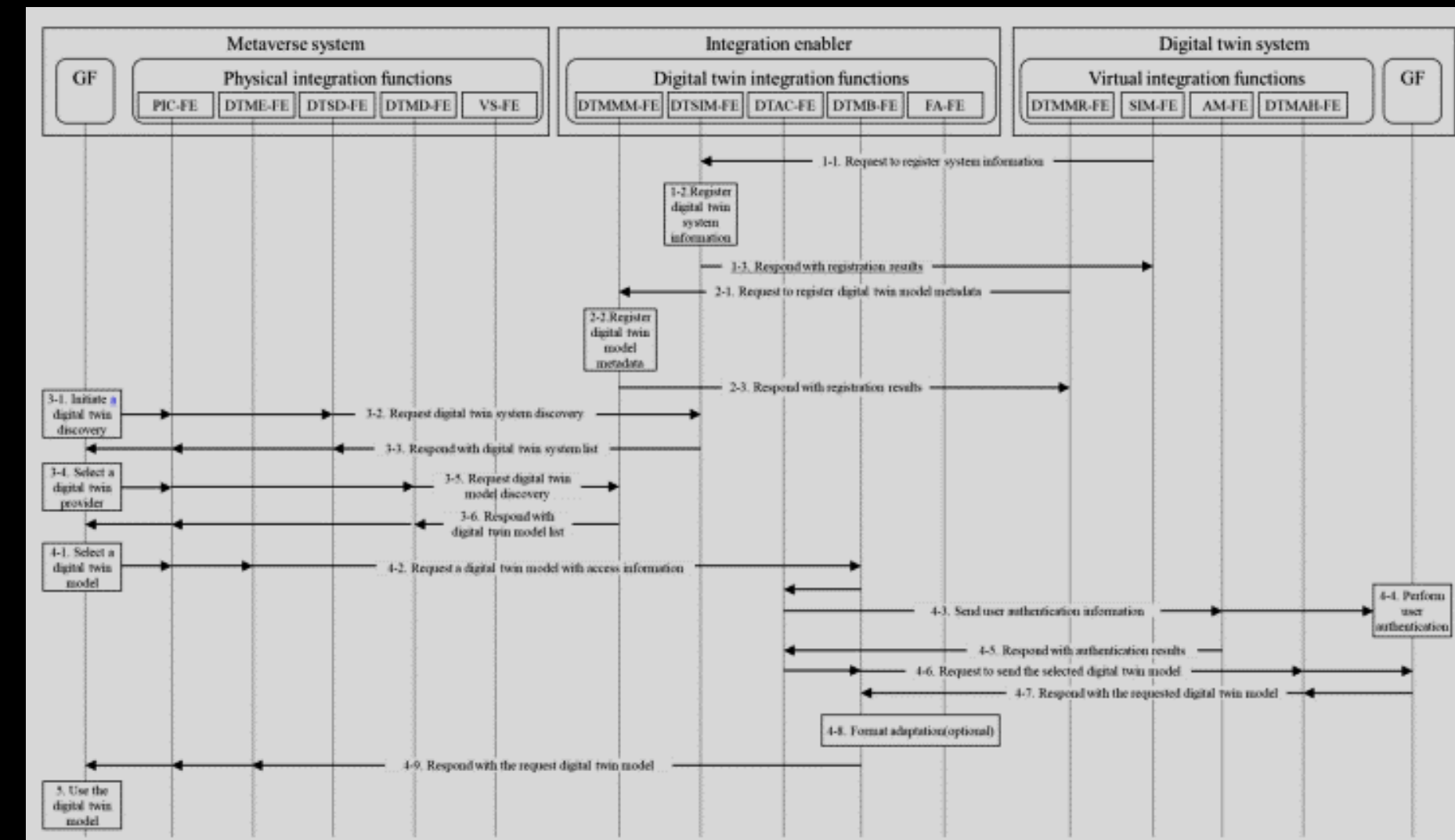


Operational procedures

Integrating third-party services



Integrating digital twins into the metaverse



**Collaborate together for a brighter
future**

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