Project Acronym:	**VICINITY**
Project Full Title:	**Open virtual neighbourhood network to connect intelligent buildings and smart objects**
Grant Agreement:	**688467**
Project Duration:	**48 months (01/01/2016 - 31/12/2019)**

Deliverable D2.4

Report on Standards Involvement over life of project and conformance assessment

Work Package:	**WP2– Standardization Analysis and VICINITY platform conformity**
Task(s):	T2.3 VICINITY platform standardization and conformity assessment
Lead Beneficiary	TU Kaiserslautern
Due Date:	31 December 2019 (M48)
Submission Date:	09 January 2020
Deliverable Status:	Final
Deliverable Type:	R
Dissemination Level:	PU
File Name:	VICINITY_D2.4_Report_on_Standard_Involvement_over_life_of_project_and_conformance_assessment_v1.0

VICINITY Consortium

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13.	HAFENSTROM AS	HITS	Norway
14.	Enercoutim – Associação Empresarial de Energia Solar de Alcoutim	ENERC	Portugal
15.	Municipality of Pylaia-Hortiatis	MPH	Greece

[1] ***Deliverable Type:***
R: Document, report (excluding the periodic and final reports)
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc.

[2] ***Dissemination level:***
PU: Public, fully open, e.g. web
CO: Confidential, restricted under conditions set out in Model Grant Agreement
CI: Classified, information as referred to in Commission Decision 2001/844/EC.

This project has received funding from the European Union's Horizon 2020 Research and innovation programme under Grant Agreement n°688467

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Revision Control

Version	Date	Status	Modifications made by
0.1	1.11.2019	Initial Draft	Kölsch (UNIKL)
0.2	11.11.2019	Draft	Hovstø (HITS)
0.3	12.12.2019	Draft	Keith Dickerson (CAL)
0.4	16.12.2019	Draft/Merge	Kölsch (UNIKL)
0.5	18.12.2019	Draft	Kölsch (UNIKL)
0.7	02.01.2019	Draft	Dickerson (CAL), Hovstø (HITS)
0.8	06.01.2020	Final Draft reviewed	Reviewers, Kölsch (UNIKL)
1.0	09.01.2020	Submission to the EC	Dickerson (CAL), Hovstø (HITS), Kölsch, Zivkovic (UNIKL)

Executive Summary

This deliverable summarises the involvement of the VICINITY project in Standardization over the life of the project from 2016 to 2019. This is covered in 4 parts:

- The use of Standards by VICINITY
- The participation of VICINITY partners in Standards bodies, fora and consortia
- The promotion of Standards by VICINITY
- VICINITY contributions to Standards

It is concluded that VICINITY has made an essential contribution to Standardization, particularly in the areas of cross-domain use cases and semantic ontologies. The incorporation of the VICINITY ontology in the W3C WoT ontology was particularly successful and VICINITY concepts also contributed to the development of SAREF, especially the extensions related to Buildings, Energy and Cities. [1]

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List of Definitions & Abbreviations

Abbreviation	Definition
ACTIVAGE	Large-scale Horizon 2020 project for assisted living communities
AIOTI	Alliance for Internet of Things Innovation
CD	Committee Draft
CDP	City Digital Profile
CECED	European Committee of Domestic Equipment Manufacturers
CIM	Context Information Management
DIS	Draft International Standard
DPM	Data Processing and Management
DTR	Draft Technical Report
EC	European Commission
ETSI	European Telecommunications Standards Institute
EU	European Union
FDL	Forum on specification & Design Languages
ICT	Information & Communication Technologies
IEC	International Electrotechnical Committee
IIC	Industrial Internet Consortium
IIoT	Industrial Internet of Things
IoT	Internet of Things
ISG	(ETSI) Industry Specification Group
ISMS	Information Security Management System
ISO	International Organization for Standardization
ITS	Intelligent Transport Systems
ITU	International Telecommunications Union
JCA	Joint Coordination Activity
OCF	Open Connectivity Foundation
OSGi	Open Service Gateway Initiative
OWL	W3C Web Ontology Language
P2P	Peer to Peer
SAREF	Smart Appliances REFerence ontology
SAREF4BLDG	Smart Appliances REFerence ontology for Buildings
SAREF4CITY	Smart Appliances REFerence ontology for Cities
SC&C	Smart Cities and Communities
SDO	Standards Developing Organisation

SEDC	Smart Energy Demand Coalition (now Smarten)
USEF	Universal Smart Energy Framework
W3C	World Wide Web Consortium
WD	Working Draft
WG	Working Group
WoT	Web of Things

1. Introduction

This Deliverable (D2.4) summarizes the involvement of the VICINITY project in standardization. The tables contained in Annexes A and B of D2.1 [2] were taken as the starting point for this involvement. These were not followed strictly as the standards environment and the needs of VICINITY changed over the life of the project. Furthermore, several of the bodies identified in the Action Tables in Annex A of D2.1 merged (such as the AllSeen Alliance which merged with OCF) or changed their names (such as SEDC which became Smarten) over the period. Several new bodies were created (such as the W3C WoT WG and MyData) which it was found necessary to participate in, while others were shown not to be relevant to VICINITY's objectives (such as IIC). Hence it can be concluded that the consortium followed a dynamic approach and adopted to evolving environment within a number of domains, while keeping core focus on semantic interoperability.

1.1. Context within VICINITY

The Deliverable 2.4 (Report on Standard Involvement over life of project and conformance assessment) document is part of WP2 (Standardization Analysis and VICINITY platform conformity). It is derived from the Deliverable 2.1 where the standardization context was analyzed and the standards to be involved were chosen.

1.2. Objectives in Work Package 2 and Task 2.3

The objective of WP2 was to validate the ontologies and interfaces specified by the project and contribute the results and experience to standardisation bodies, in particular to ETSI, ISO, IEC as the relevant SDOs. WP2 defined a semantic model for cross-domain IoT networks and demonstrated and validated it in real scenarios. WP2 supported the correlation between the proposed semantic model and existing IoT platforms and infrastructure. Finally, the evaluation of demonstrators was used to validate the model and produce recommendations on the corresponding standardization.

2. Use of standards by VICINITY

This section identifies the main areas where Standards were used by the VICINITY project. Only the most important areas to VICINITY are identified and the VICINITY platform used many embedded standards that are ubiquitous such as those used by mobile networks (e.g. from 3GPP) and by wireless LANs (such as IEEE 802). These are not considered relevant to the main aims of VICINITY project and so are not listed here. Standards for the application (pilots) areas such as ITS and eHealth are also not listed in detail.

2.1. W3C Semantic Web Standards

In order to develop the VICINITY ontology network, the following semantic web standards defined by the W3C have been used:

- RDF: Resource Description Framework (https://www.w3.org/TR/rdf11-primer/). This standard has been used as data model both for ontologies and data stored in the semantic repository.
- OWL: Web Ontology Language (https://www.w3.org/TR/owl-ref/). This standard has been used to implement the VICINITY ontology network available at http://vicinity.iot.linkeddata.es
- SPARQL: SPARQL Protocol and RDF Query Language (https://www.w3.org/TR/sparql11-query/). This standard is used by the Gateway API in order to retrieve data from different IoT infrastructures.

These standards shape the technical basis on top of which ontologies that enable the semantic interoperability are described.

2.2. Ontology Standards

Reusing ontologies is considered the best practice as reuse promotes in a straight forward way the development of more interoperable ontologies while saving resources during ontology development. In this sense, the VICINITY ontology network has been built considering the reuse of existing ontologies when possible. From the reused ontologies, the following ones are provided by standardization bodies, therefore, considered standard ontologies:

- W3C ontologies
  - sosa: Sensor, Observation, Sample, and Actuator (SOSA) Ontology (http://www.w3.org/ns/sosa/)
  - ssn: Semantic Sensor Network Ontology (http://www.w3.org/ns/ssn/)
  - ssn-system: System capabilities, operating ranges, and survival ranges ontology (http://www.w3.org/ns/ssn/systems/)
- ETSI ontologies:
  - s4bldg: SAREF 4 Building (https://w3id.org/def/saref4bldg#)
  - s4city: SAREF 4 Smart Cities (https://w3id.org/def/saref4city#)

These ontologies shape the basis which is re-used and serves as starting point of VICINITY's semantical interoperability.

2.3. Standards for Evaluation

The VICINITY evaluation framework defined in D8.1 Business Scenarios & Evaluation Framework [3] was based on ETSI TS 103 463-2 *Key Performance Indicators for Sustainable Digital Multiservice Cities* [4].

For security evaluation defined in D6.4 *VICINITY security and privacy evaluation report* [5], ISO/IEC 27001:2013 and ISO/IEC 27030 *Guidelines for security and privacy in Internet of Things (IoT)* were used for Information Security Management System (ISMS) requirements and practice using ISO/IEC 27002:2019 as a baseline standard.

2.4. Conformity with industrial standards

Interoperability, as the prime objective of VICINITY, is not just based on semantic interoperability with standards. Beyond that we have seen the importance of industrial standards that deliver the ease of use and the ability to directly start using devices without further issues. In that sense, VICINITY adapters are essential in our conformity with standards as shown in Figure 1. The set of adapters shown in Figure 1 is purely illustrative. The actual adapters used in any specific implementation will be determined by the use cases and value-added services and their interoperability requirements.

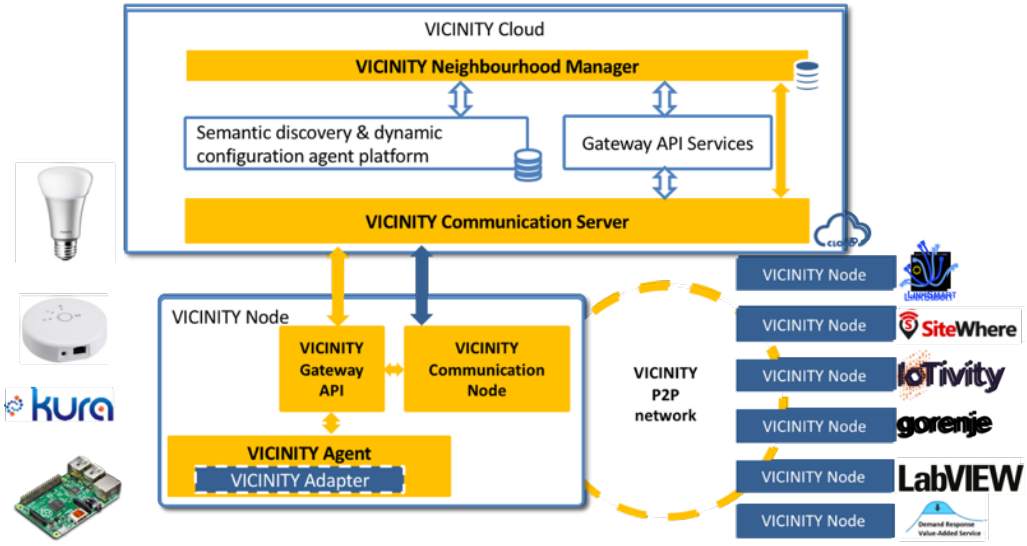


Figure 1: Use of adapters to provide standards conformance in VICINITY.

The list of VICINITY adapters at the level of IoT gateways is continuously growing and incorporates industrial standards such as Link Smart, SiteWhere, IoTivity, LabVIEW, Eclipse Kura and openHAB. A more complete list of adapters is shown below.

As of 30-12-2019, VICINITY includes the following adapters:

- IWMAC Adapter
- TinyMesh Adapter
- Cayenne Adapter
- FIWARE-NGSIv2 Adapter
- Kura Adapter
- OpenHab Adapter
- IoTivity Adapter for Smartplug

- SiteWhere Adapter
- LinkSmart Adapter
- IoTivity Adapter for MPH Houses
- PNI adapter
- IKEA Light Adapter
- LabVIEW Adapter
- SaMMY Adapter
- OneM2M Adapter
- OPA Adapter
- BARTER Adapter

An up-to-date overview can be seen under https://vicinity-h2020.eu/vicinity/content/adapters.

VICINITY has also shown conformity with industrial standards at the lower system layers. Zigbee and OSGi are especially relevant as de-facto standards in industry.

3. Participation in Standardization

This section identifies the main standards bodies, fora and consortia where VICINITY partners have participated over the life of the project in order to achieve VICINITY objectives.

The contributions made to these bodies are listed in Section 5.

This section does not include bodies such as AIOTI which do not develop standards themselves but promote the use of standardisation for the IoT. These bodies are listed in Section 4 Promotion of Standards.

3.1. British Standards Institute (BSI)

CAL participated in SDS/2 "Smart and sustainable cities and communities". Input from VICINITY contributed to deliverables on Smart City Reference Models and Architectures.

3.2. ETSI ISG City Digital Profile (CDP)

ISG CDP was set up by ETSI in 2018 to develop tools to take smart city technologies that have been successful in one city and replicate them in other cities, taking into account differences in city size, population, culture, etc. CAL and ENERC participated in ISG CDP over a period of 1 year while it was defining its scope and objectives. The contributions made are listed in Section 5. Unfortunately, the group closed prematurely in 2019, before it achieved its objectives, due to its inability to secure continuing support from representatives from city administrations. However, it developed a white paper aimed at high level decision makers (such as city mayors) on horizontal approaches to smart city initiatives. [5]

3.3. ETSI ISG Context Information Management (CIM)

This group was set up by ETSI in 2017 to develop a Context Information Management layer which will sit above the oneM2M Service Layer and be used to integrate data for Smart City and other cross-domain applications. CAL, UPM and ATOS participated in ISG CIM in 2017 and 2018 while it was defining use cases, architectures and APIs. The ETSI ISG CIM Group Report on Use Cases [6] was published in 2018 and identified a number of cross-domain use cases that are relevant to Context Information Models including:

- Sharing information between parking management systems and traffic management applications.
- Smart Street Lighting.
- Traffic Management/Pricing based on Air Quality, Congestion, and other KPIs.
- Assisted Living
- Crowd Control and Emergency Response
- Management of Optical Fiber Network Deployment

Several of these use cases included input from VICINITY via CAL and UPM.

3.4. ETSI TC SmartM2M

The ETSI Technical Committee on Smart Machine-to-Machine communications (Smart M2M) was set up in 2013 to develop specifications for M2M services and applications, focusing on IoT and Smart Cities. UPM, CAL and HITS participated in TC SmartM2M during the period 2016-2019. During this period TC SmartM2M defined the impact of Smart Cities on IoT [7] and developed SAREF [1].

3.5. Industrial Internet Consortium (IIC)

The Industrial Internet Consortium (IIC)[1] was set up in 2014 to bring together the organizations and technologies necessary to accelerate the growth of the industrial internet by identifying, assembling, testing and promoting best practices. At the EC Review in 2018 it was suggested that it might benefit VICINITY to participate in this group. UNIKL monitored IIC for a short period in 2018 but it was decided that IIC was not relevant to VICINITY, since the group doesn't provide any own standards and the use cases were out of the scope of VICINITY.

3.6. ITU-T FG/DPM

The objective of participating in the ITU-T Focus Group on Data Processing and Management was to contribute and verify examples of data processing management requirements and use cases from VICINITY. CAL and UPM participated in the group in 2018 and 2019 while the group was defining use cases, architectures and reference models. CAL provided a vice chair of FG/DPM and during this time an example use case from VICINITY was contributed to the group (see Section 5) and included in the final deliverable on use cases [8].

3.7. MyData

MyData[2] are contributing to standards for Privacy. ENERC and CAL participated in MyData in Helsinki in August 2018 and worked on privacy considerations for use cases relevant to the supply and consumption of energy.

3.8. Smarten (previously SEDC)

The objective of participating in the Smart Energy Demand Coalition (SEDC) was to contribute and verify the VICINITY energy model. ENERC participated from 2017-2019 and continues to be member. ENERC participated in workshops and contributed to policy input:

- E-Privacy
- Flexibility provision
- Energy communities

3.9. W3C WoT

VICINITY partners are part of the W3C Web of Things Interest Group and Working Group that actively participate in virtual meetings. In addition, the VICINTIY WoT ontology has been developed according to the W3C working group needs being the seed ontology for the W3C Web of Things ontology being published in these days.

Besides, we participated in the "Second W3C Workshop on the Web of Things The Open Web to Challenge IoT Fragmentation" with the article *Towards Semantic Interoperability in WoT Ecosystems.* In the article, and later presentation, we introduced the semantic interoperability approach developed in VICINITY that is based on the W3C WoT ontology. The approach allows to transparently discover Things relaying on the

[1] https://www.iiconsortium.org/

[2] https://mydata2019.org

descriptions, and then, to perform a distributed access to the suitable endpoints in order to answer an issued query. Therefore, it performs a context and content search over all the IoT infrastructures registered in VICINITY. In addition, this approach can be integrated easily with any security and privacy policy.

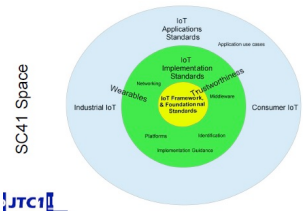
3.10. IoT.schema.org

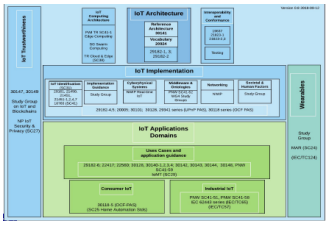
The iot.schema.org extension is a hosted extension of schema.org, a vocabulary founded by Google, Microsoft, Yahoo and Yandex and developed by community processes. This schema.org extension exploring the use and extension of schema.org for semantic interoperability with IoT having common target with the W3C Web of Things Working Group. VICINITY partners have participated in the virtual meetings of the iot.schema.org initiative.

3.11. ISO/IEC

Relevant SDO committees contributing to standards preparations for IoT are SC41 hosted by IEC. SC27 contributes on trustworthiness on IoT through their working group on Security and Privacy Controls (WG4).

3.11.1. SC41 Internet of Things and Related Technologies





JTC 1/SC41 Terms of references

Title: Internet of Things and related technologies

Scope: Standardization in the area of Internet of Things (IoT) and related technologies.

1. Serve as the focus and proponent for JTC 1's standardization programme on the Internet of Things and related technologies, including Sensor Networks and Wearables technologies.
2. Provide guidance to JTC 1, IEC, ISO and other entities developing Internet of Things related applications.

ISO/IEC	Published Standards – Titles	Year
30141	Internet of Things (IoT) – Reference architecture	2018
20924	Internet of Things (IoT) – Vocabulary	2018
21823	Internet of Things (IoT) – Interoperability for IoT Systems – Part 1: Framework	2019
TR22417	Information technology – Internet of Things (IoT) – IoT use cases	2017
29182	Information technology – Sensor networks: Sensor Network Reference Architecture	2013
30140	Information technology – Underwater acoustic sensor network	2018
30101	Information technology – Sensor networks and its interfaces for smart grid system	2014
30128	Information technology – Generic Sensor Network Application Interface	2014
19637	Information technology – Sensor networks testing framework	2016
20005	Information technology – Services and interfaces supporting collaborative information processing in intelligent sensor networks	2013
TR22560	Information technology – Sensor network – Guidelines for design in the aeronautics industry: Active air-flow control	2017

Table 1: Published Standards related to VICINITY-

On-going projects:

Project	Stage	Abstract
ISO/IEC 30149 ED1 - Internet of Things (IoT) - Trustworthiness framework	WD	Frameworks, guidance and references for trustworthiness considerations and controls of Internet of Things (IoT) Solutions
ISO/IEC 30165 ED1 - Internet of Things (IoT) – Real-time IoT framework	CD	System of a real-time Internet of Things (RT-IoT) system
ISO/IEC 30141 ED2 - Internet of Things (IoT) – Reference architecture	WD	General IoT Reference Architecture in terms of defining system characteristics, a Conceptual Model, a Reference Model and architecture views for IoT
ISO/IEC 20924 ED2 - Internet of Things (IoT) – Vocabulary	WD	Definition of Internet of Things along with a set of terms and definitions – terminology foundation for Internet of Things
ISO/IEC 30161 ED1 - Internet of Things (IoT) – Requirements of IoT data exchange platform for various IoT services	WD	Internet of Things (IoT) data exchange platform for various services
ISO/IEC 21823-2 ED1 - Internet of Things (IoT) – Interoperability for IoT Systems – Transport interoperability	DIS	Network connection framework, interfaces and requirements between and within IoT systems
ISO/IEC 21823-3 ED1 - Internet of Things (IoT) – Semantic Interoperability	CD	Basic concept of Semantic Interoperability for IoT systems, as described in the facet model of ISO 21823 Part 1
ISO/IEC 30144 ED1 - Internet of Things (IoT) – Wireless sensor network system supporting electrical power substations	CD	Intelligent Wireless Sensor Network infrastructure communications to realize the smart electrical power substations
ISO/IEC 30142 ED1 - Internet of Things (IoT) – Network management system overview and requirements	DIS	Overview and requirements of a network management system in underwater acoustic sensor network environment. 30143 provides Application Profiles
ISO/IEC 30148 ED1 - Internet of Things (IoT) – Application of sensor network for wireless gas meters	DTR	Structure and application protocol of wireless gas meter network
ISO/IEC 30162 ED1 - Internet of Things (IoT) – Compatibility requirements and model for devices within industrial IoT systems	WD	Network model for IIoT connectivity and general compatibility requirements for devices and networks within IIoT systems
ISO/IEC 30163 ED1 - Internet of Things (IoT) – System requirements of IoT/SN technology-based integrated platform for chattel asset monitoring supporting financial services	WD	System requirements of an Internet of Things (IoT)/Sensor Network (SN) technology-based platform for chattel asset monitoring supporting financial services

ISO/IEC 30166 ED1 - Internet of Things (IoT) – Industrial IoT	DTR	General industrial IoT system and landscapes which outline characteristics, technical aspects and (non-) functional elements of industrial IoT structure
IEC 62872-2 ED1 – Internet of Things (IoT) – Application framework for industrial demand response energy management	WD	IoT application framework for industrial facility demand response energy management (FDREM) in smart grid to enable efficient information exchange between industrial facilities using IoT related communication technologies

Table 2 Projects related to VICINITY

VICINITY contributed to the development of these standards via partner HITS.

3.11.2. SC27 Information Security

Information security is a significant concern of any information and communication technology (ICT) system, and Internet of Things (IoT) systems are no exception. IoT systems present particular challenges for information security in that they are highly distributed and involve a large number of diverse entities. This implies that there is a very large attack surface and a significant challenge for the information security management system (ISMS) to apply and maintain appropriate security controls across the whole system.

Privacy or Personally identifiable information (PII) protection is a significant concern for some types of IoT system. Where an IoT system acquires or uses PII, it is usually the case that there are laws and regulations that apply to the acquisition, storage and processing of PII, which the IoT system needs to comply with.

Even where regulations are not a concern, the handling of PII by an IoT system remains a reputational and trust concern for the organization involved, for example if the PII is stolen or is misused, potentially causing some form of harm to the people identified by the information.

Security and Privacy controls in this standard are developed for stakeholders in IoT system environment so as to utilized for each IoT stakeholder, through the IoT system lifecycle.

ISO/IEC 27030 Information technology – Security techniques – Guidelines for security and privacy in Internet of Things (IoT) 1stCD represents a significant update to content, better alignment to control structure in 27002 and maturity of the overall document.

SDO	No.	Title
ISO/IEC JTC1/ SC27/WG1	N19761	Information security management systems – ISO/IEC 27701:2019-08 (previously ISO/IEC 27552) – Security techniques — Extension to ISO/IEC 27001 and ISO/IEC 27002 for privacy information management — Requirements and guidelines
	N2152	Information security management systems – information security, cybersecurity and privacy protection – Information security controls ISO/IEC CD 27002:2019(E)
ISO/IEC JTC1/ SC27/WG4	N20139	Information technology – Security techniques – Guidelines for security and privacy in Internet of Things (IoT) – ISO/IEC 1st CD 27030
	N3613	Security Requirements for IoT Devices
	N3360	Information technology — Security techniques Guidelines for IoT-domotics security and privacy
ISO/IEC BSI	TR 22417	Information technology-Internet of things (IoT)-IoT use cases
ISO/IEC JTC1/ SC41	30141	Internet of Things (IoT) — Reference Architecture

Table 3: SC27 Information Security

3.12. Open Connectivity Foundation (OCF)

The Open Connectivity Foundation (OCF) submitted the following Publicly Available Specifications (PAS) to ISO/IEC JTC 1 on 14 November 2019. These documents are built on top of ISO/IEC 30118-1:2018 which specifies the core architecture, interfaces, protocols and services to enable the implementation of profiles for IoT usages and ecosystems. ISO/IEC 30118-1:2018 also defines the main architectural components of network connectivity, discovery, data transmission, device & service management and ID & security. The core architecture is scalable to support simple devices (constrained devices) and more capable devices (smart devices).

ISO/IEC	Published Standards – Titles	Year
30118-1	Information technology – Open Connectivity Foundation (OCF) – Part 1 – Core Specification	2019
30118-2	Information technology – Open Connectivity Foundation (OCF) – Part 2 – Security Specification	2019
30118-3	Information technology – Open Connectivity Foundation (OCF) – Part 3 – Bridging Specification	2019
30118-4	Information technology – Open Connectivity Foundation (OCF) – Part 4 – Resource Type Specification	2019
30118-5	Information technology – Open Connectivity Foundation (OCF) – Part 5 – Device Specification (i.e. Smart home device specification)	2019
30118-6	Information technology – Open Connectivity Foundation (OCF) – Part 6 – Resource to AllJoyn Interface Mapping Specification	2019
30118-7	Information technology – Open Connectivity Foundation (OCF) – Part 7 – Wi-Fi Easy Setup Specification	2019
30118-8	Information technology – Open Connectivity Foundation (OCF) – Part 8 – Cloud Specification	2019
30118-9	Information technology – Open Connectivity Foundation (OCF) – Part 9 – OCF Resource to oneM2M Resource Mapping Specification	2019

Table 4: OCF Specifications

VICINITY contributed to the development of these standards via partner HITS.

4. Promotion of Standards

This section identifies the main fora which VICINITY partners have used to promote standards over the life of the project. These bodies do not themselves develop standards but actively promote the use of standardisation to enable the widespread adoption of the IoT.

4.1. IoT-EPI

The IoT-European Platforms Initiative (IoT-EPI)[3] was set up by the EC to coordinate IoT platform activities across H2020 programs. At the core of IoT-EPI are the seven research and innovation projects focusing on IoT: Inter-IoT, BIG IoT, AGILE, symbIoTe, TagItSmart!, VICINITY and bIoTope. VICINITY partners have participated in the IoT-EPI since the beginning of the project and have actively contributed to its activities, such as to the production of the book "Advancing IoT Platforms Interoperability".

4.2. Alliance for Internet of Things Innovation (AIOTI)

AIOTI is a partner for the European Commission on IoT policies and stimulus programs, helping to identify and remove obstacles and fast learning, deployment and replication of IoT Innovation in Real-Scale Experimentation in Europe from a global perspective.

VICINITY partners participated in the following Working Groups (WGs):

- WG02 Innovation Ecosystems
- WG03 IoT Standardisation (including Privacy)
- WG06 Smart Farming and Food Security
- WG08 Smart Cities
- WG09 Smart Mobility
- WG11 Smart Manufacturing
- WG12 Smart Energy
- WG13 Smart Buildings and Architecture

4.2.1. WG03 IoT Standardisation (including Privacy)

AIOTI WG03 has identified a large range of standards bodies, fora and consortia that are relevant to the IoT. [8]

The objective of participating in AIOTI WG03 was to monitor IoT standards activities relevant to VICINITY and to ensure standards bodies important to VICINITY were included. We also wanted to ensure alignment on Privacy issues.

VICINITY partners have participated in AIOTI WG03 (standardization) since the beginning of the project and actively contributed to its activities, including the production of the two whitepapers on semantic interoperability [12, 13]. VICINITY is one of the few projects mentioned at the end of these white papers. CAL contributed the CECED and USEF bodies to the AIOTI standards landscape diagram.

4.2.2. WG08 Smart Cities

The objective of participating in AIOTI WG08 was to contribute VICINITY cross-domain use cases to standardisation. A cross-domain (or cross-cutting) use case is one which, to be realised effectively, requires

[3] https://iot-epi.eu/

access to information normally contained in different (possibly legacy) silos or data-sets. Smart Cities, because of their wealth of different domains, provide some of the best examples of cross-domain use cases. CAL participated from 2017 - 2018 while WG08 was defining use cases and requirements for smart city applications. CAL were editors for the deliverable "Smart City Replication Guidelines Part 1: Cross-Domain/Application Use Cases" published in June 2018. [9] This included cross-domain use cases on:

- Smart lighting so that street lighting is only provided when needed (Bordeaux).
- Air Quality Monitoring, Traffic Routing and Road Pricing (VICINITY)
- Monitoring assisted persons outside the home (ACTIVAGE).
- Smart Parking and Assisted Living (VICINITY and ACTIVAGE).
- Smart Street Lighting, Air Quality Monitoring and Pedestrian Safety (Madrid).
- Mobility inside the City (REPLICATE).
- Next Generation Emergency Services Crowd Control and Emergency Response (NGES).
- Mobility as a Service (SynchroniCity)

The project mainly responsible for developing and contributing the cross-domain use case is shown in brackets in the above list. Two of the use cases were based largely on information provided by VICINITY.

The essential Information required to be specified in a cross-domain use case was defined to be:

- What city need is addressed?
- Description,
- Information to be exchanged,
- Relevant Actors,
- Data Sources,
- Why the use case is cross-domain,
- Why the use case is commercially viable.

The following contributions were made by VICINITY to AIOTI WG08 Smart Cities:

- "VICINITY cross domain use cases".
- "Smart City Use Cases and Replication Requirements"
- "Why commercially viable cross-domain use cases will drive innovation and horizontalization of IoT-enabled smart cities".
- "The positive contribution of ICTs (and IoT) in Climate Change mitigation and adaptation".

These contributions helped to establish a series of cross-domain use cases which were used to develop requirements for new horizontal platform standards.

4.2.3. WG09 Smart Mobility

The aim in this working group is to identify the IoT benefits and enablers for progressing Smart Mobility. On 16 December 2019 HITS joined the workshop on TESTFEST[4].

The purpose of the workshop was to present the results of the interoperability trials (remote TESTFEST) between pilot sites, data interoperability with SynchroniCity and also to discuss further actions after the LSP, i.e. in relationship with standardisation activities on IoT (e.g. oneM2M).

The results of the workshop showed various business models for smart parking in a city commuted by SynchroniCity.

[4] https://autopilot-project.eu/event/testfest-results-presentation-workshop/

4.2.4. WG12 Smart Energy

The objective of VICINITY participating in AIOTI WG12 was to align with VICINITY objectives on Smart Energy. ENERC participated from 2017 and took over the chair in 2018. WG12 drafted white papers on Open Energy Marketplaces coordinated and managed by ENERC, supported and contributed towards workshops in collaboration with WG9 Smart Cities. [10]

Other activities were related to SRIAs for AI partnerships.

4.2.5. WG13 Smart Buildings and Architecture

The objective of participating in AIOTI WG13 was to monitor to check alignment with VICINITY objectives on Smart Buildings. TINYM and ENERC (in 2018-2019) participated in 2017 and 2018. AIOTI WG13 drafted white papers on standards for the built environment.

4.3. ITU Academy

During the life of the VICINITY project, CAL developed an MSc level training programme on ICT and Climate Change for the ITU Academy[5]. Each of the 20 modules developed for this programme promoted relevant ICT standards. VICINITY was also included as an IoT-based mitigating technology for action against climate change.

4.4. Conferences and workshops

4.4.1. IoT Week

In Bilbao at IoT Week 2018, UPM organised a SAREF4CITY validation workshop: CAL presented the VICINITY use cases to the ETSI SAREF4CITY validation workshop. SAREF4CITY is developing standardized ontologies for Smart Cities and the workshop looked at use cases involving smart mobility, air quality, smart parking and assisted living (many of these were originally contributed from VICINITY). The workshop was organized by UPM and ATOS, CAL and ENERC participated actively during the workshop.

4.4.2. ETSI IoT Week

For all 4 years of the project, contributions have been made from VICINITY to ETSI IoT Week stressing the importance of standards for IoT interoperability. An example was the contribution “The impact of the VICINITY IoT-EPI project on the ability to Scale Up Smart City Solutions and LSPs” made to ETSI IoT Week in October 2017. UPM also made a contribution on the VICINITY interoperability framework to ETSI IoT Week in October 2019.

4.4.3. Making Smart Cities Sustainable

The “Making Smart Cities Sustainable” conference was organised by Bordeaux Metropole in conjunction with ETSI on 7-8 June 2017. CAL made a presentation entitled “Scaling up Smart Cities Solutions” stressing the importance of standards as a major element of this.

4.4.4. OASC (Open and Agile Smart Cities)

Open and Agile Smart Cities (OASC)[6] is an international smart city network set up to create and shape the nascent global smart city data and services market. CAL, ENERC and UPM have participated in OASC to

[5] https://academy.itu.int/home

[6] https://oascities.org/

promote relevant standards, in particular at the Connected Smart Cities Conference (CSCC) held in Brussels in January 2018.

CAL organised a session on "Energy: Interoperable Smart Homes and Grids". During this session, Rolf Riemenschneider (DG CONNECT IoT Unit) presented the EU Vision for Smart Energy and the interoperability requirements. CAL provided the background and introduced the session while ENERC presented on "IoT as an enabler for the Energy Market".

UPM also presented on "Standards for Semantic Interoperability" in the session on Global Standards for IoT and Smart Cities & Communities, focusing on the requirements for SAREF extensions.

4.5. Tutorials

4.5.1. EKAW 2018

The 21st International Conference on Knowledge Engineering and Knowledge Management (EKAW2018) took place at INRIA premises at Nancy, France. The conference gathered together numerous stakeholders in semantic technologies with a focus on research but also industry partners. The specific background of attendants ranged from IoT or stream data to food or education domains.

The conference hosted both sessions for presenting research papers and co-located events such as workshops and tutorials. The tutorial "Catching up with ontological engineering: To git-commit and beyond (With VICINITY use cases)" proposed by UPM was accepted to be co-located together with the conference.

The tutorial material is available at https://tutorials.oeg-upm.net/ekaw2018/

4.5.2. Forum on specification & Design Languages (FDL) 2019

The goal of the FDL is to bring researchers and industry experts to discuss state of the art trends in the application of languages for the design and modelling of electronic systems. Electronic systems of interest are those used in IoT, Cyber-Physical Systems, automotive applications, embedded systems for high-performance computing. The conference program included embedded tutorials, panels and technical sessions. UPM lead the tutorial entitled "Integrating ontological development with software engineering trends".

In the tutorial both methodological and technical aspects of collaborative ontology development were presented. It included a practical activity that showed how the development of ontologies can be supported by several tools. The methodology and the ontologies developed in VICINITY were shown as examples in this practical activity. The role of the VICINITY ontologies within the project was also explained during the tutorial.

5. Contribution to standards

This section identifies the contributions that VICINITY has made to standards bodies, fora and consortia where VICINITY partners have participated during the life of the project.

VICINITY has provided the Standards community with many examples of IoT Architectures, use cases, reference models and applications. It has provided an alternative model for the IoT, one where adapters are used to enable communication between different types of platforms and standards, and VICINITY has provided a distributed, peer-to-peer IoT Architecture as a counterpart to the centralised oneM2M type of Architecture.

Conformity Assessment was achieved through validation of the ontologies that serves as the basis for further standards recommendations and extensions where UPM actively contributed.

5.1. ETSI ISG City Digital Profile (CDP)

The following contributions were made by VICINITY to ETSI ISG CDP (City Digital Profile):

- “Proposed Use Case-Based Methodology for ISG CDP”
- "Input to Smart City Surveys”
- “Smart Energy as a Core Service for Cities”

These contributions helped to develop requirements for horizontal (cross-domain) standards for smart cities.

5.2. ETSI ISG CIM

The following contributions were made by CAL on behalf of VICINITY to ETSI ISG CIM (Context Information Management):

- “VICINITY cross domain use cases”.
- “Smart Cities Architecture & Reference Models”.
- “Air Quality Monitoring, Traffic Routing and Road Pricing Cross-Domain Use Case”.
- “E-Health and Smart Parking Cross-Domain Use Case from VICINITY”.
- “Smart Agriculture Use Case from VICINITY”.

These contributions established a representative set of use cases which were used to develop requirements and APIs for providing context information to applications.

5.3. ITU-T FG/DPM

The following contributions were made by CAL on behalf of VICINITY to the ITU-T Focus Group on Data processing and Management (FG/DPM):

- “Presentation by Dr David Faulkner and Aida Mynzhasova “Introducing the collaborative project VICINITY” This was at the ITU-T JCA-IoT and SC&C meeting, Dubai, 16 March 2017, and this JCA led to the formation of the Focus Group.
- “Examples of Use Cases in the Health Sector for Assisted Living”, David Faulkner, Contribution i-064, 20-25 October 2017, Geneva, Switzerland. This is now included in Deliverable D1.1 on use-case classification at conclusion of the FG in July 2019.

5.4. W3C WoT Thing Description ontology

At the moment of developing the VICINITY ontology network the use of Web of Things proposals were taken into account; however, the standardization efforts were still quite incipient. At that moment, even though definitions and needs were stated, no implementation was provided by standardization bodies. During the VICINITY network development, the requirements defined by the W3C Web of Things working group were incorporated into the VICINITY requirements[7] and implemented in the VICINITY WoT ontology.[8] Figure 2 shows the first code contribution from VICINITY efforts to the W3C Thing Description ontology taken as seed the VICINITY WoT ontology. The current version of the W3C ontology is available at https://www.w3.org/2019/wot/td#.

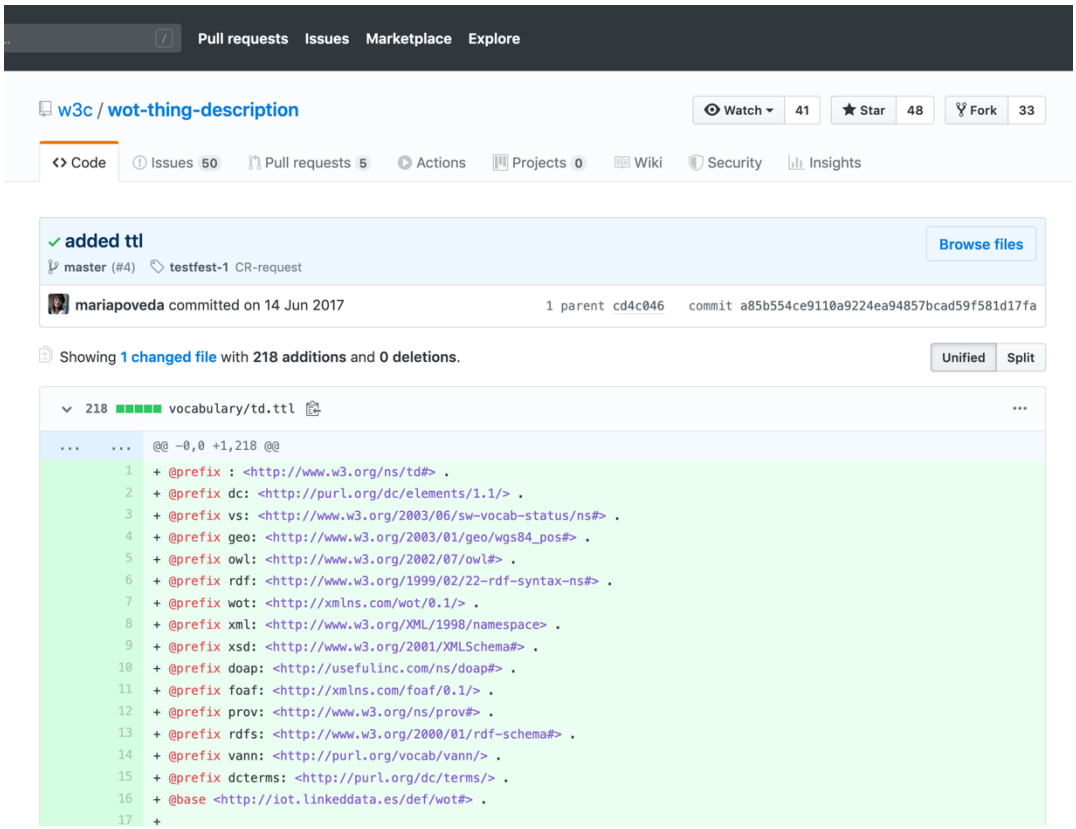


Figure 2. WoT ontology contribution to W3C wot thing description

5.5. W3C WoT mappings

In order to automatically process data from different IoT infrastructures that provide data under heterogeneous formats and models, it is not enough the merely use of the WoT ontology. For this reason, the WoT mapping ontology has been developed as part of the VICINITY ontologies. This ontology is used to map such heterogeneous data into the common VICINITY model, and therefore, allowing its translation into RDF; which would enable such data to be queried in SPARQL in a transparent way. Such extension of the

[7] WoT ontology requirements available at http://vicinity.iot.linkeddata.es/vicinity/requirements/report-wot.html

[8] WoT ontolgoy available at http://iot.linkeddata.es/def/wot

WoT ontology, that is, the WoT Mappings ontology,[9] could be proposed as a potential extension of the W3C WoT model.

5.6. Other contributions to W3C WoT

Future potential contributions to the W3C Web of Things Working Group, based on the work performed in VICINITY, could be:

- To extend the expressivity of the WoT-Mappings.
- Javascript libraries, since is the preferred language of the working group, to compute and process the WoT mappings presented.
- Introduce security mechanisms and authentication protocols to WoT Thing Descriptions and WoT Mappings.
- We would like to propose the exchange of WoT Thing Descriptions plus their WoT-Mappings in order to decentralise silos of IoT infrastructures, moving the focus of the interoperability to the clients that may rely on both elements to interact (discovery+access) IoT infrastructures; and may exchange both to provide third-party access to their IoT infrastructures.

[9] WoT Mappings ontolgoy available at http://iot.linkeddata.es/def/wot-mappings/

6. Conclusions

This deliverable has summarised the involvement of the VICINITY project in Standardization over the life of the project from 2016 to 2019 in 4 areas:

- The use of Standards by VICINITY
- The participation of VICINITY partners in relevant Standards bodies, fora and consortia
- The way VICINITY has promoted Standards
- The contribution of the VICINITY project to Standards

VICINITY has made an essential contribution to Standardization, particularly in the areas of use cases and semantic ontologies.

In the area of use cases VICINITY has contributed to the definition of cross domain use cases. VICINITY pilots have provided clear examples of cross-domain use cases which were taken up enthusiastically by several standards bodies for their own objectives.

However, the most important contribution of the VICINITY project to Standardisation has been in the area of semantic ontologies including on the content of SAREF and extensions. Conformity Assessment was achieved through validation of the ontologies that served as the basis for further standards recommendations and extensions.

7. References

[1] „ETSI TS 103 264 “Smart Appliance Common Ontology and oneM2M mapping.,“ [Online].

[2] „VICINITY D2.1 “Analysis of Standardisation Context and Recommendations for Standards Involvement”,“ [Online].

[3] „VICINITY D8.1 "Business scenarios & evaluation framework”,“ [Online].

[4] „ETSI TS 103 463-2 V1.1.1 (2019-06) “Sustainable Digital Multiservice Communities; Key Performance Indicators for Sustainable Digital Multiservice Areas; Part 2: Global KPIs for Sustainable Digital MultiService Areas”,“ [Online].

[5] „“The 4th Industrial Revolution and the Municipal CEO”, http://docbox.etsi.org/ISG/CDP/Open/,“ [Online].

[6] „ETSI GR CIM 002 “Context Information Management (CIM): Use Cases (UC)”,“ [Online].

[7] „ETSI TR 103 290 “Machine-to-Machine communications (M2M); Impact of Smart City Activity on IoT Environment”,“ [Online].

[8] „“IoT LSP Standard Framework Concepts”, Alliance for Internet of Things innovation WG3 (IoT Standardisation), Release 2.4, 2016,“ [Online].

[9] „AIOTI WG08, “Smart City Replication Guidelines Part 1: Cross-Domain/Application Use Cases”, Version 1.0, June 2018,“ [Online].

[10] „https://aioti.eu/events/workshop-open-energy-marketplaces-and-the-enabling-technologies/,“ [Online].