

How does the WiTWINtake project use FIWARE technology to seamlessly connect systems in the wine industry?

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Introduction

WiTWINtake is an innovative project to modernize and elevate the Wine Production Digital Twin by connecting it with several software solutions for wine industry, including vineyard management, cellar diary, financial control software, and Camera-Based Grape Intake Control system. The project proposes a transformative approach to integrating grape production and winemaking processes by advancing data management practices and improving information flow from the vineyard through the early processing stages to the end product, wine. The project aims to enhance process efficiency, decision-making, and traceability throughout the winemaking value chain by leveraging cutting-edge digital technologies.

WiTWINtake solution

Innovations in WiTWINtake support data-driven winemaking processes, improve product quality, and enhance transparency across the supply chain, aligning with the broader goals of sustainability, traceability, and digital transformation in agri-food systems. The goal was achieved through seamless integration between vineyard, financial and cellar information systems, as well as on the level of processes in all sectors of the winery. This enables real-time data sharing and process coordination, implemented by using standards-compliant digital twin frameworks that support comprehensive traceability from the final bottled product to vineyard conditions and interventions, including automated data collection by deployment of camera-based sensor technologies for automated grape quality assessment at grape intake into the winery.

By integrating the eVineyard and AccountingBox solutions, we empower wineries to transform winery management through an innovative, modular system built on digital twin technologies. The solution drives digital innovation, operational excellence, and sustainability across the winemaking value chain by offering real-time insights, improved grape quality control and assessment for processes such as grape sorting, and end-to-end traceability. The WiTWINtake pilot solution is installed at Radgonske Gorice, the oldest and largest producer of sparkling wines in Slovenia.

About Data Spaces, FIWARE, and how they are used in WiTWINtake

We are transforming into a digital society. British mathematician Clive Humby declared, "Data is the new oil." However, all the data has no value if it is inaccurate, formatted incorrectly, or unavailable. Let us take a closer technical look at the WiTWINtake project and its data management, based on the Data Spaces. The Data Spaces concept was founded under the Digital Europe Program. The program comprises multiple domains, including smart communities, manufacturing, mobility, and agriculture. Data spaces are a concept from Data governance and digital ecosystems that refer to federated environments where participants (organizations, systems, or devices) can share, access, and reuse data in a controlled, interoperable, and trustworthy way — while maintaining sovereignty over their data. We are using a living digital replica of something physical - a Digital Twin. A



This project has received funding from the European Union's i3 programme under grant agreement No 101083989. This project reflects the views of the author and the European Union is not responsible for any use that may be made of the information it contains during the lifetime of the project and should not do so after the project ends.

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Digital Twin is a virtual representation of a real-world object, system, or process that is continuously updated with real-time data. It mirrors the physical entity's state, behaviour, and lifecycle, enabling monitoring, simulation, and optimization in a digital environment. In winemaking, a digital twin of a bottle of sparkling wine can track it's location, production history, state, storage conditions and more. Based on the described principles, the data spaces have multiple possible implementations. One of the important organizations in the data space domain is the FIWARE Foundation [¹].

The FIWARE Foundation coordinates the FIWARE ecosystem, which provides standardized APIs, open-source components, and reference architectures to help developers, companies, and public institutions create interoperable, scalable, and smart applications.

The core activities of the FIWARE Foundation are maintaining the FIWARE Open Source Platform. The platform is centred around the FIWARE Context Broker, which implements the NGSI-LD standard for managing real-time context information. FIWARE supports the creation of data spaces and smart solutions by ensuring systems can exchange data seamlessly through common APIs and data models.

The solutions of FIWARE-compliant products, such as the WiTWINtake project solution, provide its owners and clients using the solutions with the following benefits:

- Decentralized control: No central authority owns all the data each participant retains sovereignty.
- Interoperability: Common data models, vocabularies, and APIs enable seamless data exchange.
- Trust and governance: Usage policies and identity management ensure trusted collaboration.
- Data sovereignty: Data providers retain control over how their data is accessed and used.
- Modularity: Participants can plug into the space with different technical architectures and tools.

At the technology level, the WiTWINtake project leveraged those technologies as a foundation for secure, standardized data sharing, enabling the deployment of Digital Twins to achieve seamless system integration and real-time operational insights.

The core of the solution is the Context Broker. A Context Broker is the core component of a FIWARE-based system that manages, stores and distributes real-time context information from various data sources such as sensors, devices, applications, and services. So that other systems can understand what is happening in real-time and act accordingly. The Context Broker collects from sensors, devices, and other services (e.g., temperature readings, location, machine status). It updates this information as new data comes in and serves requests from other applications or services that want to know the current state of something — or be notified when something changes. NGSI V2 or NGSI-LD compliant Context Brokers enable Subscription/Notification operations: e.g., "Notify me when this sensor detects a value over maximum threshold value in the vine cellar", interoperability across different systems and real-time data flows that power

¹ <u>https://www.fiware.org/</u>







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dashboards, analytics, and automation. The data used in the Context Brokers has a reference architecture and is compatible with the Smart Data Models. The Fiware webpage describes Smart Data Models as follows [²]: A smart data model includes four elements.

- The schema, or technical representation of the model, defines the technical data types and structure.
- The specification of a written document for human readers.
- A URI with a working URL with basic data about the attribute or the entity.
- The examples of the payloads for NGSIv2 and NGSI-LD versions.

WiTWINtake project further evolved incubated Wine Traceability data models in Smart Data Models initiative, and contributed them to the Smart Data Models GitHub for re-use by other companies in the industry.

NGSI-LD is a standardized API and information model designed to manage real-time context data in a semantic, linked-data format. It enables interoperability between heterogeneous systems by describing entities (e.g., sensors, vehicles, buildings) and their relationships using JSON-LD and Linked Data principles. JSON-LD format adds semantic meaning, enabling machines to understand and connect information across domains. In the WiTWINtake project solution, several software solutions and specialized systems such as grape grading technologies communicate using NGSI-LD. NGSI-LD standardized API is maintained by ETSI (the European Telecommunications Standards Institute) and is a foundational standard used in FIWARE-based architectures and data spaces. WiTWINtake uses NGSI-LD for linking data about various stages of wine production.

The Context Broker and NGSI-LD standardized API connect other FIWARE Generic Enablers and custom-made modules made by the WiTWINtake project. The Generic Enablers are standardized software modules that offer ready-to-use capabilities — such as data management, context processing, IoT integration, identity access management, and more — enabling developers to build complex smart systems efficiently and consistently. Fiware Foundation offers a catalogue of FIWARE-ready generic enablers [³]. For the purposes of the WiTWINtake project, we have brought together a vast amount of wine production data including agricultural and grape intake data from IoT platforms in the vineyard and the wine cellar. In addition to that, our solution integrates the data from the accounting, marketing and all business processes.

For all interested in the Data spaces and Fiware framework, we want to highlight the upcoming ETSI GS CIM 009 V 1.9.1 document [⁴]. The document formally describes the future Context Information Management API (NGSI-LD) Specification. Mr. Jason Fox, Technical Evangelist at FIWARE, presented the specification in the FIWARE Webinar titled Solving the Challenges of Distributed Operations within Data Spaces [⁵]. The FIWARE webinar explores how to overcome key challenges in managing distributed operations within data spaces, especially when multiple organizations and systems need to share real-time context data. It highlights recent updates to

⁵ <u>https://youtu.be/NqVdEU3HVag</u>









² <u>https://www.fiware.org/smart-data-models/</u>

³ <u>https://www.fiware.org/catalogue/#components</u>

⁴ <u>https://www.etsi.org/</u>



the NGSI-LD standard, including new features like Conformance Indicators, Entity Maps, and Snapshots that ensure data consistency, interoperability, and traceability across distributed environments. The webinar also introduces concepts like Transient Entities for handling mobile and ephemeral data sources. By implementing these advancements through FIWARE components such as Orion-LD Context Broker, organizations can achieve seamless, trustworthy, and efficient data sharing, enabling robust, federated smart ecosystems.



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