FIWARE: an open standard-based framework for data integration based on digital twins

Juanjo Hierro
CTO
FIWARE Foundation
juanjo.heirro@fiware.org, @FIWARE
Digital Twins: an approach for integration at multiple levels

Architecting Smart Solutions

Integrating systems and sharing data within organizations (system of systems)

Integrating services and sharing data across organizations (Data Spaces)
What are we referring to as Digital Twin?

- **Digital Twin** = Digital representation of a real-world asset
  - Characterized by attributes
    - Properties
    - Relationships
    - Linked Data
  - Values of attributes may change over time (or not)
  - Typically have a location (but it is not a must requirement)

- (digital representation of) **Context** = Digital Twins Collection

- **Cornerstone for the development** of interoperable and replicable (portable) Smart Solutions:
  - **Standard API** for getting access to Digital Twin data (context)
  - **Common Data Models** associated to Digital Twin classes

- **FIWARE** has driven standardization+adoption:
  - **NGSI: NGSlv2** □ ETSI NGSI-LD API
  - **Smart Data Models initiative** (500+ data models)
FIWARE driving key standards: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Bus
- Location
- No. passengers
- Driver
- Licence plate

Citizen
- Name-Surname
- Birthday
- Preferences
- Location
- ToDo list

Shop
- Location
- Business name
- Franchise
- Offerings

Entities
(Digital Twins)

Incident / claim
- Date
- Location
- Type
- Issuer
- Description

Attribute

Bus
- Location
- No. passengers
- Driver
- License plate
FIWARE driving key standards: ETSI NGSI-LD

Application/Service

FIWARE NGSI API
(NGSIv2 → NGSI-LD)

Context Broker

Tractor
- Location
- Speed
- Planed route

Crop
- Humidity
- Leaf area
- Age

Drone
- Location
- Battery level
- Speed
- Planed route

Entities
(Digital Twins)

Crop
- Humidity
- Leaf area
- Age

Drone
- Location
- Battery level
- Speed
- Planed route

Tractor
- Location
- Speed
- Planed route

Attribute
FIWARE driving key standards: ETSI NGSI-LD

Application/Service

FIWARE NGSI API (NGSIv2 → NGSI-LD)

Context Broker

Ambulance
- license plate
- location
- speed
- equipment
- current alert

Alert
- alert id
- emergency level
- description
- location
- patient id

Surgery Room
- id
- hospital
- equipment
- surgery plan

Hospital
- name
- address
- total patient rooms
- occupied patient rooms
- total surgery rooms

Doctor
- id
- specialties
- location
- visits plan

Patient
- id
- location
- patient record
- treatment

Entities (Digital Twins)

Ambulance
- License plate
- location
- speed
- equipment
- current alert

Attribute
FIWARE driving key standards: ETSI NGSI-LD

Application/Service

FIWARE NGSI API (NGSIv2 → NGSI-LD)

Context Broker

Transport robot
- Id
- location
- speed
- transported items
- destination

Palletizer robot
- Id
- product
- Items quantity
- Layers
- Size
- Weight

Operator
- Id
- Location
- Assigned task
- Profile

Transport robot
- Id
- location
- speed
- transported items
- destination

Entities
(Digital Twins)

Palletizer robot
- Id
- product
- Items quantity
- Layers
- Size
- Weight

Operator
- Id
- location
- assigned task
- profile

Shopfloor Door
- Id
- location
- status
(open/close)

Attribute
FIWARE driving key standards: ETSI NGSI-LD

Application/Service

FIWARE NGSI API (NGSIv2 → NGSI-LD)

Context Broker

Wind Turbine
- location
- power
- wind speed
- pitch angle

Wind Plant
- Location
- Active Power
- Reactive Power
- Frequency

Smart Home
- location
- address
- installed PV
- energy consumption

Energy Storage
- active power
- reactive power
- SoC
- SoH

Entities (Digital Twins)

Wind Turbine
- location
- power
- wind speed
- pitch angle

Substation
- Hi voltage
- Lo voltage
- nominal power
- power flow

Attribute
FIWARE driving key standards: ETSI NGSI-LD

- NGSI-LD is a simple yet powerful REST API
  - Simple: simple operations are rather simple, what you would expect in a RESTful API
    - Entity types, entities, attributes have a path
    - You perform standard GET, POST, PUT, PATCH, DELETE operations
  - Yet powerful: powerful operations supported
    - Geo-queries
    - Subscription / Notification
    - Pull/Push styles for gathering data
    - Multiple data "renderings" (key value, normalized, GeoJSON)
    - Temporal operations
    - Federation mechanisms
FIWARE driving key standards: Smart Data Models

- **Goal:** provide a useful global “resource library” for developers

- **For each model:**
  - documentation in 6 languages
  - mapping (with validation schemas and examples) to DTDL and 4 serialization formats: JSON, JSON-LD, CSV, GeoJSON feat.

- **Principles:**
  - Agile process (6 weeks)
  - Implementation-driven
  - Cross-sector

- **Defined data models rely on relevantly adopted standards** (e.g., schema.org, SAREF, IEC CIM in Energy or UNE 178503 for Tourism) and contributions from real projects by the Community

---

https://github.com/smart-data-models

---

Entity: WeatherAlert

### List of properties

- **alertSource** - Source of the alert
- **category** - Category of the entity
- **data** - Payload containing the data retrieved
- **dateIssued** - The date and time the item was issued in ISO8601 UTC format
- **description** - Description of the entity
- **severity** - Severity of the Alarm
- **subcategory** - Weather categories
- **type** - NGSI Entity type. It has to be Alert.
- **validFrom** - The start of the validity period for this forecast as a ISO8601 timestamp
- **validTo** - The end of the validity period for this forecast as a ISO8601 timestamp

### Data Model description of properties

- **alertSource**
- **category**
- **dateIssued**
- **description**
- **severity**
- **subcategory**
- **type**
Smart Data Models: domains and subjects

**DATA-MODELS**
- Guides for coding new data models
- Template for new data models and examples
- Directory for scripting tools to check data models
- Inventory of domains and data models
- Inventory of attributes and terms
- @Context for json-ld

**DATA MODELS**
- README.md
- /doc/spec.md
- /examples
- schema.json
- Adopters
- LICENSE

**DOMAINS REPOSITORIES**
Readme pointing to the list of subjects
General info or shared resources

**SUBJECTS’ REPOSITORIES**
Readme pointing to the list of data models for the objects
Contributors.md
subject-schema.json

**LIFECYCLE MANAGEMENT REPOSITORIES**
- Incubated
- Harmonization

---

---
Endorsement at global level: Relevant standard and industry bodies

ETS1 created Jan 2017 an Industry Specification Group (ISG CIM) for defining a Context Information Management API

FIWARE NGSIv2 provided the basis for the NGSI-LD specs published by ETSI

FIWARE provides several open source implementations of ETSI NGSI-LD

The GSMA published a Reference Architecture for IoT Big Data Ecosystem which recommends to mobile operators

NGSI-LD plays the core role for the integration of components and the development of applications in the defined Reference Architecture

TM Forum supports FIWARE NGSI for real-time access to context information in cities

TM Forum and FIWARE collaborate in development of data marketplace platform components

TM Forum and FIWARE also collaborate in definition of common data models (smart data models initiative)
Endorsement at global level: Recommendations in cities

OASC MIMs (Minimum Interoperability Mechanisms) are being adopted by cities and the living-in.EU initiative

ETSI NGSI-LD specs maps to MIM-1

OASC has joined the smart data models initiative as base for developing MIM-2

MIM-3 leverages TM Forum recommendations

IUDX, which provides the trusted data exchange framework recommended to cities by the government of India, has adopted NGSI-LD as API for data exchange

IUDX will join the smart data models initiative and play a leading role in definition of data models for cities
Digital Twins: an approach for integration at multiple levels

Architecting Smart Solutions

Integrating systems and sharing data within organizations (system of systems)

Integrating services and sharing data across organizations (Data Spaces)
Digital Twins: an approach for integration at multiple levels

Architecting Smart Solutions

Integrating systems and sharing data within organizations (system of systems)

Integrating services and sharing data across organizations (Data Spaces)
Four major layers:
- Data acquisition
- Data management
- Data processing/analysis & visualization
- Application layer

Data acquisition layer
- Interface to IoT devices
- Interface to cameras
- Interface to robots

Processing/analysis and visualization
- Integration with most popular Apache processing engines (Spark, Flink, …)
- Advanced web mashup and if-then-else tools

You may use FIWARE components … or pick those you are interested and combine with 3rd components to create hybrid platforms
Smart Vertical Solutions
Digital Twins: an approach for integration at multiple levels

Integrating systems and sharing data within organizations (system of systems)

System 1
System 2
System 3
System 4

Integrating services and sharing data across organizations (Data Spaces)

Smart City
Smart Building
Smart Logistics
Smart Grid
Smart Organizations: Reference Architecture following a System of Systems approach (Smart Manufacturing)
Digital Twins: an approach for integration at multiple levels

Architecting Smart Solutions

Integrating systems and sharing data within organizations (system of systems)

Integrating services and sharing data across organizations (Data Spaces)
Smart Organizations: Reference Architecture following a System of Systems approach (Smart Cities)
Smart Organizations: Reference Architecture following a System of Systems approach (Smart Agrifood)
Smart Organizations: Reference Architecture following a System of Systems approach (Smart Energy)
FIWARE vision for Data Spaces

- Fundamental principle in Data Spaces for a Data Economy:
  - Data providers publish data resources knowing that consumers, which are unknown “a priori”, will know how to consume them
  - Data consumers know how to consume data resources published by data providers they can discover

- This requires all participants to speak the same “language”:
  - Data exchange API (the sentences you construct)
  - Standard data models (what you speak about - dictionary)
  - Common mechanisms for Identity and Access Management (IAM) (who speaks under what rules)

- Data Spaces powered by FIWARE involve smart applications exchanging context / digital twin data:
  - Standard Digital Twin API: ETSI NGSI-LD
  - Common data models: Smart Data Models initiative
  - IAM based on standards: OpenID Connect → VC/VP, XACML
    PEP/PDP/PMP architecture implementing ABAC/RBAC

- Besides:
  - Trust Anchor Services leveraging eIDAS
  - Publication and Marketplace services: DCAT-AP, TM Forum APIs
  - Management of provenance, traceability: integration with DLTs
Effective and trusted data sharing

Marketplace / Publication Platform

Traffic prediction service
- IdP
- Auth

Trust Authority

Data Space

Weather Forecast Service

Smart City

Smart Packet Delivery Co

IdP

Auth

Context Broker
FIWARE: what is going on

- Digital Twin standardization
  - Consolidate NGSI-LD as reference standard
  - Standardization of advanced Digital Twin features
- Continue the definition of standard Data Models
  - Smart Data Models initiative – JOIN US!
  - Cross-domain perspective
- Integration with blockchain / DLTs:
  - Transparency in processes - quality certification
  - Audits and forensics
- Integration with AI/ML technologies:
  - Standard architecture enabling "AI/ML as a service"
  - plug&play extensibility of systems with AI/ML services
- Integration with Robotic systems:
  - Standardization of interfaces to robotics systems
  - Context-aware, smart, collaborative robots

- Data Spaces / Marketplaces – Data Economy
  - Creation of multi-side markets
  - Monetization of data to incentivize sharing
  - Decentralized Identity and Access Management (IAM)
  - Data Usage Control
Success Stories (some of the Impact Stories on fiware.org)

- **Smart Cities:**
  - Japan municipalities collaborating for disaster resiliency and sustainable growth
  - A platform to support the decision-making of public administrations on environmental matters
  - A Powered-by-FIWARE solution to provide a personalized view of urban data to citizens in the City of Malaga

- **Smart Industry:**
  - Elliot Cloud is helping São Paulo to manage its water resources network
  - Container and Shipment tracking System in India
  - SARA IoT platform: designed to operate with maximum efficiency
  - Discover trends and predict anomalies in the shopfloor

- **Smart Agrifood:**
  - IoT, AI and Blockchain based platform improving livestock Farming
  - AGRICOLUS: the cloud data platform to support and optimise Farmers’ work

- **Smart Energy:**
  - FIWARE Context Broker: The engine for future energy systems

- **Health:**
  - How biosurveillance and Open Source technologies are jointly contributing to fight COVID-19
Conclusions

- FIWARE brings response to existing challenges regarding interoperability and replicability of smart solutions in multiple sectors:
  - Relying on Digital Twin vision
  - Supporting System of Systems – Data Spaces integration
- An approach paving the way for the connection of systems across domains
- An approach that is future proof – comprehensive roadmap in place
- And don’t forget …

FIWARE is open, for all, for ever !!
Don’t miss the opportunity!

Get ready for two days of world-class innovation, collaboration, and networking.

Our two-days physical Summit is back – and we cannot wait to see you all again!

Play a key role in a truly smart journey to Digital Transformation – be part of this growing global network.

FIWARE connects all who want to change the world, foretell the future and transform markets for the better - based on recognized Open Source technology.

i4Trust 2nd Open Call
Data Spaces for effective and trusted data sharing

Apply now

OPEN CALL CALENDAR
Submission of Application Starts:
May 4, 2022 (10:00, CEST)

Submission Deadline:
September 12, 2022 (16:00, CEST)
Sounds nice? - Contact us!

http://fiware.org
Follow @FIWARE on Twitter

Juanjo Hierro
FIWARE Foundation CTO
juanjose.hierro@fiware.org