System-of-Systems Description (SoSD) Digital Twin

4 januari 2024

Document title		Document type
Digital Twin		SoSD
Date		Version
4 januari 2024		1.0
Author		Status
Jesper Frisk		Proposed
Contact		Page
jesfri-8@student.ltu.se		2(12)

1 System of Systems Overview

Older robotics, micro controllers, PLCs and more can often have limitations to battery life availability and outdated communication protocols. This makes it difficult to have many different system that are based on modern communication protocols use their services. Instead a digital twin is created, this system connects to the robot, micro controller, PLC or other system via it's communication protocol and extends the functionalities of that system. In this document and accompanying documentation the system that is extended with a digital twin is referred to as a physical twin.

To create and host a digital twin a digital twin hub system is used. This system offers services to create and remove digital twins and it is responsible for the created digital twin. The digital twin hub hosts all necessary services for each digital twin, connects to the physical twin and saves necessary data for the digital twin.

To demonstrate a created digital twin two different systems are used, a controller system that wants to send control commands to the physical twin, and a sensor system that wants to view sensor data from the physical twin. Furthermore a controller system is used in another cloud, to demonstrate inter cloud communication between the digital twin and other system that consumes it's services.
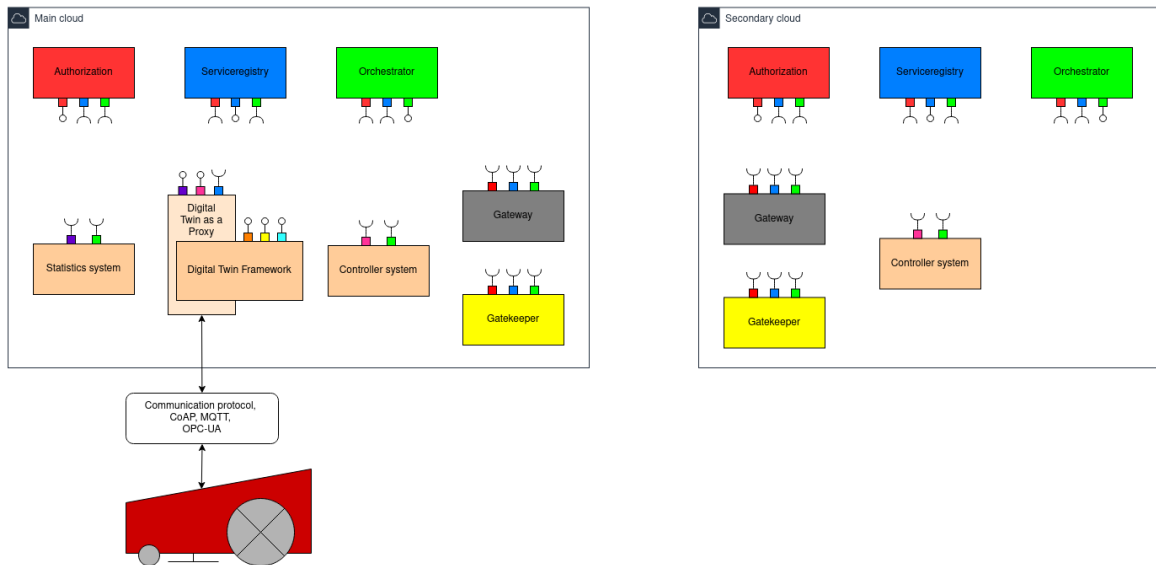

Figur 1: System architecture

Document title		Document type
Digital Twin		SoSD
Date		Version
4 januari 2024		1.0
Author		Status
Jesper Frisk		Proposed
Contact		Page
jesfri-8@student.ltu.se		3(12)

2 Systems

Table 1 Pointers to the SysD documents

System name	Path
Digital Twin Hub	DigitalTwin/digital-twin-hub_sysd.tex
Digital Twin	DigitalTwin/digital-twin_sysd.tex
Controller	Controller/controller_sysd.tex
Sensor Retrieval	SensorRetrieval/sensor-retrieval_sysd.tex

	Document title	Document type
	Digital Twin	SoSD
	Date	Version
	4 januari 2024	1.0
	Author	Status
	Jesper Frisk	Proposed
	Contact	Page
	jesfri-8@student.ltu.se	4(12)

3 Use-cases

Table 2 Create Digital Twin Use-case description

Create Digital Twin
ID: 1
Brief description:
A system operator creates a new digital twin system.
Primary actors:
Digital Twin Hub
Secondary actors:
Physical Twin
Preconditions:
The create process must be started by a system operator.
Main flow:
1- The operator consumes the create-digital-twin service, and defines the connection to the physical twin and the services that the digital twin will extend.
2- The digital twin hub sets up the necessary communication to the physical twin as defined.
3- The digital twin hub sets up a rest api on a arbitrary and available port, and creates endpoints for all defined services that is extended from the physical twin.
4- A new digital twin system is registered in the service registry, with all its accompanying services.
5- Necessary data about the digital twin is saved in a local database.
Postconditions:
The digital twin hub is hosting a new digital twin, that can connect to the physical twin, and provides services that extends the physical twins functionalities, also all services created are registred in the service registry.
Alternative flows:
Any possible alternative flows to the sequence presented in the Main flow section.

Document title	Document type
Digital Twin	SoSD
Date	Version
4 januari 2024	1.0
Author	Status
Jesper Frisk	Proposed
Contact	Page
jesfri-8@student.ltu.se	5(12)

Table 3 Remove Digital Twin Use-case description
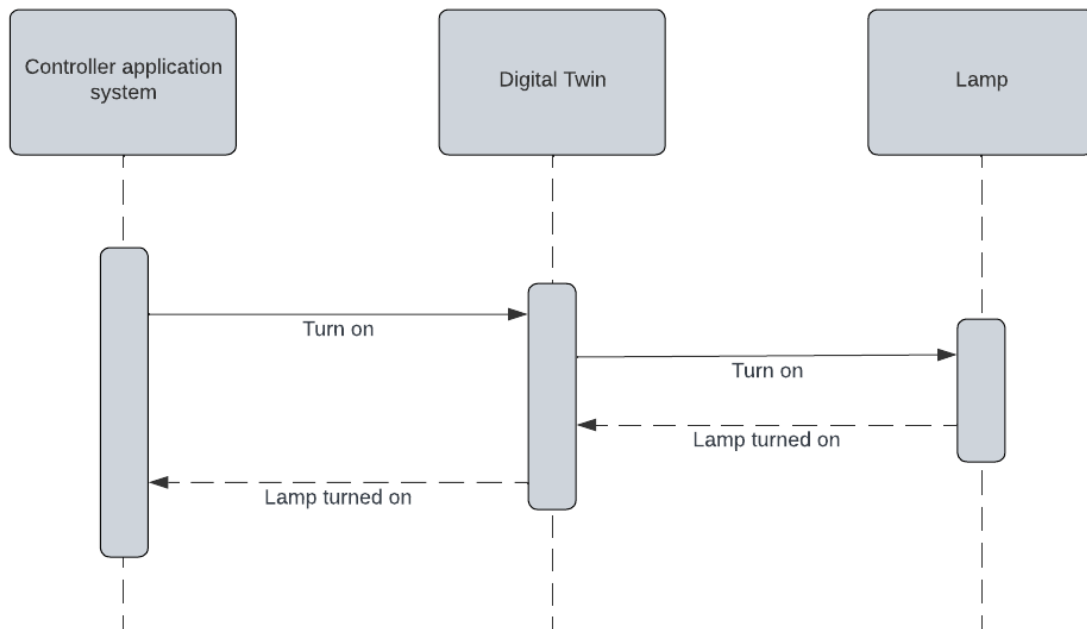
Remove Digital Twin
ID: 2
Brief description:
A system operator removes a existing digital twin system.
Primary actors:
Digital Twin Hub
Secondary actors:
Preconditions:
The remove process must be started by a system operator.
Main flow:
1- The operator consumes the remove-digital-twin service, and provides the address and port of the digital twin that is to be removed.
2- The digital twin hub shuts down the rest api of that digital twin.
3- The digital twin system and the accompanying services are unregistered from the service registry.
4- All saved data about the digital twin is removed from the digital twin hubs local database.

	Document title	Document type
	Digital Twin	SoSD
	Date	Version
	4 januari 2024	1.0
	Author	Status
	Jesper Frisk	Proposed
	Contact	Page
	jesfri-8@student.ltu.se	6(12)

Table 4 Control a physical twin Use-case description

Control a physical twin
ID: 3
Brief description:
An application system consumes a service that is provided by a digital twin system, in order to control a physical twin.
Primary actors:
Consuming application system, Digital Twin
Secondary actors:
Physical Twin
Preconditions:
The consuming application system orchestrates for a desired service.
Main flow:
1- The application system consumes a control service provided by the digital twin, and forwards a control command.
2- The control command is forwarded to the physical twin.
3- The response of the control is returned to the application system.
Alternative flows:
If the physical twin cannot be reached by the digital twin system, an error is returned to the consuming application system.

Document title		Document type
Digital Twin		SoSD
Date		Version
4 januari 2024		1.0
Author		Status
Jesper Frisk		Proposed
Contact		Page
jesfri-8@student.ltu.se		7(12)

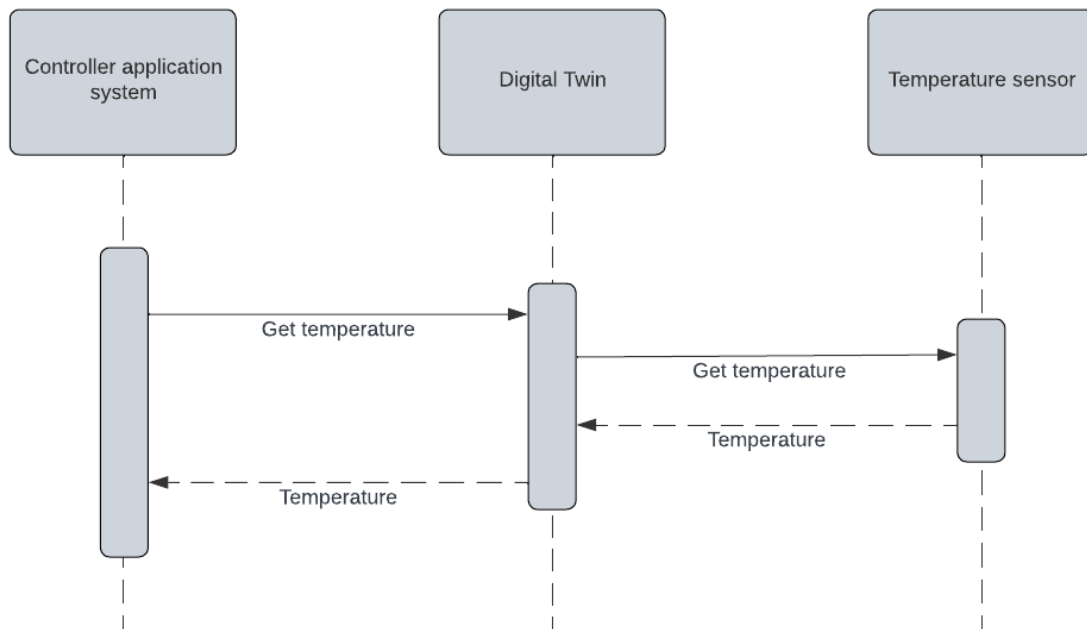Figur 2: Sequence diagram of sending control commands, as an example the physical twin is in this case a lamp.

	Document title	Document type
	Digital Twin	SoSD
	Date	Version
	4 januari 2024	1.0
	Author	Status
	Jesper Frisk	Proposed
	Contact	Page
	jesfri-8@student.ltu.se	8(12)

Table 5 Immediately view sensor data from physical twin Use-case description

Immediately view sensor data from physical twin
ID: 4
Brief description:
An application system consumes a service that is provided by a digital twin system, in order to view sensor data from a physical twin.
Primary actors:
Consuming application system, Digital Twin
Secondary actors:
Physical Twin
Preconditions:
The consuming application system orchestrates for a desired service.
Main flow:
1- The application system consumes a sensor service provided by the digital twin.
2- The sensor request is forwarded to the physical twin.
3- The sensor data is saved in the digital twin hubs database.
4- The sensor data is returned to the application system.
Alternative flows:
If the physical twin cannot be reached by the digital twin system, the latest data saved in the database is returned instead.

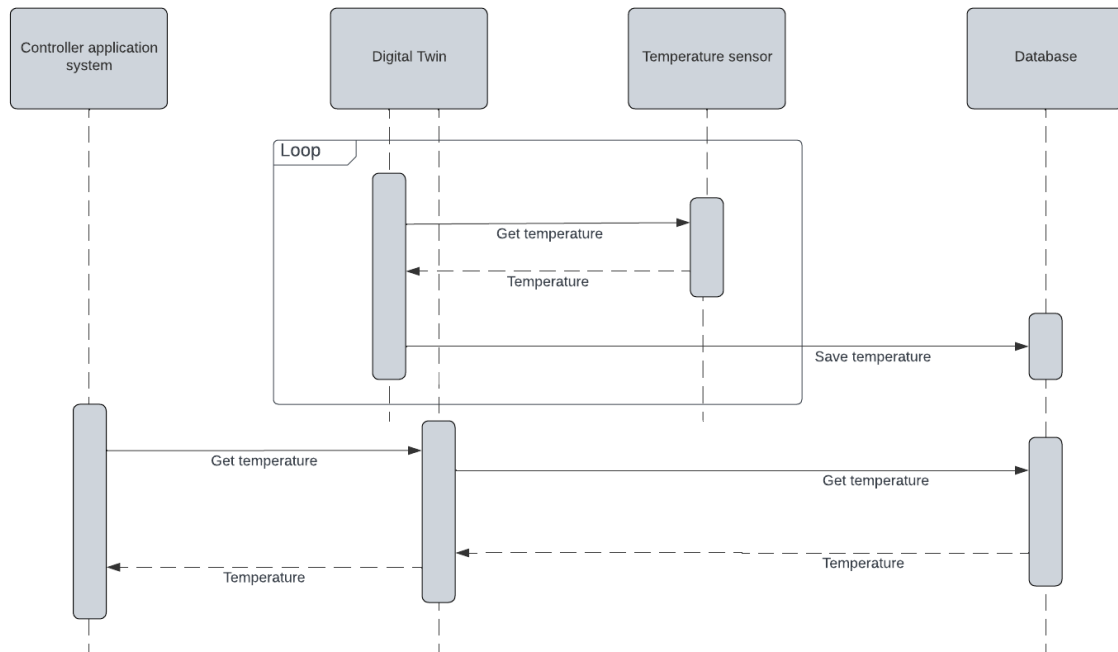| Document title	Document type
Digital Twin	SoSD
Date	Version
4 januari 2024	1.0
Author	Status
Jesper Frisk	Proposed
Contact	Page
jesfri-8@student.ltu.se	9(12)

Figur 3: Sequence diagram over immediate retrieval of sensor data, as an example the physical twin is in this case a temperature sensor.

Document title	Document type	
Digital Twin	SoSD	
Date	Version	
4 januari 2024	1.0	
Author	Status	
Jesper Frisk	Proposed	
Contact	Page	
jesfri-8@student.ltu.se	10(12)	

Table 6 View sensor data from physical twin by interval retrieval Use-case description

View sensor data from physical twin by interval retrieval
ID: 5
Brief description:
An application system consumes a service that is provided by a digital twin system, in order to view sensor data from a physical twin.
Primary actors:
Consuming application system, Digital Twin
Secondary actors:
Physical Twin
Preconditions:
The consuming application system orchestrates for a desired service.
Main flow:
1- The digital twin asks the physical twin for the sensor data.
2- The sensor data is saved in the digital twin hubs database.
3- The application system consumes a sensor service provided by the digital twin.
4- The latest sensor data is retrieved from the database and returned to the application system.

Document title		Document type
Digital Twin		SoSD
Date		Version
4 januari 2024		1.0
Author		Status
Jesper Frisk		Proposed
Contact		Page
jesfri-8@student.ltu.se		11(12)

Figur 4: Sequence diagram over interval retrieval of sensor data, as an example the physical twin is in this case a temperature sensor.

Document title	Document type
Digital Twin	SoSD
Date	Version
4 januari 2024	1.0
Author	Status
Jesper Frisk	Proposed
Contact	Page
jesfri-8@student.ltu.se	12(12)

4   Behaviour diagrams

The diagrams proposed in this section are behaviour diagrams that provide a high level view of the SoS. The use of UML Activity diagrams, and BPMN or SysML Activity diagram is proposed.

The UML Activity diagrams are used to model a higher-level business process or processes.

The BPMN diagrams provide a notation that is easily understandable by all business users. This includes the business analysts that create the initial drafts of the processes to the technical developers responsible for implementing the technology that will perform those processes.

The SysML diagrams support the specification, analysis, design, verification and validation systems that include hardware, software, data, personnel, procedures and facilities.

This section can also reports Sequence diagrams to specify how the involved systems interact with each other. The use of UML or SysML is proposed.

5   Security

All systems use certificate security, and thus a valid certificate must be provided that follows the arrowhead certificate chain. To communicate with the Digital Twin hub a proper system operator certificate is needed.