Questionnaire on Digital **Twin** Reference **Architecture** (TwinArch)

TwinArch is our Digital Twin Reference Architecture, designed and documented in alignment with the *Software Engineering Institute's Views and Beyond* approach and the ISO 42010 standard. The foundation of TwinArch was established through a Systematic Literature Review (SLR), which identified the essential architectural elements defining Digital Twin systems. These elements were further refined and enriched with capabilities drawn from *Azure Digital Twins, Eclipse Ditto, and FIWARE* technologies.

TwinArch is structured in :

- **Module Twin View** (MTV) models high-level **Digital Twin Domain Entities** (DTE) using *UML Class Diagram*.
- **Component Twin View** (CTV) focuses on the **Digital Twin components** and their interactions, represented with *UML Component Diagram*.
- **Traceability Twin View** (TTV) establishes a mapping between MTV and CTV elements using a *Matrix Diagram*, ensuring traceability from high-level domain entities to detailed components.
- **Dynamic Twin View** (DTV) illustrates runtime interactions among structural elements such as classes or components in *UML Sequence Diagrams*.

* Indica una domanda obbligatoria

Research team and objective

Who we are. We are a team of researchers specializing in *Digital Twin* (DT) technology and *Software Engineering*.
Our goal. We aim to improve the design and development of DTs by offering a reference architecture that supports practitioners in creating effective Digital Twin systems.

Data Treatment

How your data will be processed. Any personally identifiable information will be removed from any formal publication. We will discard all personally identifiable information we have stored about you as soon we have finished the analysis process.

Who have access to the data. Only the research team will have access to the data. An anonymized dataset might accompany any research publication that might result from this study.

Consent withdraw. At any point during this process, you can request to withdraw your consent and delete your data. We will proceed to delete any information we have obtained from you in this study upon reception of such request.

Where you can get more information. The ethical impact of this research has been reviewed. No personal information, information that can harm participants nor third parties will be part of the research process. If you want more information, you can email us at the contacts provided below.

1. Your affiliation and your position: *

   This information is collected solely for statistical purposes and will never be disclosed.

2. Affiliation country: *

3. Your email: *

4. Years of experience in Digital Twins research: * Dropdown

   Contrassegna solo un ovale.

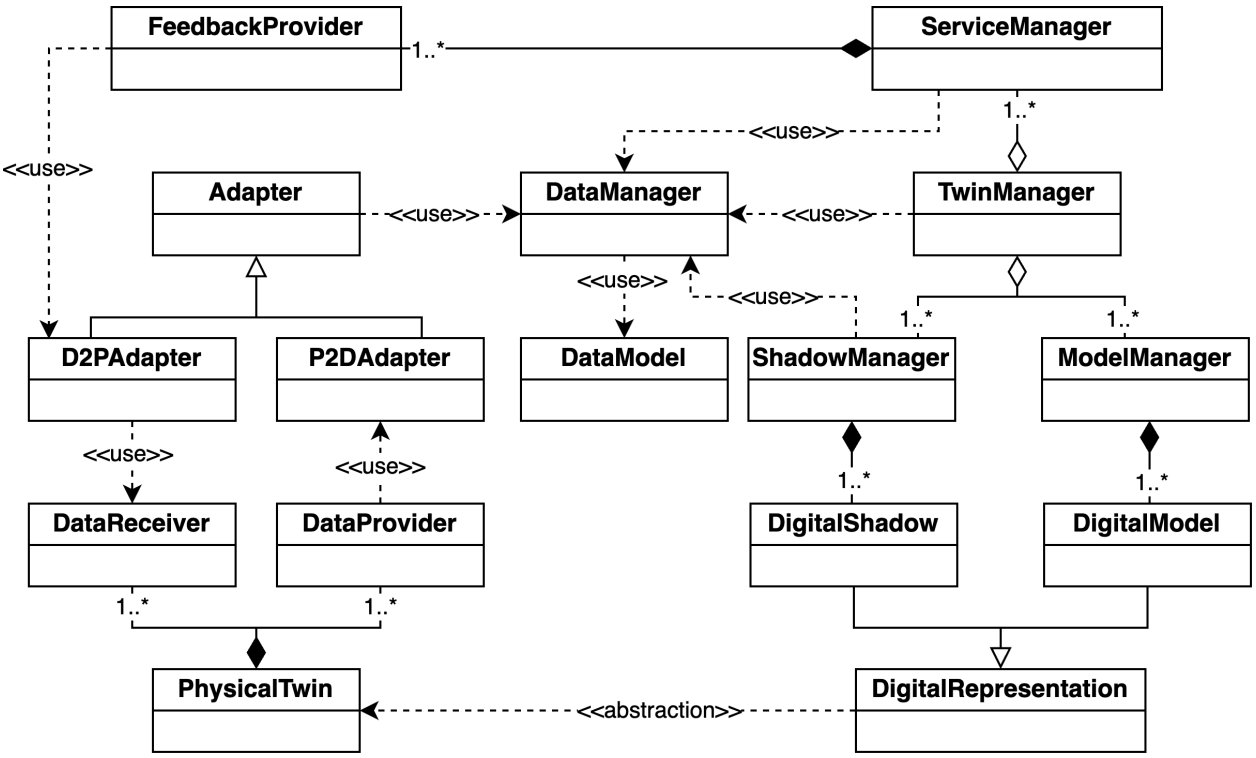
   - Less than 1
   - Between 1 and 3
   - More than 3

5. Technologies used to develop Digital Twins (if any):

Module Twin View

The Module Twin View (MTV) organizes the structure of a Digital Twin system by defining its key components, known as **Digital Twin Domain Entities** (DTEs), and the relationships between them in **UML Class Diagram**. DTEs act as foundational elements, capturing the structural and functional characteristics of real-world entities or abstract concepts essential for Digital Twin operations.

MTV CLASS DIAGRAM



6. On a scale from 1 to 5, how do you rate the *Class Diagram* of the *Module Twin View* as **complete**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

7. On a scale from 1 to 5, how do you rate the *Class Diagram* of the *Module Twin View* as **useful**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

8. On a scale from 1 to 5, how do you rate the **preceived usability** of the *Class Diagram* of the *Module Twin View*? *

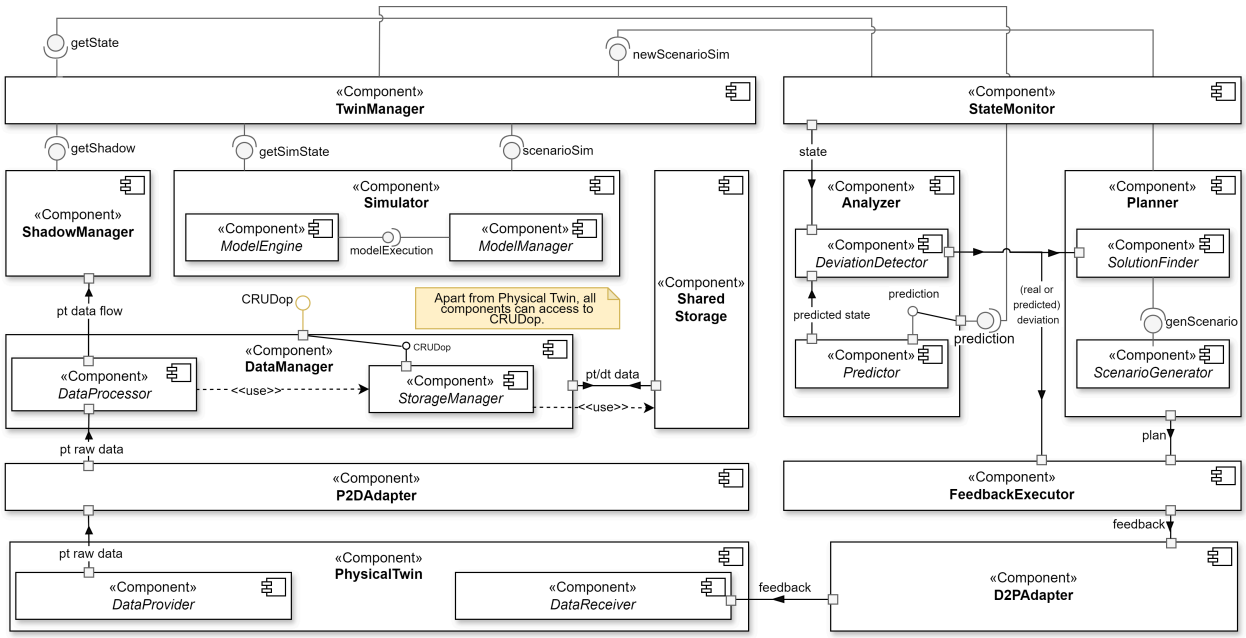
Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

Component Twin View

The Component Twin View (CTV) defines the internal architecture of a Digital Twin system, focusing on its software components and their interactions. This view provides a finer level of granularity compared to the Module Twin View, offering insights closely aligned with the software's implementation. It comprises **Digital Twin Components** (DTCs), which are self-contained software entities designed to perform specific roles, in **UML Component Diagram**.

CTV COMPONENT DIAGRAM



9. On a scale from 1 to 5, how do you rate the *UML Component Diagram* of the *Component Twin View* as **complete**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

10. On a scale from 1 to 5, how do you rate the *UML Component Diagram* of the *Component Twin View* as **useful**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

11. On a scale from 1 to 5, how do you rate the **preceived usability** of the *UML Component Diagram* of the *Component Twin View*? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

Traceability Twin View

The Traceability Twin View (TTV) connects the Module and Component views in the Reference Architecture in a **Matrix Diagram**, ensuring consistency between the system's high-level goals and the detailed software components that implement them.

TTV Matrix Diagram

DTC/DTE ID and NAME		dte_1 Physical Twin	dte_2 Data Provider	dte_3 Data Receiver	dte_4 Adapter	dte_5 P2D Adapter	dte_6 D2P Adapter	dte_7 Digital Representation	dte_8 Digital Shadow	dte_9 Shadow Manager	dte_{10} Digital Model	dte_{11} Model Manager	dte_{12} Twin Manager	dte_{13} Service Manager	dte_{14} Feedback Provider	dte_{15} Data Manager	dte_{16} Data Model
dtc_1	Physical Twin	✓															
dtc_2	Data Provider		✓														
dtc_3	Data Receiver			✓													
dtc_4	P2D Adapter				✓	✓											
dtc_5	D2P Adapter				✓		✓										
dtc_6	Data Processor															✓	✓
dtc_7	Storage Manager															✓	
dtc_8	Data Manager															✓	
dtc_9	Shared Storage															✓	✓
dtc_{10}	Shadow Manager							✓	✓	✓							
dtc_{11}	Model Manager							✓			✓						
dtc_{12}	Model Engine										✓	✓					
dtc_{13}	Simulator							✓			✓	✓					
dtc_{14}	Twin Manager												✓				
dtc_{15}	State Monitor													✓			
dtc_{16}	Deviation Detector													✓			
dtc_{17}	Predictor													✓			
dtc_{18}	Analyzer													✓			
dtc_{19}	Solution Finder													✓			
dtc_{20}	Scenario Generator													✓			
dtc_{21}	Planner													✓			
dtc_{22}	Feedback Executor														✓		

12. On a scale from 1 to 5, how do you rate the *Matrix Diagram* of the *Traceability Twin View* as **complete**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

13. On a scale from 1 to 5, how do you rate the *Matrix Diagram* of the *Traceability Twin View* as **useful**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

14. On a scale from 1 to 5, how do you rate the **preceived usability** of the *Matrix Diagram* of the *Traceability Twin View*? *

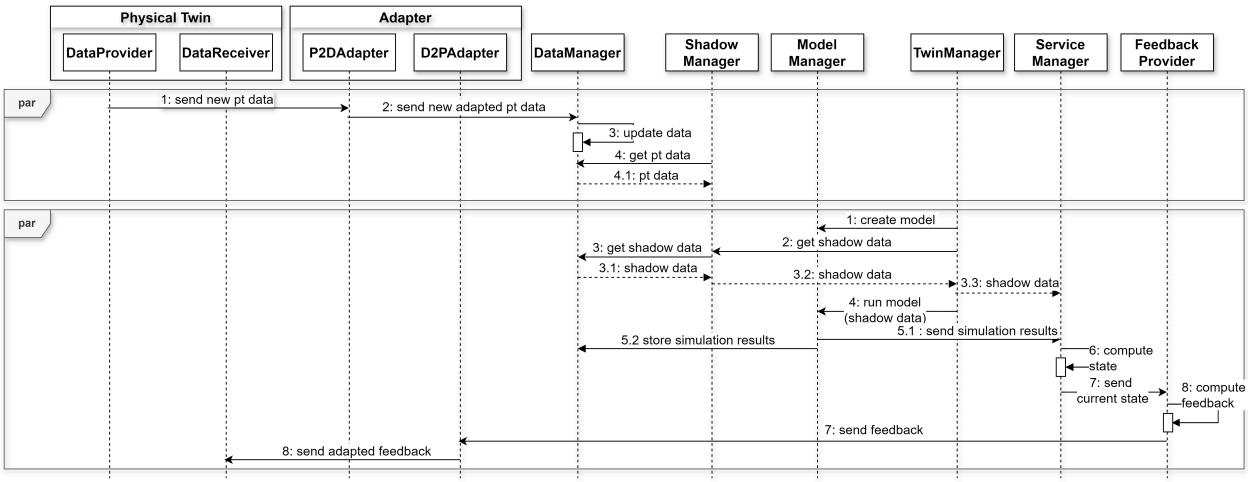
Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

Dynamic Twin View

The Dynamic Twin View (DTV) represents the behavioral perspective of the Digital Twin system, illustrating interactions between entities or component to implement specific use cases. It includes multiple **UML Sequence Diagrams** that detail various operational scenarios, such as monitoring, control, prediction, or simulation.
For the sake of brevity, the attached diagram focuses specifically on the monitoring use case (considering DTEs), where the primary goal is to track and update the state of a physical system using Digital Twin entities.

DTV SEQUENCE DIAGRAM



15. On a scale from 1 to 5, how do you rate the *UML Sequence Diagram* of the *Dynamic Twin View* as **complete**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

16. On a scale from 1 to 5, how do you rate the *UML Sequence Diagram* of the *Dynamic Twin View* as **useful**? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

17. On a scale from 1 to 5, how do you rate the **preceived usability** of the *UML Sequence Diagrams* of the *Dynamic Twin View*? *

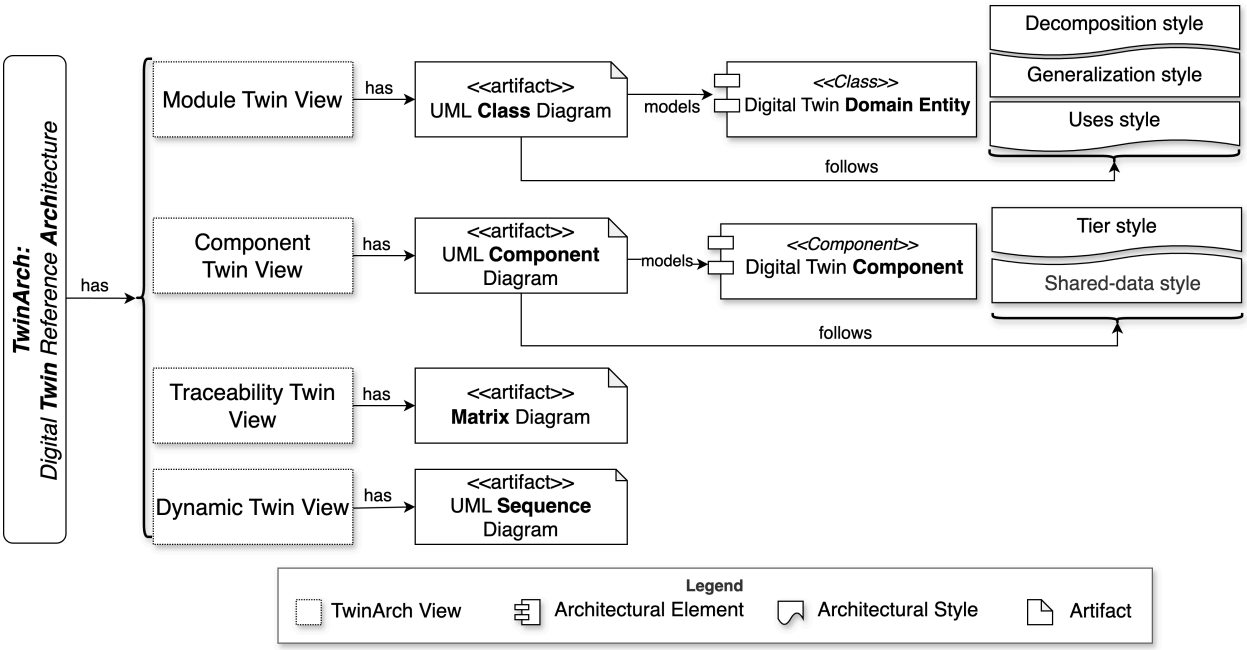
Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

TwinArch Evaluation

This final section is intended to gather feedback on the overall reference architecture.

TwinArch Structure in accordance with SEI Views and Beyond and ISO standard.



18. On a scale from 1 to 5, how would you rate the **completeness** of the *TwinArch* design and documentation in accordance with SEI and ISO standard? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

19. On a scale from 1 to 5, how would you rate the **usefulness** of the *TwinArch* design and documentation in accordance with SEI and ISO standard? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

20. On a scale from 1 to 5, how would you rate the **preceived usability** of the *TwinArch* design and documentation in accordance with SEI and ISO standard? *

Contrassegna solo un ovale.

	1	2	3	4	5	
Stro	◯	◯	◯	◯	◯	Strongly Agree

21. Could you please describe the **unnecessary and/or missing elements**, if any?

22. Could you briefly describe the **strengths** of the proposed TwinArch? *

23. Could you briefly describe the **limitations** of the proposed TwinArch? *