Mission Statement

The InterConnect Semantic Interoperability Framework (SIF) is pioneering semantic interoperability without a centralized facilitator in cross domain challenges related to grids and smart homes/buildings.

Description

The InterConnect Semantic Interoperability Framework (SIF) is specified, implemented and validated in the scope of the InterConnect project (Interoperable Solutions Connecting Smart Homes, Buildings and Grids) which was funded by the European Commission as part of the Horizon 2020 work program under grant agreement number 857237. 50 partners worked on the project between 1st of October 2019 until 31st of March 2024.

One of the main challenges that the InterConnect project was tasked with was establishing and demonstrating semantic interoperability between digital systems (platforms, services, devices) from the grid/energy domain and IoT (smart buildings and homes) domain. To this end, the consortium members worked on specification and implementation of the InterConnect SIF. The SIF is realized as a set of tools, software components and validated methodologies that allow stakeholders to interconnect their semantically interoperable solutions into interoperable ecosystems. These interoperable ecosystems are the basis for developing innovative services, use cases and business models capitalizing on the semantic interoperability, knowledge dissemination and control in cross-domain setups.

A top-down and bottom-up approach were conducted for deriving requirements and identifying the best practices for the SIF. The top-down approach included analysis of reference architectures and best practices from other initiatives and previous projects. Projects like Platoon, Platone, OneNet, European IoT Platform Initiative projects (most notably Vicinity, symbIoTe and InterIoT) and initiatives like BRIDGE, FI-WARE, BDVA, IDSA and OpenDEI were carefully assessed, especially their approaches for handling intra/inter domain interoperability on syntactic and semantic levels. The bottom-up approach started with creation of the InterConnect catalogue of digital platforms brought to the project pilots by the project's participants. Their capabilities and requirements for syntactic and semantic interoperability, knowledge sharing and semantic based control limitations and potential and security and data protection mechanisms are assessed and used as guiding requirements for SIF specification. This was necessary in order to ensure acceptance and validation at scale, first by consortium members and then by 3rd party integrators.

Based on collected requirements and identified best practices, the InterConnect project team proceeded to specify and implement the SIF as a collection of software enablers and tools namely

the Semantic Interoperability Layer, the Service Store, the Generic Adapter and the P2P marketplace enablers. A set of supporting tools is also available which ease the process of achieving semantic interoperability and becoming part of InterConnect semantically interoperable ecosystems. We started by confirming the main challenges for cross domain semantic interoperability and, in general, the main obstacles for wider adoption of semantic web technologies in the domains covered by the project:

- Steep technology learning curve - It is a disruptive paradigm based on information dissemination, rather than a one-to-one data exchange approach used today by digital systems.
- Agreeing business level interoperability between industrial leaders requires that the process is cost effective and risk free.

Most solution deployed, in practice, call for centralized interoperability facilitator, but that comes with a set of challenges:

- Dependability on centrally hosted facilitators both technically- and business-wise;
- Data needs to be processed by a 3rd party which opens new data and privacy protection risks;
- Performance is dictated by capacity of the facilitating platform;
- Accepting new technologies and standards depends on the facilitating platform operator;
- End-to-end cybersecurity is limited by the security measures employed by the facilitating platform.
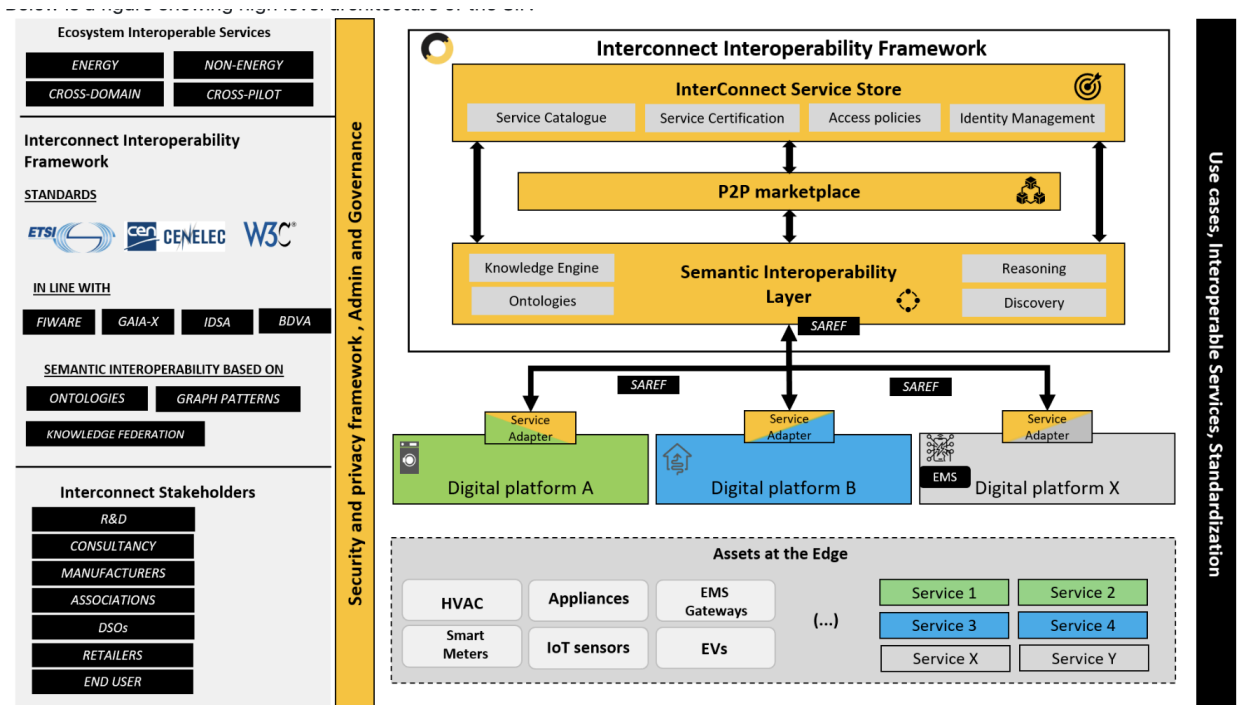 The SIF addresses these challenges and requirements in the following way:
- The project enables cross-domain semantic interoperability to be established in a distributed manner among already existing digital platforms – no need for a centrally hosted facilitating platform.
- Interoperability originates at stakeholder's end, and it does not disrupt existing practices – this is achieved with the Service Adapters.
- Semantic interoperability within the project is based on SAREF ontology. However, the developed enablers are ontology agnostic.
- The achieved semantic interoperability enhances security and privacy protection measures by securing communication interfaces and providing integrators with means to enforce their security related best practices as well as to customize knowledge flows through selecting.
- The enablers of the project can be deployed on all system levels from devices over the edge to the cloud.
- Finally, semantically interoperable ecosystems provide federate knowledge spaces capable of providing answers to complex queries issued by stakeholders. This is also the basis for establishing intra and inter-domain data spaces.

The InterConnect SIF is developed as an open source software framework which includes several key software components which have their own repositories and can be even used separately from the rest of the framework. The core components are:

- Semantic Interoperability Layer is based on the Knowledge Engine technology aimed at providing semantic interoperability by means of two features: translation and discovery. Both features require a common ontology. The ontology of choice for the InterConnect Interoperability Framework is SAREF together with several extensions that complete the InterConnect ontology. It is important to state that the Knowledge Engine is ontology agnostic and, in principle, able to work with any ontology if it is expressed in the RDF/OWL format. The Knowledge Engine is an open source project managed by TNO, one of three core partners behind interConnect SIF (see current leads).
- Service Store is the "frontend" of the whole interoperable ecosystem built with the InterConnect SIF. The service store is conceptualized as a web service with its front-end and back-end modules and processes. The main objective is to enable building of the InterConnect ecosystem of service providers and adopters by allowing them to register new interoperable services and browse existing ones to identify services best suited for the challenge at hand and get all necessary information for accessing and properly utilizing selected services. The service store is the main identity provider for the SIF project, and it is responsible for providing trustworthiness towards integrators that the services listed in its catalogue are indeed interoperable and can be trusted for integration into semantically interoperable ecosystems. The Service Store also provides Knowledge Explorer functionality which enables visualization of the semantically interoperable ecosystems established by stakeholders. The Service Store is available for independent hosting by integrators if necessary.
- Generic Adapter is a software gateway for secure and trusted communication between a service and a wider Interoperability Framework instance (including Service Store and the Knowledge Engine). The project introduced three adapter concepts. First, we have a Service Specific Adapter (SSA) where legacy interfaces and data models of the integrator's services are mapped onto the InterConnect SIF interfacing logic and project's SAREF-based ontology. Next, we have the Generic Adapter (GA). The GA provides unified REST API towards Service Specific Adapter. This GA REST API ensures communication with the Service Store for authentication and authorization of the service and the GA itself with the central identity provider. The GA REST API also facilitates interactions with the semantic interoperability layer (Knowledge Engine instance) by providing methods for Knowledge Base and Knowledge Interaction registration and also methods for executing corresponding knowledge exchanges. The SSA and GA combine into InterConnect Service Adapter which represent a complete semantic interoperability enabler which on the "south side" integrates with the legacy interfaces and service logic and on the "north side" exposes unified interface that all participants in the semantically interoperable ecosystem understand.
- P2P marketplace enablers which are provided as deployable containers that allow pilot owners and integrators to deploy and fully manage P2P marketplace instances. The established P2P marketplaces are in full control and under jurisdiction (regulatory, market wise, data privacy protection) of the integrators. The goal was to develop enablers which would allow establishment of blockchain ledgers shared between community members and supporting community specific services for data exchange in the project pilots. The P2P marketplace enablers include Hyperledger Fabric blockchain network configurations, set of smart contracts for energy related trading and aggregation, configurable order matching engine and white labeled web application for testing purposes. This component is an auxiliary part of the InterConnect SIF.

Below is a figure showing high level architecture of the SIF.

The InterConnect SIF has been validated within 7 pilots in Greece, France, Italy, Germany, The Netherlands, Belgium and Portugal. More than 60 integrators of the framework components until now.

Is this a new project or an existing one?

Existing one. InterConnect SIF is implemented under the EU funded H2020 project InterConnect.

Current lead(s)

- INSTITUTO DE ENGENHARIADE SISTEMAS E COMPUTADORES, TECNOLOGIA E CIENCIA (short INESC TEC) from Portugal represented by Fabio Coelho (fabio.a.coelho@inesctec.pt) and David Rua (david.e.rua@inesctec.pt).
- FONDACIJA VIZLORE LABS (short VLF) from Serbia represented by Milenko Tosic (milenko.tosic@vizlore.com).
- NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETENSCHAPPELIJK ONDERZOEK (short TNO) from the Netherlands represented by Gjalt Loots (gjalt.loots@tno.nl).

Sponsoring organization(s), along with any other key contributing individuals and/or organizations

The European Commission supported the base context and provided grant for developments. Current sponsors - INESC TEC, VLF and TNO (see the Current Leads section).

Detail any existing community infrastructure, including:

- Github/GitLab, or other location where the code is hosted
- Website and/or docs
- Communication channels (such as Mailing lists, Slack, IRC)
- Social Media Accounts

GitLab with Wiki page:

https://gitlab.inesctec.pt/groups/interconnect-public/-/wikis/home#interconnect-interoperability-framework

Page under the InterConnect project website: https://interconnectproject.eu/about/#sif

Youtube videos (within the InterConnect youtube channel):

https://www.youtube.com/watch?v=2ug6t6QIE3Q

https://www.youtube.com/@interconnectproject571/videos

LinkedIn page of the InterConnect project: https://www.linkedin.com/company/interconnect-project/

Facebook page of the InterConnect project: https://www.facebook.com/InterConnectPrj/

Are there any specific infrastructure needs or requests outside of what is provided normally by LF Energy ? If so please detail them.

No at the moment.

Why would this be a good candidate for inclusion in LF Energy?

- Interoperability is considered as one of the biggest challenges in the energy systems. The InterConnect SIF brings a set of open source software tools and best practices from a large scale European union innovation project that can be used by integrators from various domains to reach semantic interoperability and unlock full potential of deployed resources and services.

- InterConnect SIF is focused on standard ontology from ETSI (SAREF ontology). This provides a solid basis for modeling knowledge representations and opens ways for direct standard extensions in line with the needs of the energy sector.
- InterConnect SIF is a proven solution for achieving cross domain interoperability. The grid stakeholders must interoperate with stakeholders from other domains (e-mobility, IoT - Smart Homes/Buildings, Smart Cities, Smart Manufacturing etc.) in order to boost efficiency and stability of the overall system.
- The InterConnect SIF software enablers can be used by other LF Energy projects to achieve semantic interoperability with a standard ontology. The SIF is ontology agnostic and other standard or best practice ontologies can be utilized.

How would this benefit from inclusion in LF Energy?

- Visibility worldwide - we have good visibility within the EU and we want to expand the reach globally.
- InterConnect SIF software compliance checks and validation. Improving existing and establishing missing open source software and community practices.
- Securing community contributions and co-development of the key enablers, verification of the best practices and introduction of new support tools.
- Cooperation with other LF Energy projects on interoperability challenges and bringing their digital solutions into the SIF interoperable ecosystem.
- Under LF for Energy we seek to establish a vendor neutral project which would improve its appeal towards major integrators.
- Receiving technical and market guidance from a broader group of experts and potential stakeholders.

Provide a statement on alignment with the mission in the LF Energy charter.

We are an open source project addressing interoperability challenges in cross domain setups of grids and smart buildings. This maps are well to the point 1.a) under the LF Energy Charte mission. 1.a The purpose of the Directed Fund is to raise, budget and spend funds in support of various open source and/or open standards projects relating to the generation, transmission, distribution and delivery of energy, including infrastructure and support initiatives related thereto.

What specific need does this project address?

InterConnect SIF addresses the challenge and need of interoperability among digital systems, services and devices on syntactic and semantic level. The SIF provides a framework approach so that the semantic interoperability can originate at the interface of existing services and platforms without the need for a centralized facilitator. The integrators remain in full control over the knowledge

dissemination provinces and they choose with whom to establish semantically interoperable ecosystems and around which services and interfaces.

Describe how this project impacts the energy industry.

The EU and global energy market is conditioned by digitalisation. New rules and technological developments allow the proliferation of energy service providers in all markets with users having full knowledge and control over their appliances. However, interoperability represents a serious problem. Major systems are vendor locked and organized within protocol/standard siloes. There is limited interoperability within the energy sector and especially between energy sector and other sectors which put significant strain onto the overall system stability (e.g. IoT, smart homes, buildings, cities, e-mobility, smart manufacturing). Users are also seeking options to avoid vendor lock-in not just for appliances and devices but also for service providers. Only properly established interoperability on semantic level can create a truly flexible ecosystem where knowledge is disseminated and used within and between domains which would provide benefits for end users and stability and further growth for the energy system.

Describe how this project intersects with other LF Energy projects/working groups/special interest groups.

InterConnect SIF could benefit all existing LF Energy projects with a set of enablers for achieving semantic interoperability. This approach and framework can be used by all other projects within LF Energy with the need for syntactic and semantic interoperability. The existing projects could expand their services in cross--domain setups with the newly established semantic interoperability. The InterConnect SIF project can adapt to new standards and interfacing technologies and complement existing interoperability capabilities towards a more connected ecosystem.

Who are the potential benefactors of this project?

- Other LF Energy projects seeking interoperability enablers.
- Manufacturers of appliances and other devices.
- Service providers (grid and smart buildings).
- Integrators of grid and smart home/building solutions.
- Grid operators, retailers, aggregators.
- Smart building operators.
- EV fleet and charging network operators.
- Data space initiatives and projects.
- Other research projects.

What other organizations in the world should be interested in this project?

European and global data space initiatives and projects - BDVA, IDSA, Gaia-X.
Organizations representing the above listed benefactor categories.

Plan for growing in maturity if accepted within LF Energy

- Refactoring the code base towards production ready state.
- Validation of the solutions and established best practices with new integrators.
- Confirming replicability at a global level (EU based until now).
- Alignment with additional standards (protocols, data models and ontologies).
- Validation and strengthening of open source practices.
- Establishment of a roadmap supported by a community.
- Improving user (service providers) experience and streamlining the onboarding and maintenance process based on feedback from the community and new integrators.

Project license

Apache 2.0 and GNU 3.0 (Service Store to be migrated to Apache 2.0).

Is the project's code available now? If so provide a link to the code location.

Yes, the key building blocks have their own repositories all under the project Gitlab.
Knowledge Engine - https://gitlab.inesctec.pt/interconnect-public/knowledge-engine
Service Store BE - https://gitlab.inesctec.pt/interconnect-public/service-store-backend
Service Store FE - https://gitlab.inesctec.pt/interconnect-public/service-store-frontend
Generic Adapter - https://gitlab.inesctec.pt/interconnect-public/generic-adapter
P2P marketplace enablers (different branches are different configurations) -
https://gitlab.inesctec.pt/interconnect-public/p2p-marketplace

Does this project have ongoing public (or private) technical meetings?

Yes, private meetings.

Does this project's community venues have a code of conduct? If so, please provide a link to it?

Our ongoing activities are specified by the project's grant agreement and consortium agreement (standard practice for the EU funded projects). Going forward we will fully align with the LF for Energy code of conduct.

Describe the project's leadership team and decision-making process.

The project is currently led by a team of four decision makers (from three organizations - see the Current Leads section) with equal voting rights. All decisions regarding new research directions, development, integration, partnering and deployment is made with voting where 3 out of 4 in favor constitutes a decision to move forward.

Does this project have public governance (more than just one organization)?

Yes, three organizations are directly involved in the project and decision making (see Current Leads section).

Does this project have a development schedule and/or release schedule?

Yes, the development roadmap and release schedule were followed in line with the InterConnect project's work plan and grant agreement.
Going forward, the release schedule and roadmap are going to be set in accordance with new opportunities and LF for Energy requirements.

Does this project have dependencies on other open source projects? Which ones?

Yes,
Knowledge Engine.
Hyperledger Fabric for P2P marketplaces.

Details for all dependencies (libraries and open source tools) can be found within the main repositories.

Describe the project's documentation.

Wiki page for overall description of the project and key components also providing linkage to the main repositories. Technical documentation, guidelines and examples accompanying every key repository.
https://gitlab.inesctec.pt/groups/interconnect-public/-/wikis/home

Describe any trademarks associated with the project.

None

Do you have a project roadmap? If so please attach or provide a link.

Roadmap was aligned with the InterConnect work plan and Grant Agreement.
A new roadmap is in preparation for the next two years and it will be aligned with the LF for Energy community requirements.

Are this project's roadmap and meeting minutes public posted?

No

Does this project have a legal entity and/or registered trademarks?

No

Has this project been announced or promoted in any press?

Yes, as part of the InterConnect project, the InterConnect SIF was featured in news articles, public events and newsletters.

https://interconnectproject.eu/clippings/

https://www.youtube.com/watch?v=2ug6t6QIE3Q

Does this project compete with other open source projects or commercial products?

No. The InterConnect SIF is positioned as an enabling technology for building interoperable ecosystems on syntactic and semantic levels. It can complement or run in parallel with other solutions and middlewares for interoperability.

Add tasklist