STF 628: Digital Twin Modelling, Interoperability and Standardization Opportunities

oneM2M Meeting

November 2023

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ETSI STF – 628 – What we do

STF 628, financed entirely by ETSI, has been tasked to cover the missing key elements of modelling and making uniform the communication concept IoT Digital Twins and their blueprint communication reference architecture

- Identify use cases and deployments where IoT Digital Twins can be effectively adopted in order to identify all the requirements and specifications associated to the definition of their functionalities and specifications
- Derive requirements and guidelines towards a horizontal cross-domain interoperability and standard, with the specification of minimum requirements for usability of professional and general public IoT services
- Based on these use cases, requirements and guidelines, map IoT Digital Twins within the oneM2M framework
- Contribute to ISO/JTC1/SC41 through the definition of a set of new specifications in order to both embrace new functionalities and to effectively exploit the existing features (e.g., discoverability, security, modularity, etc …)

ETSI STF – 628 – What we do (Some details)

- Identify use cases and deployments where **IoT Digital Twins** can be effectively adopted in order to identify all the **requirements** and specifications associated to the definition of their **functionalities** and **specifications**
- Derive requirements and guidelines towards a horizontal **cross-domain interoperability and standard**, with the specification of minimum requirements for usability of professional and general **public IoT services**
- Based on these use cases, requirements and guidelines, **map IoT Digital Twins within the oneM2M framework**
- **Contribute to ISO/JTC1/SC41** through the definition of a set of new specifications in order to both embrace new functionalities and to effectively exploit the existing features (e.g., discoverability, security, modularity, etc …)

ETSI STF – 628 – Why we do it

- ETSI has determined that:
  - There is the concrete need to support a **cross-domain and cross-vendor DT interoperability** in order to **avoid closed siloes solutions**. It is not reasonable to think that each country, company or service will design a new and different DT by creating a plethora of heterogeneous implementations, thus opening the way to lack of interoperability. **OneM2M** and **SAREF** already provide a **good basis** for that, but the **peculiarity of DT requires specific additional work** to complete the interoperability framework offered by standardization.
  - Nevertheless, **DTs interoperability potential is still underexplored** and represents a relevant opportunity to design a new and shared approach aiming to achieve the **seamless integration of data and services in heterogeneous IoT edge deployments**. Through a last-mile DT digitalization it will be possible to handle physical heterogeneity as close as possible to the devices and to simplify the interaction and cooperation with upper layers

ETSI STF – 628 – Goals

- The technical work is developed in 2 technical tasks, covering:
  - Analysis, Use Cases and Requirements for Digital Twins in IoT
  - Standardization of functionalities, communication reference architecture and guidelines for Digital Twins
- These tasks will provide a general solution as Digital Twins reference architecture. The **instantiation** of such general solution in the **oneM2M context is also included**. So that these tasks also include the preparation of the technical solution to be exported in oneM2M.
- A third task covers the **dissemination** towards oneM2M and other associations/fora representing potential stakeholders of the proposed standard.

ETSI STF – 628 – Timeframe

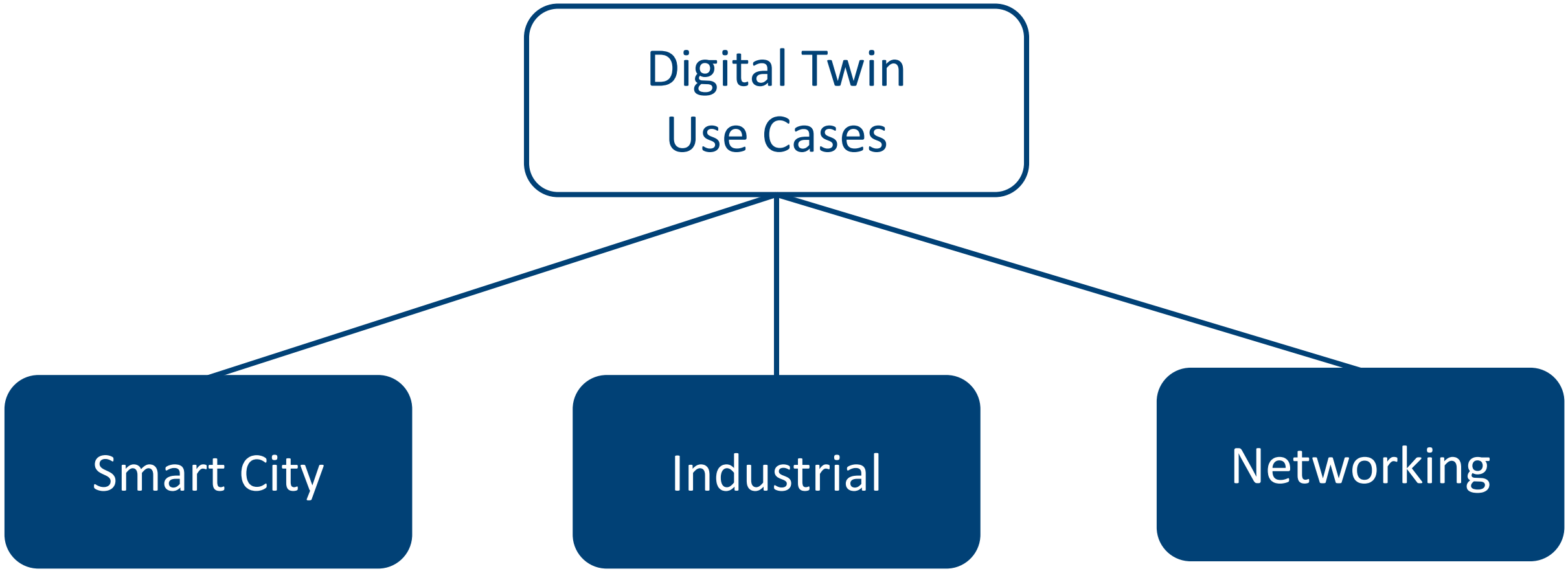
- Work Started on **01/02/2023**
- 7 Milestones defined
- Work completion scheduled for **31/07/2024**
- Currently Two milestones achieved and mai documents are at the following stage:
    - D1 – Final Draft
    - D2 – Stable Draft
    - D3 – Early Draft

D1 – Digital Twins and Standardization Opportunities in ETSI Final Draft

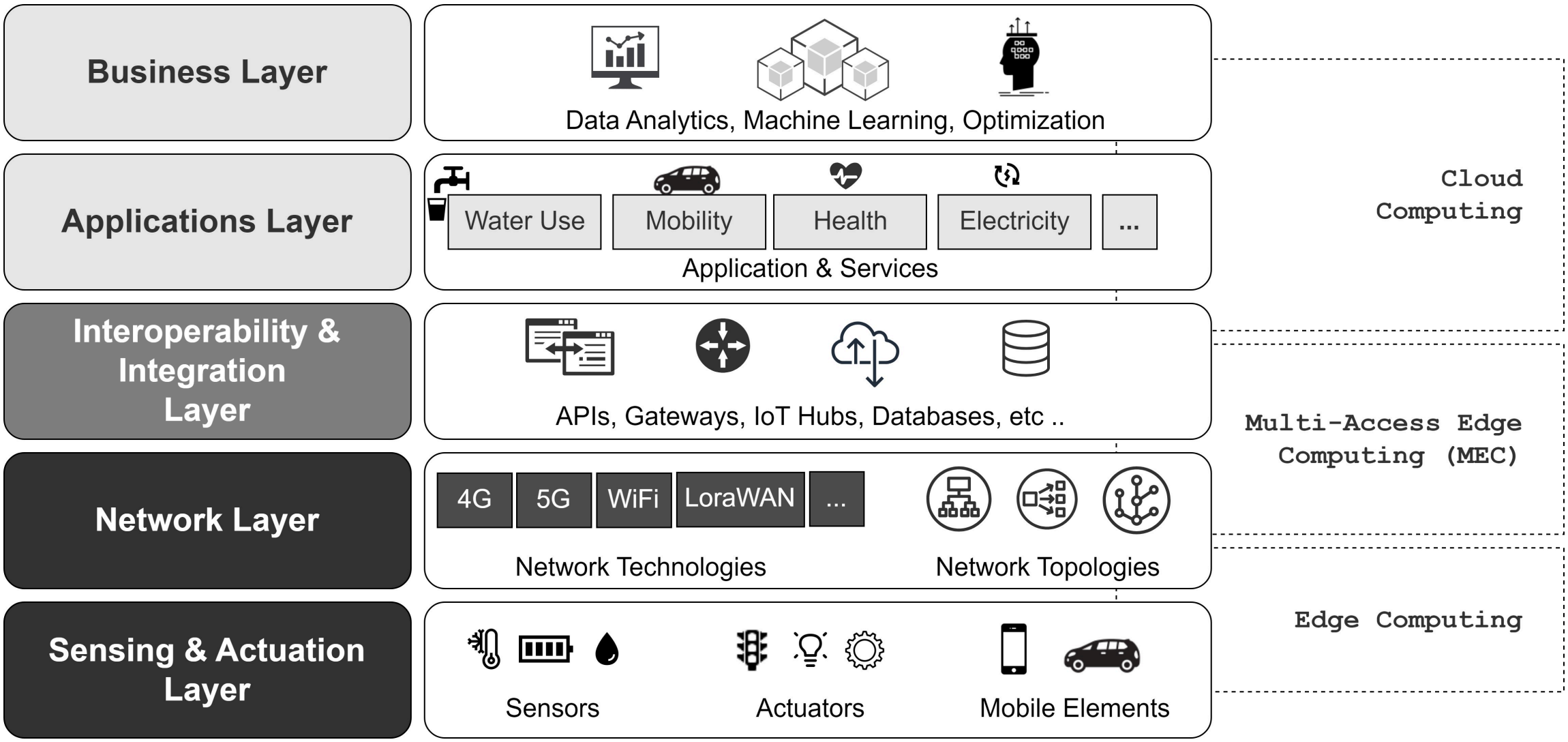
The purpose of the present document is to show in a structured and comprehensive way the main requirements for the definition of interoperable and standardized Digital Twins within the context of challenging cyber-physical use cases and application scenarios. The main objectives can be summarized as follows:

- Analysis the major requirements and challenges of cyber-physical systems and the identified use cases
- Analysis of the main requirements, characteristics, and architecture of DTs
- Identification of DTs major functionalities and responsibilities
- Selection of the candidate communication approaches for standardization

D1 – Digital Twins and Standardization Opportunities in ETSI Final Draft



D1 – Smart City Use Case



D1 – Smart City Use Case – Characteristics & Requirements

- Several actors, services, and stakeholders involved, including as the most important:
  - City government
  - Service providers
  - Citizens & People
  - Private sector
- The main services involved in a Smart City use case can vary depending on the specific application scenario, but may include as challenging and reference ones:
  - Mobility services
  - Energy management services
  - Environmental services
  - Public safety and security services
  - Citizen engagement services
- Main Identified Requirements are:
  - Interoperability
  - Data management
  - Abstraction
  - Security
  - Scalability
  - Resilience
  - Real-time responsiveness
  - Edge-Cloud Continuum
  - Standardization
  - Human-centric design
  - Sustainability

D1 – Smart City Use Case – Challenges

- To fully realize their potential, several technical challenges must be addressed.

  These challenges are directly related to Smart City requirements and includes:

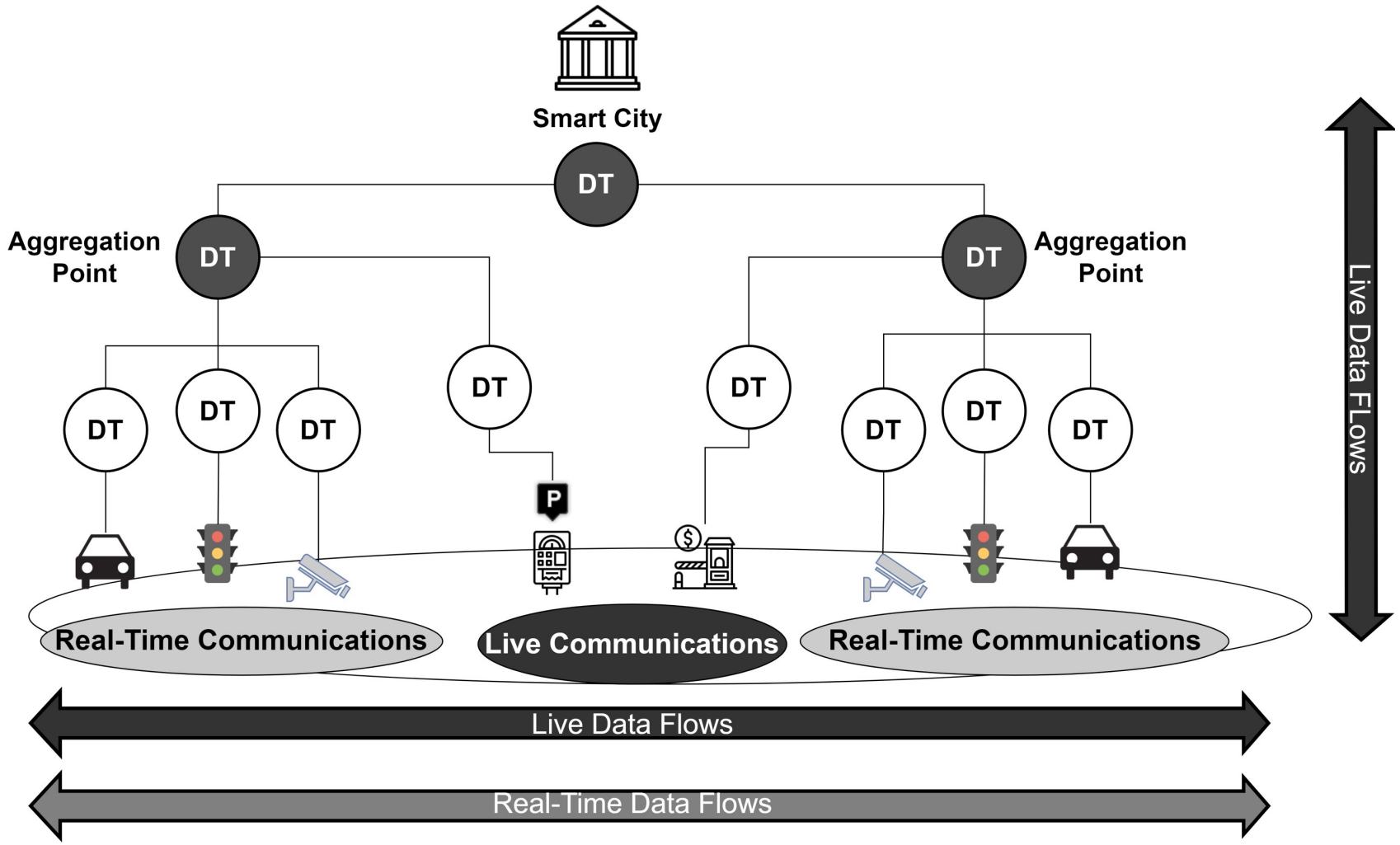
  - Fragmentation of physical devices and cross-domain integration
  - Heterogeneity of communication protocols and data formats
  - Scalability and real-time processing of big data
  - Data privacy and security
  - Multiple Abstraction Points
  - Reliability and resilience
  - Interoperability and standardization
  - Integration of edge and cloud services
  - Longevity and sustainability

D1 – Smart City Use Case & Digital Twins

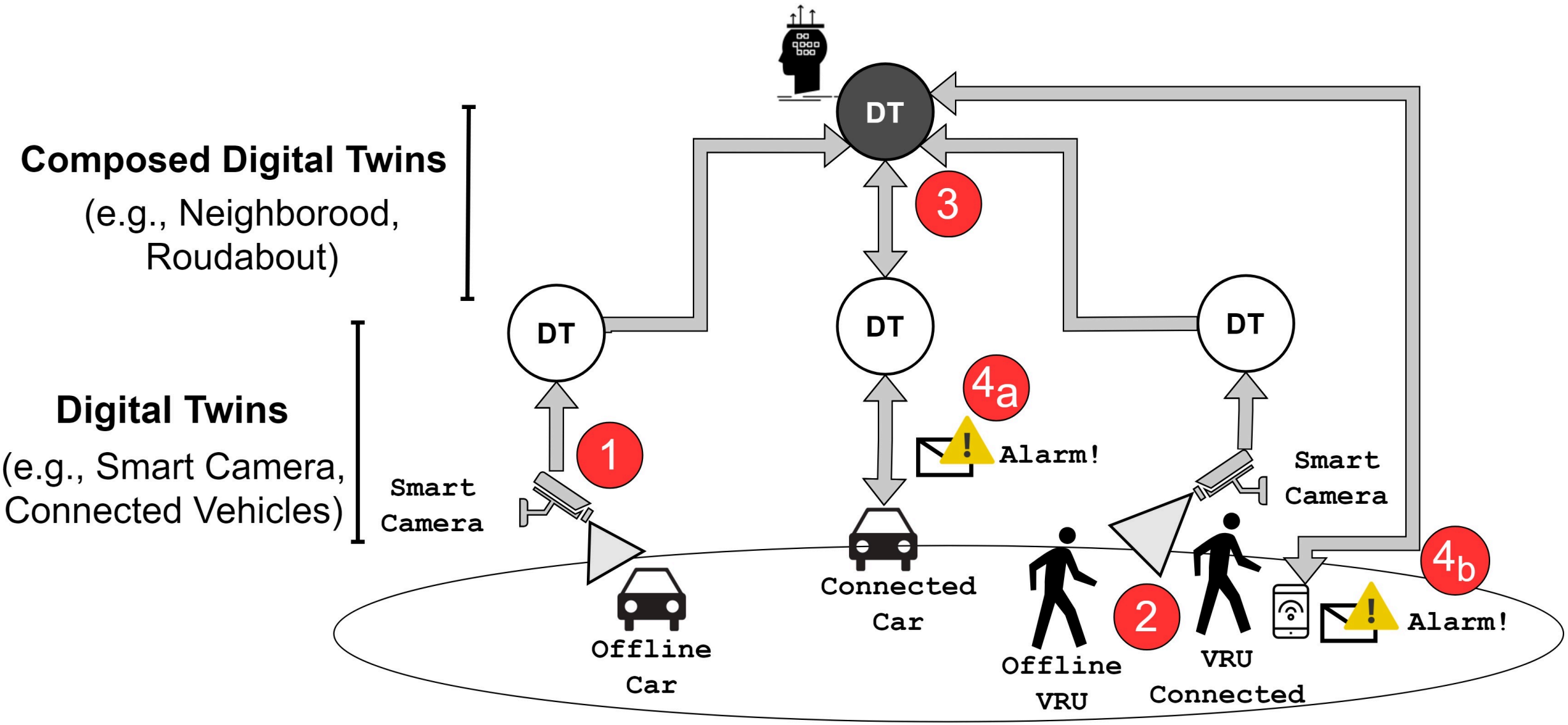
Composed Digital Twins
(Extended Awareness & Coordination)

Digital Twins
(Uniform Representation & Cyber-Physical Interactions)

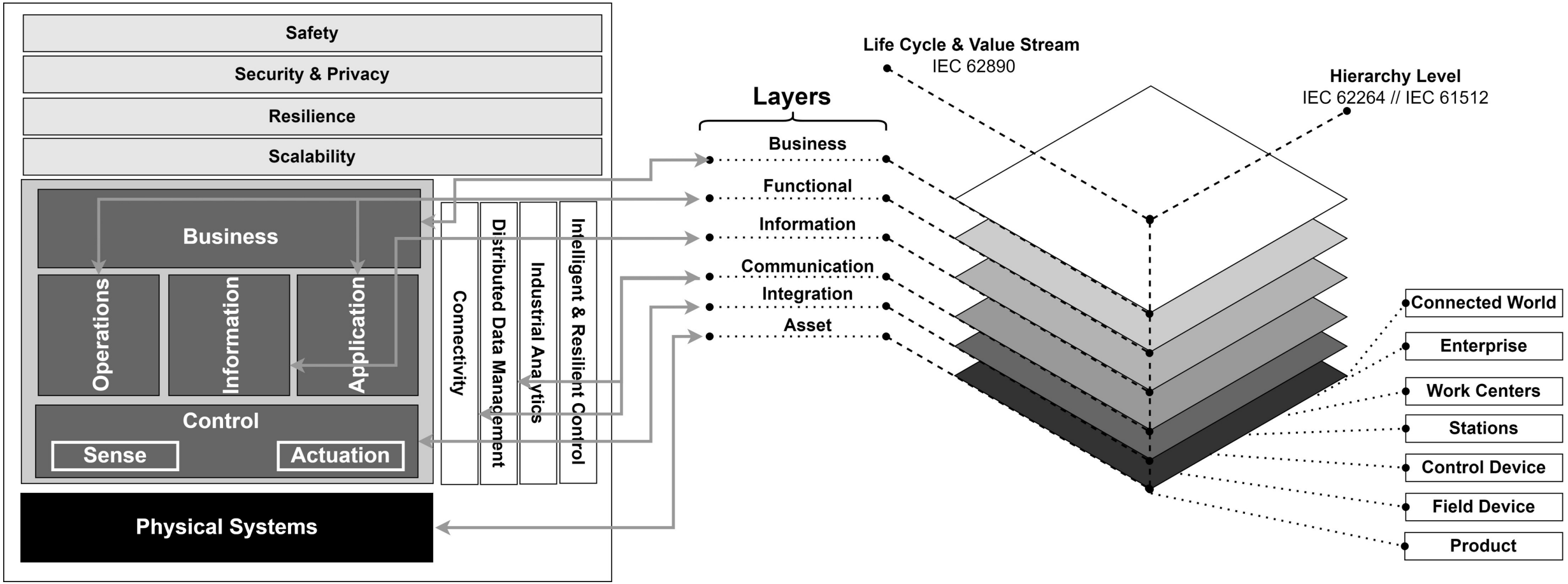
Physical Layer
(High Level of Heterogeneity with Live & Real-Time Data Flows)



D1 – Vulnerable Road Users Application Scenario



D1 – Industrial Use Case



D1 – Smart City Use Case - Characteristics & Requirements

- Various actors, services, and stakeholders involved, which can vary depending on the specific use case:
  - Physical assets and devices
  - Industrial Internet of Things (IIoT) platforms
  - Digital applications and services
  - Cloud service providers
  - System integrators
  - End-users
  - Regulators
- Some of the main services involved in an Industrial use case are:
  - Manufacturing Process Optimization
  - Predictive Maintenance
  - Supply Chain Management
  - Human-to-Machine Interaction
  - Energy Management
  - Product Lifecycle Management
- Main Identified Requirements are:
  - Interoperability
  - Real-time performance
  - Scalability
  - Security
  - Flexibility
  - Data management
  - Artificial intelligence and machine learning
  - Human-machine interaction
  - Augmenting physical capabilities
  - Multiple and hierarchical abstraction points

D1 – Industry Use Case – Challenges

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  These challenges are directly related to Industry requirements and include:

  - Security and privacy risks
  - Interoperability issues
  - Low-latency requirements
  - Complexity management
  - Hierarchical Abstraction
  - Scalability and flexibility
  - Data management and analytics
  - Human-machine interaction

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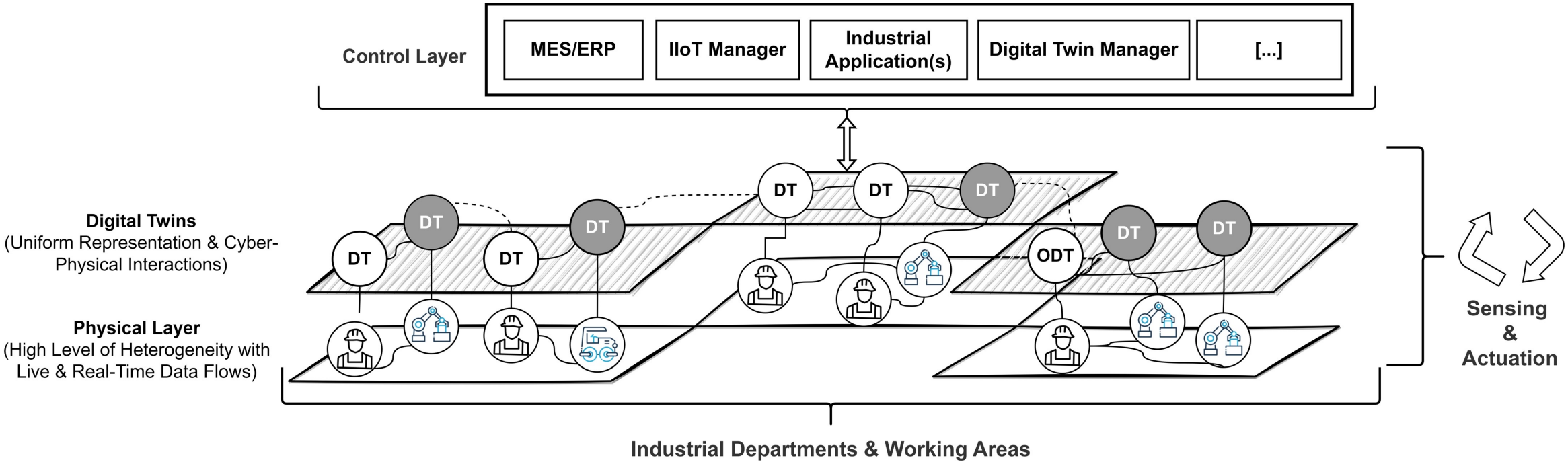
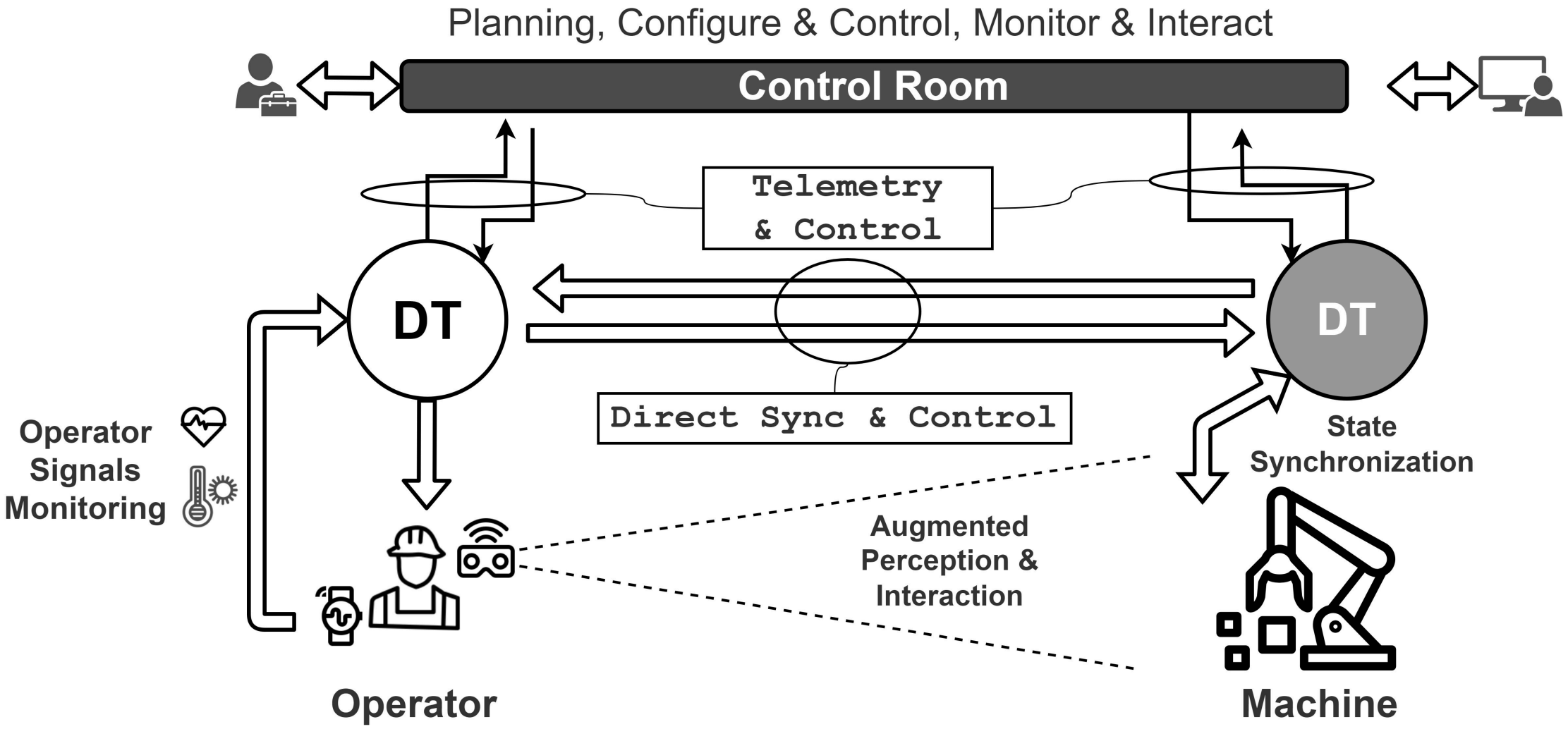
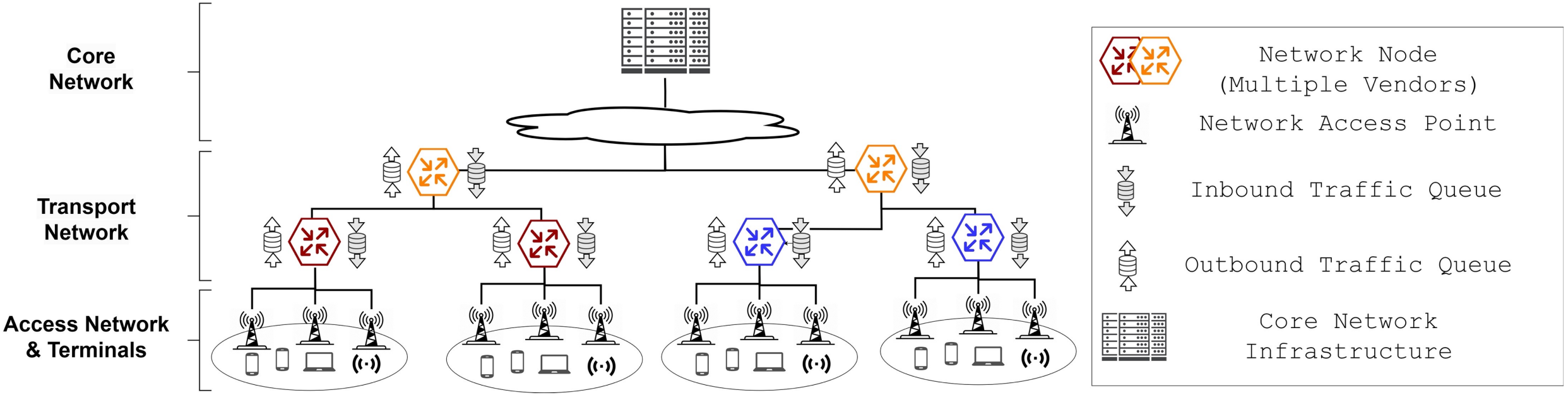


D1 – Operators & Machines Collaboration



D1 – Networking Use Case



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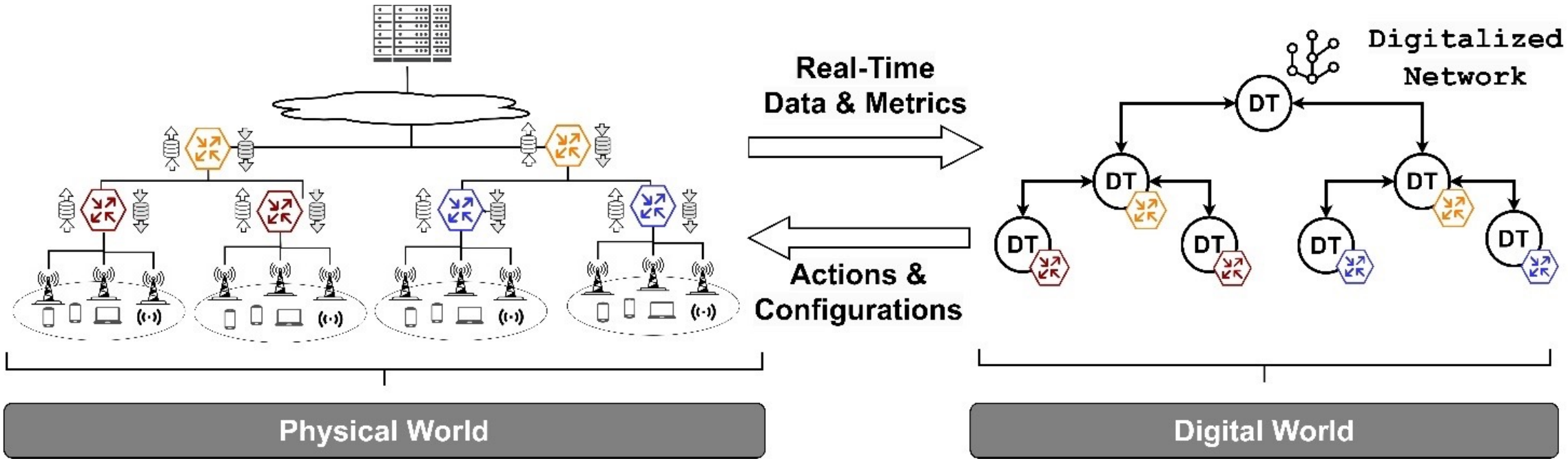

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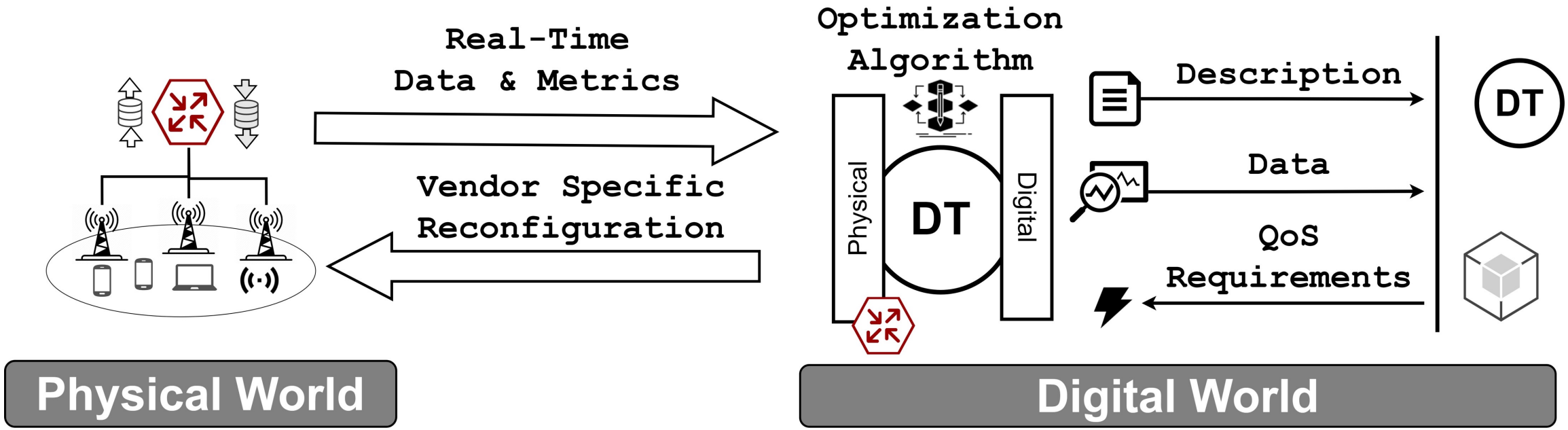


D1 – DT Standardization Opportunities

- A DT should have a **unique identifier** too in order to make it addressable into a software space and it should be clearly associated to the associated PTs (e.g., using a unique identified of the physical entity)
- DT may have both a **1-to-1 or a 1-to-N cardinality/relation** between the assets and the digital instance
- A DT should be supported by a **Model** responsible for the digitalization process and designed and implemented with a set of goals and purposes and refer to a target context in which the DT operate
- A DT is the digital replica of one or more associated PTs and its digitalization is determined on how much it is able to represents the original PTs in terms of:
    - Properties
    - Relationships
    - Events
    - Behaviours & Actions
- The DT should at least represent those properties, behaviors and relationships that are necessary and sufficient to qualify it in the target operational context (e.g., optimize energy consumption in a building)
- The State of a DT is the combination of Properties, Relationships, Events, and Behaviors associated to a **specific timestamp** when the DT's State has been computed by the DT's Model. Each DT's State should be associated to a reference timestamp identifying its computation time within DT's evolution timeline and with respect also to the evolution of the associated physical counterparts
- Since PTs come with well-defined functionalities and services that are fixed for the entire life cycle of the object, DTs can leverage the software dematerialization to modify, update, and improve its functions over time. In other words, the PT's state of can be functionally **augmented** through the integration of new Properties, Relationships, Events and Behaviours/Actions

D1 – DT Characteristics

- Some of the identified fundamental characteristics that a DT and its description (DTD – Digital Twin Description) should include are:
  - Identity and Metadata
  - State Description
    - Properties
    - Relationships
    - Events
    - Behaviours & Actions
  - DT's Physical & Digital Communication Capabilities
  - DT's Monitoring
  - Security & Privacy
  - Semantics and Contextual Information

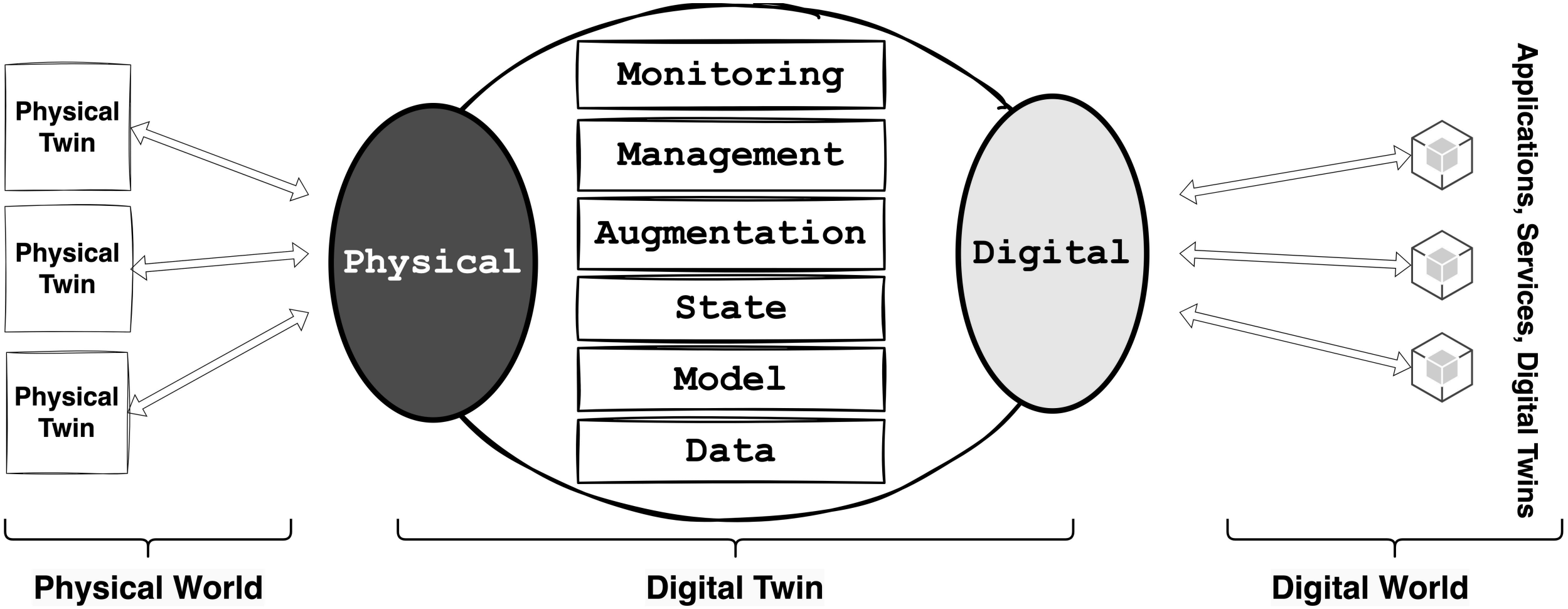
D1 – DT Capabilities & Responsibilities

- According to the recent scientific and industrial literature and the conducted analysis of the target use cases the main aspects that should be taken into account referring to DT's capabilities and responsibilities are the following:
  - Representativeness & Contextualization
  - Reflection
  - Observation & Interaction
  - Augmentation
  - Replication
  - Composition

D1 – DT Design Requirements

- Identified Design Requirements useful for DTs definition both in terms of architectures and development of a single DT instance or of an ecosystem of twins are:
  - Flexibility
  - Compatibility
  - Scalability
  - Interoperability
  - Discoverability
  - Accountability & Manageability
  - Cross-Domain Interactions

D1 – DT Abstraction, Interoperability & Communications



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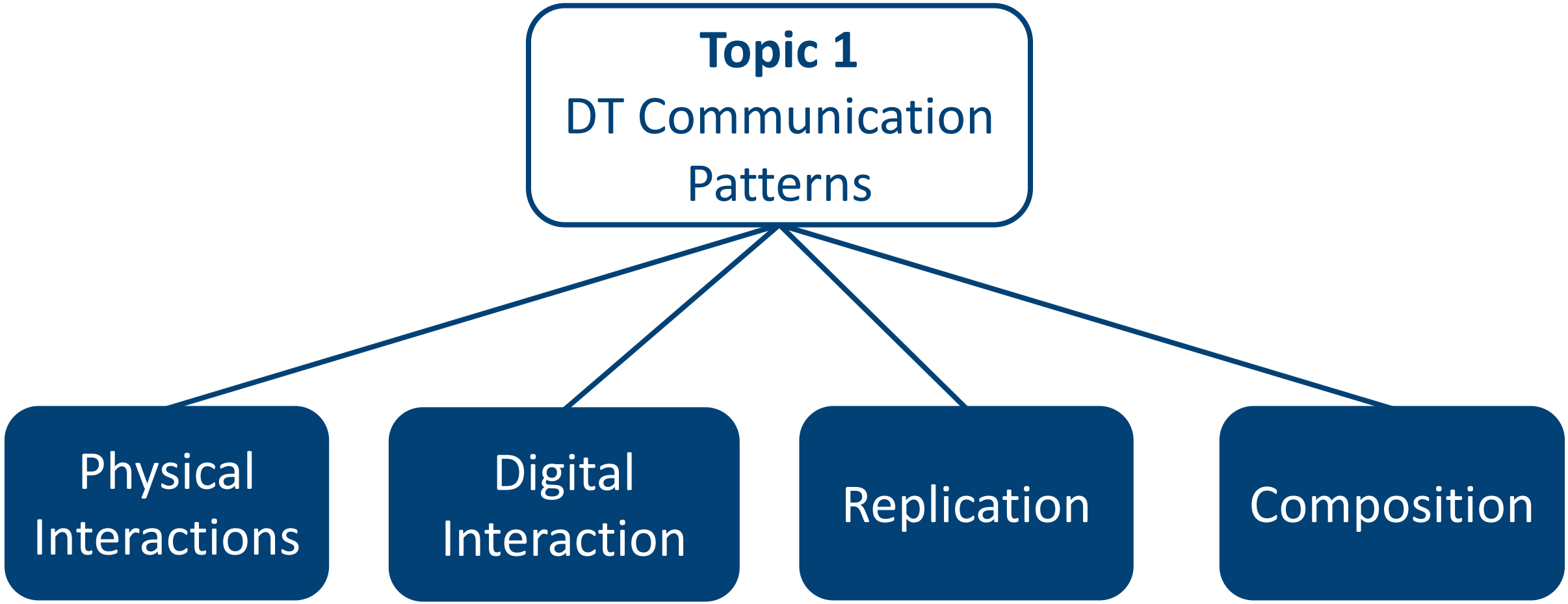
D2 – Digital Twins Communication Requirements - Stable Draft

- The document specifies the definition **and communication aspects for Digital Twins (DTs)**, defining their fundamental characteristics and the requirements for their communications and interoperability, through edge-cloud continuum deployments and with respect to their Physical and Digital Communication Channels.
- The purpose of the present document is to **enable the use cases in DTR/SmartM2M-103844 (D1) and to support all the major use cases and requirements in the context of DT**s
- It deals with the **architectural aspect of the communication and the set of information needed to ensure interoperability** across installations and platforms, without specifying the specific applications that use this information.
- The communication for DTs relies on existing specifications that are referenced in the present document, but the definition of the elements and the information to be exchanged is kept independent from the underlying communication framework and technology.
- The document focuses on the definition of DTs communication functionality and properties, as well as the standardization of DTs communication requirements.

D1 – Digital Twins Communication Requirements – Stable Draft



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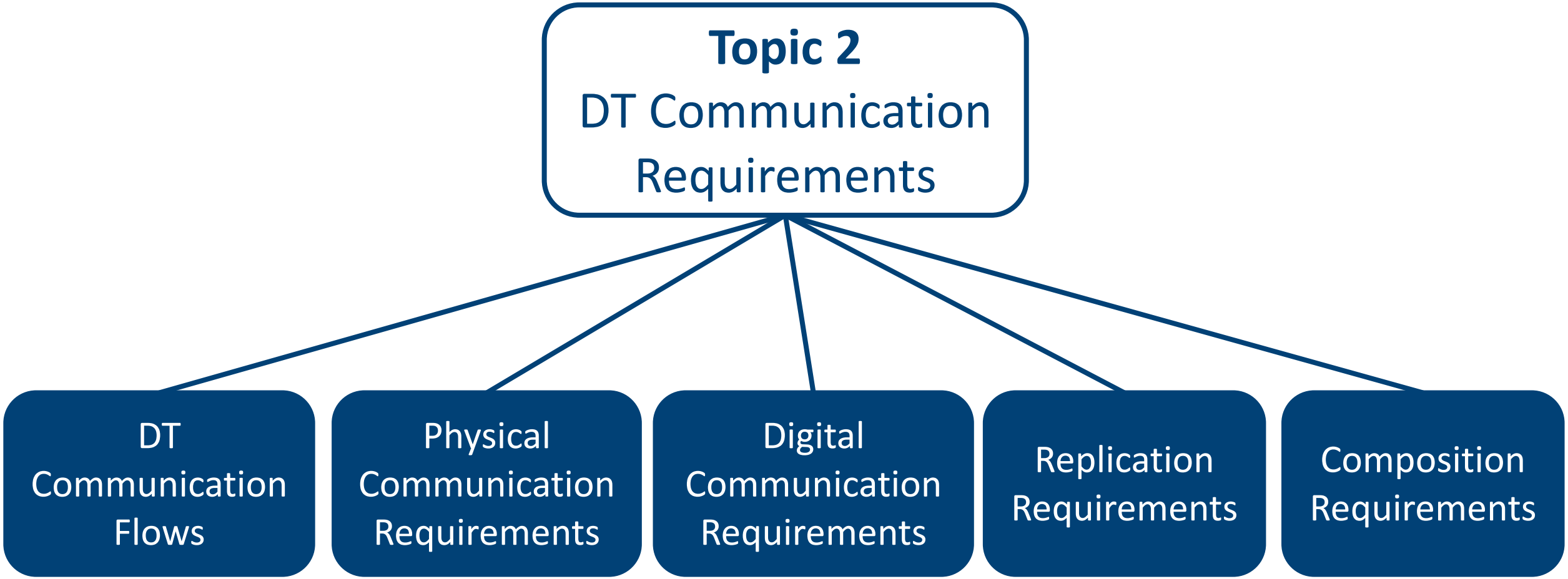

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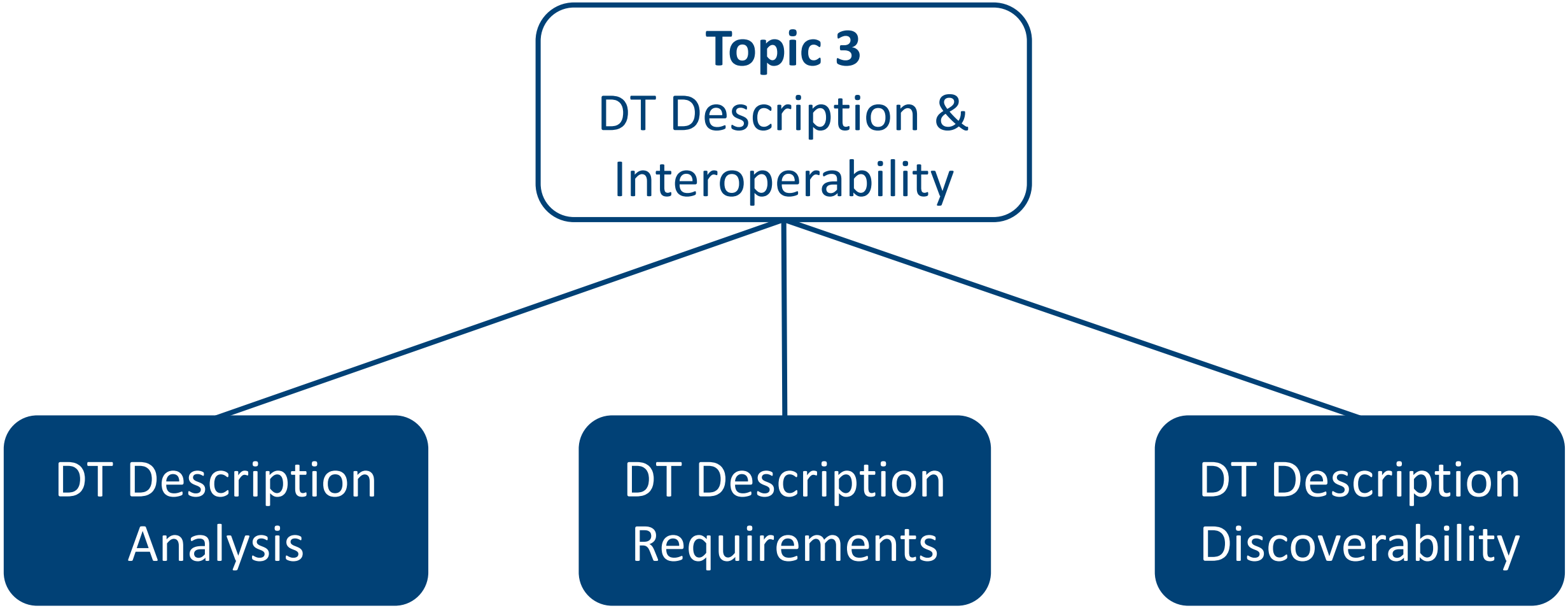
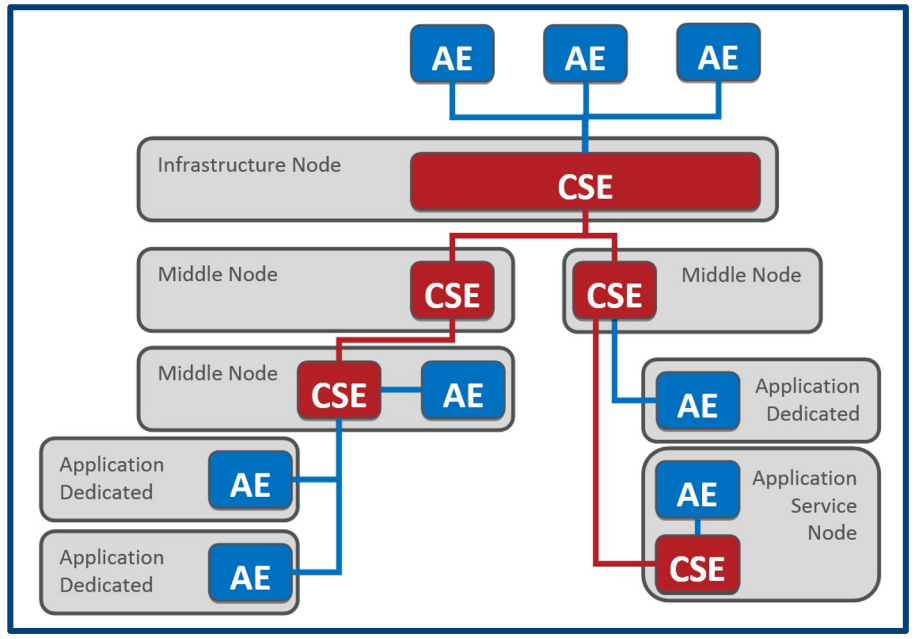
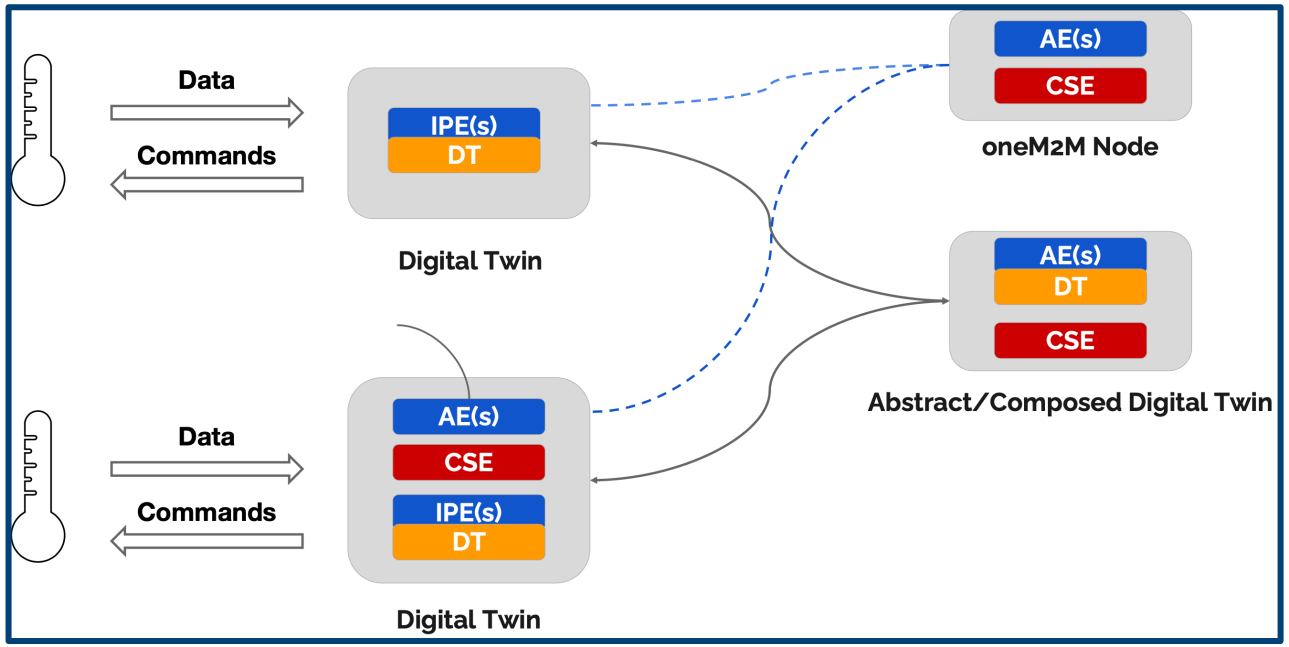


oneM2M & Digital Twins Integration Opportunities (Next Working Plan)





oneM2M Architecture ⟷ **oneM2M & Digital Twins Integration**

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