D6.11 Standardisation plan and activities II

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Table of Contents

List of Tables

List of Figures

List of Acronyms

Abbreviation / Acronym	Description
AIOTI	Alliance for the Internet of Things Innovation
API	Application Programming Interface
BDVA	Big Data Value Association
CEN	European Committee for Standardisation
CENELEC	European Committee for Electrotechnical Standardisation
CNCF	Cloud Native Computing Foundation
CPU	Central Processing Unit
DApp	Decentralised Application
Dx.y	Deliverable number y belonging to WPx
DoA	Description of Action
DSS	Decision Support System
DLT	Distributed Ledger Technology
ESO	European Standardisation Organization
ETR	ETSI Technology Radar
ETSI	European Telecommunications Standards Institute
EU	European Union
GSM	Global System for Mobile Communications
GSMA	GSM Association
ICT	Information and Communications Technology
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IERC	European Research Cluster on the Internet of Things
IETF	Internet Engineering Task Force
IIoT	Industrial IoT
IoT	Internet of Things
ISG	Industry Specification Group
ISO	International Organization for Standardisation
ITU	International Telecommunication Union
JDBC	Java Database Connectivity
MANO	Management and Orchestration
MEC	Multi-access/Mobile Edge Computing
NFV	Network functions virtualization
NGSI	Next Generation Service Interface
OACA	Open Alliance for Cloud Adoption
OSC	Open Source Community
OSM	Open Source MANO
RESTful	Representational State Transfer
SDO	Specification Developing Organisation
SIG	Special Interest Group

Abbreviation / Acronym	Description
SLA	Service Level Agreement
SLI	Service Level Indicator
SLO	Service Level Objective
SME	Small and Medium-sized Enterprise
SOE	Slicing and Orchestration Engine
TEE	Trusted Execution Environment
TF	Task Force
Tx.y	Task number y belonging to WPx
URI	Uniform Resource Identifier
W3C	World Wide Web Consortium
(T)WG	(Technical) Working Group
WPx	Work Package number x
WSC	World Standards Cooperation

Executive Summary

This deliverable contains an overview of the standardisation bodies and initiatives followed by Pledger, together with the activities undertaken to ensure the project results sustainability by promoting the latter to the corresponding standardisation working groups. The five main core standardisation results of the project are presented, ranging from landscape reports to Open Source contributions. Beyond these results and activities, the deliverable also presents some future standardisation opportunities.

Pledger has met its standardisation goal of contributing to SLA metrics and orchestration languages, and has successfully established the baseline for future related activities extending beyond the official lifecycle of the project.

This deliverable is the updated and final version of *D6.4 "Standardisation plan and activities"*. While the previous version focused on setting the foundations for the project's standardisation activities through the analysis of already developed standards and on-going projects in standardisation organisations as well as the mapping of Pledger outputs to them, this deliverable presents the outcomes of the set standardisation roadmap as well as an updated plan for potential future standardisation activities. Since there is almost no content repeated between the two versions, parties interested in studying all of the information related to the Pledger standardisation plan should read both deliverables.

1 Introduction

1.1 Purpose of the document

This deliverable is the outcome of the amalgamation of all the activities undertaken under Pledger's Task *T6.4 "Standardisation and contribution to Open Source Community"*, part of *WP6 "Dissemination, Exploitation and Standardisation"*.

The scope of the current deliverable is to map and document with sufficient detail the activities of Pledger in standardisation bodies and initiatives throughout the lifetime of the project. The targeted activities being presented are the ones that resulted in valuable input and concrete contributions to the standardisation community, entailing both a) the bodies and associations working on technical standards specifications or standardisation landscape reports, and b) the Open Source Community producing standardisation outcomes. The said results are either briefly presented and referenced (in case they have already become public) or presented in more detail and linked to the Annex of the document (in case they are not yet made public, as of the day of delivery of this document).

Beyond the presentation of the already produced standardisation outputs of the project, the goal of this document is also to present an updated standardisation plan focusing on potential future activities of the Pledger consortium partners that could either promote further the current standardisation results of the project in the standards community or produce new standards contributions. To present both the already performed and the potential future standardisation activities of the project, a short analysis of targeted standardisation bodies and communities is also presented in parallel.

The ultimate goal of the Pledger standardisation activities is to secure an extra path towards the sustainability, dissemination, and adoption of the project's results by promoting them to the interested groups and parties and integrating them in their own core initiatives.

1.2 Relation to other project work

This deliverable is the updated and final version of *D6.4 "Standardisation plan and activities"*. While the previous version focused on setting the foundations for the project's standardisation activities through the analysis of already developed standards and on-going projects in standardisation organisations as well as the mapping of Pledger outputs to them, this deliverable presents the outcomes of the set standardisation roadmap as well as an updated plan for future standardisation activities.

The standardisation activities and plan being presented are the means of verification of the Pledger's 15th measure of success, as presented in the DoA of the project. More specifically, the said measure of success set as a target *"the contribution to at least 2 standards as outcome to standardisation activities with relation to SLA metrics and orchestration languages"*. As shown in the next sections, this target has been successfully reached, with Pledger managing to provide concrete contributions to even more standardisation activities focusing on standards and standardisation gaps analysis/ landscape of the field.

This measure of success is directly linked to the 7th Objective of the project, which is "to enable the extension of the Edge/Cloud combined business model and provide an extensive replicability and best practices framework". Under this context, the results of this deliverable are part of the wider *WP6 "Dissemination, Exploitation and Standardisation"* activities and are related to other tasks of the WP. For example, *Task T6.1 "Dissemination and Communication activities"*, due to its nature and focus on the dissemination of all the project's results, inevitably contributed to the promotion of the Pledger standardisation contributions not only within the standardisation and Open Source communities, but also outside them.

Pledger partners have provided and will keep extracting standardisation contributions based on the concrete results of the project, as they have been identified in the deliverables of its technical WPs: *WP2 "Requirements Analysis and Architecture"*, *WP3 "Performance, QoS and orchestration mechanisms"*, and *WP4 "Trust, Smart Contracts and Decision Support mechanisms"*.

1.3 Structure of the document

Beyond this point, the document is structured in 3 major chapters:

- **Chapter 2**, in its first part, presents the methodology followed by the Pledger consortium under the context of the *Task T6.4 "Standardisation and contribution to Open Source Community"* activities. It provides a classification schema for entities and activities of interest as well as lists of definitions of the related terms chosen to specify the targets and outcomes of the task. It also briefly presents the overall procedure followed, from the selection of specific standardisation working groups to work with (and within) to the several options available for contributions. In its second part, the Chapter provides a bird's-eye view of the standardisation results.
- **Chapter 3** is the core section of this document and presents in detail the actual standardisation contributions of the project as well as the plan for future related activities. Considering all of these contributions and activities are taking place within specific standardisation and Open Source communities, the chapter provides a subsection for each such community of interest. Each one of these subsections includes a brief presentation of the nature, focus, and activities of the community, the Pledger contributions provided to some of the activities of the said community, as well as the potential extra activities that could be executed by the Pledger consortium partners to provide further results based on the project's outcomes, thus increasing its impact.
- **Chapter 4** concludes this deliverable and makes a final remark on the nature and importance of the Pledger standardisation contributions and impact.

Finally, the Annex at the end of the document provides in further detail some of the project's standardisation contributions, as they have not been made public yet through other documentation (as of November 2022).

2 Standardisation Methodology & Activities Overview

2.1 Overall Methodology and Definitions

2.1.1 Roadmap

The overall Pledger standardisation plan can be summarised in four activities:

- **Activity 1 – Staying up-to-date:** This activity entails the continuous analysis of already developed standards and on-going initiatives in standardisation organisations. It also entails the active monitoring of specific standardisation entities of interest and their activities. This activity sets the baseline for all other activities and has been in place since the design phase of Pledger.
- **Activity 2 – Staying relevant:** For Pledger results to make their way into new standards-related contributions, it has been decided for the Pledger partners to focus on related activities undertaken in relevant standardisation initiatives. This activity focuses on mapping relevant standards and standardisation activities to the project's outputs (or inputs). In other words, this step identifies the potential points of contact between Pledger results and standardisation activities already in progress, thus isolating specific opportunities for Pledger to contribute to the creation or update of standards.
- **Activity 3 – Staying connected:** This activity entails all the necessary communication actions for the consortium partners to remain (or become) active members of special and new standardisation initiatives. The Pledger partners have obtained significant standardisation relevance and business acumen during years of experience on the respective fields, thus, their involvement in each standardisation initiative can produce important contributions.
- **Activity 4 – Contributing to standards:** This activity includes the actual action of direct (or indirect) contribution to specific standards, which is the ultimate goal of the Pledger standardisation roadmap. Throughout Pledger's lifecycle, each partner has been monitoring and contributing to relevant activities through the participation to the corresponding working groups and task forces. Such activities shall be continued after the end of the project too.

The following four types of Pledger results have been identified as potential standards contributions:

- Pledger **experiences** and **requirements** for standardisation roadmaps and landscapes.
- Pledger **use cases** as candidate input to relevant standardisation organisations.
- Pledger **architecture**, functionalities, **functional components**, and procedures as direct contribution to relevant standards specifications.
- Pledger **framework** and **code** as contribution to Open Source Communities and related initiatives.

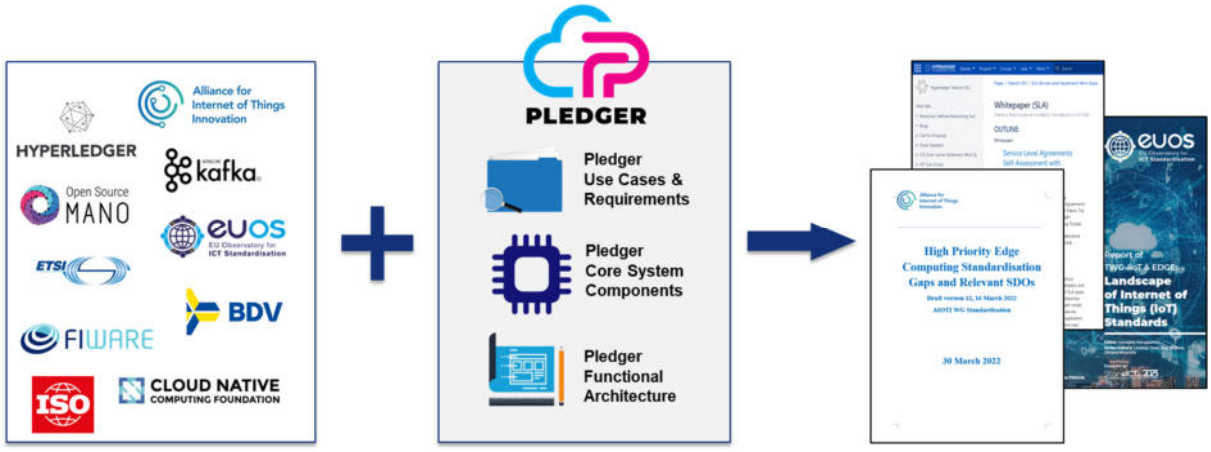

Figure 1: Promotion of Pledger results in standardisation initiatives.

2.1.2 Monitored Standardisation Initiatives

There are several types of standardisation initiatives that are active in the field of standardisation. Three different types of such initiatives have been identified as the primary target of the Pledger standardisation activities, taking under consideration the nature of the project's results:

- **Specification Developing Organisation (SDO):** A standards organisation in its strict sense, with the primary function of developing and revising technical standards through consensus-based or non-consensus-based processes.
- **Alliance:** Any legal entity that is an association of other entities and, among other activities, undertakes the task of contributing directly to technical standards or assisting fundamental activities preceding or accompanying them (e.g., identification of standardisation gaps).
- **Open Source Community (OSC):** A community that engages in activities related to open collaboration for the creation of new software, sometimes managing to introduce new standards (either de jure or de facto).

Many entities under these three categories tend to be complex. This very complexity and the nature of some initiatives, in some cases, may make the borders between the categories unclear. For example, a specific OSC may be considered to be a special type of an Alliance, whereas a lot of Alliances may undertake open-source activities. Nevertheless, this categorisation makes it easier to identify some specific patterns for monitoring and engaging different standardisation activities.

Of course, there are more than three types of standardisation-related entities, ranging from single corporate entities to government agencies. However, given the established network of the Pledger partners, it has been decided to focus on these three types only.

For each one of these categories, specific standardisation initiatives were taken under consideration based on the mapping of the project's results to on-going activities, as well as the capability of the consortium partners to actually join and participate to the corresponding working groups. The following standardisation initiatives have been contacted or have been identified as future candidates for the Pledger standardisation activities:

- **SDOs of interest:** On a European level, the SDOs of interest are the three European Standardisation Organizations (ESOs): the European Committee for Standardisation (CEN [1]), the European Committee for Electrotechnical Standardisation (CENELEC [2]), and the European Telecommunications Standards Institute (ETSI[3]). In the European Union, only standards created by CEN, CENELEC, and ETSI are recognized as European standards, according to Regulation (EU) No 1025/2012. On a global level, the SDOs taken under consideration are the three largest ones, comprising the World Standards Cooperation (WSC [4]): the International Organization for Standardisation (ISO[5]), the International Electrotechnical Commission (IEC[6]), and the International Telecommunication Union (ITU[7]). Other organisations of interest are the Institute of Electrical and Electronics Engineers (IEEE[8]), and, on a lower level, the Internet Engineering Task Force (IETF[9]), and the World Wide Web Consortium (W3C[10]).
- **Alliances of interest:** Alliances that have been chosen as candidate initiatives for standardisation contributions are the Alliance for the Internet of Things Innovation (AIOTI[11]), the European Research

[1] https://www.cencenelec.eu/about-cen/
[2] https://www.cencenelec.eu/about-cenelec/
[3] https://www.etsi.org/about/about-us
[4] https://www.worldstandardscooperation.org/
[5] https://www.iso.org/home.html
[6] https://www.iec.ch/homepage
[7] https://www.itu.int/en/Pages/default.aspx
[8] https://www.ieee.org/
[9] https://www.ietf.org/
[10] https://www.w3.org/
[11] https://aioti.eu/

Cluster on the Internet of Things (IERC[12]), the Open Alliance for Cloud Adoption (OACA[13]), the Big Data Value Association (BDVA[14]), and StandICT.eu[15].

- **OSCs of interest:** Finally, selected OSCs through which Pledger could promote its results and contribute to open-source/standardisation activities are the Hyperledger Foundation[16], the FIWARE Foundation[17], LF Edge[18], the Cloud Native Computing Foundation (CNCF[19]), and Open Source MANO (OSM[20]).

More details about the nature and activities of these entities are provided in the first version of this deliverable (*D6.4 "Standardisation plan and activities"*) and in Chapter 3 of this document.

2.1.3 Types of Contribution

The results coming from the aforementioned organisations can contribute to establishing standards that can be either de jure (standards mandated by legal requirements or generally formal standards) or de facto (a specification, protocol, or technology that has achieved widespread use and acceptance, often without being approved by any SDO, or receiving such approval only after it already has achieved widespread use). In the context of Pledger, the contribution of the project to standardisation initiatives can be split into two different types: abstract standards contribution and concrete standards contribution.

Abstract standards contribution is any indirect contribution that promotes the standardisation activities, mainly through communication activities. Abstract contribution can be the sharing of experiences and ideas, participation to the discussions of specific technical committees or working groups, and high level input to generic tasks. This contribution is not directly mapped to tangible results (e.g., specific documentation), but is a necessary step for future concrete contributions.

On the other hand, **concrete standards contribution** refers to direct contribution to specific standardisation items that are produced by either SDOs or Alliances and OSCs. Such items can be:

- **Standard Specification:** A standard in its strict sense. Standards are (technical) specifications that are recognised at broad industry or government level.
- **Open Source:** Open source software is developed in a decentralised and collaborative way, relying on peer review and community production.
- **Guideline/Recommended Practice:** A guideline presents a methodology and the steps that have to be followed to use standards specifications or open source in a specific context. Similarly, a recommended practice entails the identification of physical characteristics, configuration, material, performance, personnel or procedure, the uniform application of which is recognised as desirable in the interest of safety, regularity or efficiency.
- **Framework:** A framework presents the basic structure underlying a system or concept, providing the 'frame' to contextualise information. Frameworks are those that are normally put into practice in the absence of well-defined standards. A framework can be thought of as a set of principles.
- **Landscape/Roadmap**: These items provide a collection of information related to standardisation entities, activities, and items (e.g., specific documents and reports) and may include a (partial) analysis of this input. The target behind this type of items is to aggregate all the necessary input for future standardisation activities, such as the identification of standardisation gaps or the definition of new standardisation goals.

[12] http://www.internet-of-things-research.eu/
[13] https://www.oaca-project.org/
[14] https://www.bdva.eu/
[15] https://www.standict.eu/
[16] https://www.hyperledger.org/
[17] https://www.fiware.org/
[18] https://www.lfedge.org/
[19] https://www.cncf.io/
[20] https://osm.etsi.org/

Information about these items can be provided in different formats. Such a format can be a whitepaper, a document that is exploring the problems, goals, and solutions of a specific industry area. Another format can be that of a report, a document that describes the process, progress, or results of technical or scientific research or the state of a technical or scientific research problem.

2.2 Activities overview

Throughout Pledger's lifecycle, the consortium partners have been interacting actively with most of the standardisation bodies identified in the previous section, continuously providing **abstract standardisation contributions** through regular communication.

An example of such abstract contributions can be provided for the case of activities related to Open Source MANO. OSM, a community-led project, is developing an open source Management and Orchestration (MANO) stack aligned with ETSI NFV Information Models. OSM MANO is used as part of the SOE framework (one of the Pledger core components, under development by i2CAT). i2CAT is a member of ETSI Open Source MANO and, as such, has been participating in regular OSM meetings and workshops. i2CAT has discussed with other members of the community ideas about new, valuable features that could be integrated into OSM MANO, based on the Pledger results.

Another example can be provided for the case of the Intrasoft Apache Kafka Community of Practice, an internal group of INTRA that focuses on exchange of practices and open source with frequent presentations and demos. INTRA promotes activities pertaining to the use of the StreamHandler platform to the Intrasoft Apache Kafka Community of Practice and has promoted the platform created for Pledger in dedicated community sessions.

By default, documenting the abstract contributions provided by the consortium is difficult (and of little value). As such, the rest of the deliverable is focusing on concrete standardisation contributions. Table 1 associates each standardisation body (in its wide sense) of interest with some of the respective Pledger consortium partners, and identifies the **concrete contribution** provided by Pledger to and through these bodies, as of November 2022.

Table 1: Association of partners to standardisation bodies

Body	Type	Partner	Current Concrete Contribution
AIOTI	Alliance	ICCS	Standardisation Landscape (report)
BDVA	Alliance	FILL, HOLO	-
CNCF	OSC	ATOS	-
ETSI	SDO	ATOS, ICCS	Standardisation Landscape (report)
FIWARE	OSC	ENG	Open Source Guideline (schema)
Hyperledger	OSC	INNOV, ICCS	Open Source Framework (whitepaper)
IERC	Alliance	INTRA	-
ISO/IEC	SDO	ICCS	-
LF Edge	OSC	ATOS	-
OACA	Alliance	INNOV, FILL	-
OSM	OSC	i2CAT	-
Stand.ICT	Alliance	ICCS	Standardisation Landscape (report)

3 Concrete Contributions to Standardisation initiatives

3.1 AIOTI – Alliance for the Internet of Things Innovation

3.1.1 Initiative's Profile

The Alliance for the Internet of Things Innovation (AIOTI[21]), launched by the European Commission, is an organisation that actively leads on the convergence of IoT/IIoT and other technologies, bringing together key entities (industrial, academic, academia and small and medium-sized enterprises) that want to contribute in providing policy and standardisation input. The alliance consists of more than 200 members, ranging from small start-ups and SMEs to corporate members, researchers, and academia associations. AIOTI organise their work in 14 horizontal and vertical Working Groups (WG), with horizontal groups covering areas that can be applied to any sector, and vertical groups covering domain-specific areas. It builds on the work of the IoT European Research Cluster (IERC) and aims to help the European Commission in the planning of future IoT research as advancement and normalization strategies; this also provides an opportunity to address legal barriers for the further integration of IoT and to forge consensus in related activities.

In the context of Pledger, of special interest is the AIOTI Standardisation WG[22] which has as a vision to provide contribution to the relevant EU policies, strategies, and standardisation activities. The WG is structured into five taskforces (TFs): TF1 – IoT & Edge Computing Landscape, TF2 – High Level Architecture, TF3 – Semantic Interoperability, TF4 – Privacy, and TF5 – Security.

3.1.2 Nature of Contribution

ICCS, representing Pledger, was one of the two main editors of the ***"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"*** AIOTI report[23], made public in April 2022. This report is the amalgamation of all the activities related to TF1 – "IoT & Edge Computing Landscape" of the AIOTI Standardisation WG.

This report introduces an approach for the definition and identification of key edge computing and/or combination of IoT/IIoT, edge computing, and cloud computing gaps in several initiatives. Based on the prioritisation of these gaps, the deliverable starts addressing the work done within the relevant SDOs that need to cooperate in order to solve these gaps. The purpose of the document is to reflect a structured discussion within the wider standardisation community and to provide consolidated technical elements as well as guidance and recommendations.

More specifically, in the context of Edge Computing, the report includes:

- Definition and identification of research challenges.
- Definition and identification of standardisation challenges.
- Classification scheme of challenges and gaps.
- Mapping of challenges to 100 other standardisation reports.
- Identification of standards gaps coming from SDOs/Alliances/OSCs initiatives.

Through the corresponding analysis, the report identifies (among others) the existence of standardisation gaps related to the IoT and Edge computing coexistence/integration/interoperability and continuum across several sectors and platforms (Figure 2).

[21] https://aioti.eu/
[22] https://aioti.eu/wg_standardisation/
[23] https://aioti.eu/wp-content/uploads/2022/04/AIOTI-High-Priority-Edge-Computing-Gaps-Final.pdf

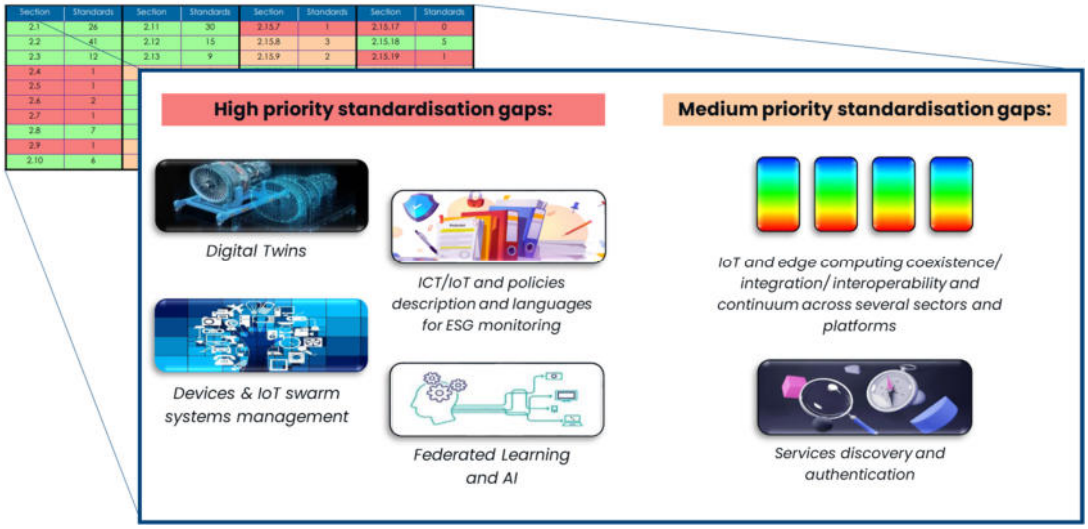

Figure 2: Edge Computing Standardisation Gaps identified in AIOTI report.

3.1.3 Mapping to Pledger outputs

A lot of Pledger research results and outputs map to the core principles and fundamentals of the corresponding AIOTI initiatives. As one of the two main editors of the *"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"* AIOTI report mentioned above, Pledger contributed considerably to the completion of the document. Beyond classification and mapping of challenges, and the analysis and identification of specific standardisation gaps, Pledger provided direct input from its documentation, so as to assist in the analysis of identified research and standardisation challenges. Out of the thirty core challenges identified, five of them were directly enhanced through input from Pledger outcomes. More specifically, the Pledger deliverables *D2.1 "Pledger Detailed Use Cases"* and *D2.2 "Pledger Requirements Analysis"* were used to provide information relevant to the challenges identification and description. The said information was extracted from the description of the Pledger use cases deployed for the project's trials, and the corresponding elicitation of user and technical-side requirements captured by the different stakeholder groups.

3.1.4 Future Monitoring and Engagement Plan

AIOTI is continuously and rapidly changing. In order to track such developments, Pledger partners have identified (and will keep monitoring and contributing to) specific WGs of the alliance.

Beyond TF1 – IoT & Edge Computing Landscape of the Standardisation WG, where ICCS will keep providing contributions to future planned reports (e.g., update of the *"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"* AIOTI report for 2023), Pledger partners will extend their engagement to the activities of TF2 – High Level Architecture (HLA). This TF aspires to provide guidelines for an IoT & Edge Computing Reference (High Level) Architecture and its mapping with existing IoT & Edge Computing Reference Architectures. Under this context, the Pledger architecture and overall framework developed can be used as direct concrete input to future discussions and contributions of the TF.

Another TF under investigation is TF5 – Security. This TF focuses on providing guidelines on a concrete standard framework & references to enable "IoT Trust" based on IoT "Security by design". Under this context, results extracted from Pledger *WP4 "Trust, Smart Contracts and Decision Support mechanisms"* can be used to enhance the current findings of the TF.

Finally, Pledger partners will follow to a greater extent another AIOTI WG, that of "Distributed Ledger Technologies". Under this context, future contributions to the WG can be based on the Pledger results related to the Pledger blockchain subsystem and the related mechanisms, as they have been presented in Pledger *T4.2 "Smart Contracts and DApps on edge and cloud"* documentation.

3.2 EUOS-StandICT.eu

3.2.1 Initiative's Profile

StandICT.eu 2023[24] is an EU framework H2020 Coordination and Support Action project with the central goal to ensure a neutral, reputable, pragmatic, and fair approach to support European and Associated states presence in the international ICT standardisation scene. StandICT.eu 2023 aspires to build the human European network of ICT Standard Experts with a solid base of diligent and active standards contributors. StandICT.eu 2023 addresses the specific challenges of the topic ICT-45-2020 "Reinforcing European presence in international ICT standardisation"[25]. StandICT.eu 2023 delivered in February 2021 the "EUOS – ICT Standardisation Observatory[26]". The brand new EUOS will thoroughly monitor the global Standardisation landscape, providing a comprehensive and accurate coverage of the most important ICT Standards, Working Groups, and Technical Committees that affect the key ICT topics of the Digital Single Market and the EU ICT Rolling Plan for Standardisation.

3.2.2 Nature of Contribution

EUOS is a brand new initiative that will thoroughly monitor the global Standardisation landscape. AIOTI colleagues, including ICCS members, have been appointed to the new Stand.ICT Technical WG – Edge and IoT. The TWG operates in full autonomy and transparency. Activities were initiated in January 2022.

In October 2022, the TWG published its first report titled *"**Landscape of Internet of Things (IoT) Standards**"*[27]. The goal of this report was to capture the landscape of IoT activities and IoT documents/specifications published and/or under publication by SDOs, Alliances, and OSCs initiatives. A similar report is to be published in December 2022, titled ***"Landscape of Edge-Computing Standards"***.

3.2.3 Mapping to Pledger outputs

Pledger contributed to the two StandICT reports by identifying and listing relevant Edge-Computing SDOs and specifications that should be mapped for a complete standardisation landscape. In a sense, the work performed is partially similar to the one executed during the *"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"* AIOTI report preparation (see previous section). The difference between the StandICT reports and the AIOTI ones is that AIOTI provided a relatively brief landscape view, but also a gap analysis of the field, whereas the StandICT reports provided a very extensive presentation of the landscape through the aggregation of the corresponding reports, but with no analysis of the results, apart from their high level classification.

3.2.4 Future Monitoring and Engagement Plan

The StandICT.eu 2023 and EUOS initiatives are two opportunities that appeared in the midth of the project (and for this reason, they were not reported in the previous version of the deliverable). The Pledger partners will stay engaged in the already initiated activities (promotion and update in the next years of the two IoT and Edge Landscape reports), and will keep monitoring the developments of the alliance, should new opportunities arise. Due to the nature of the current activities, contributions are expected to stay on a high level (use cases and requirements analysis), unless the group undertakes tasks related to technical standards specifications.

[24] https://www.standict.eu/
[25] https://cordis.europa.eu/programme/id/H2020_ICT-45-2020
[26] https://www.standict.eu/euos
[27] https://zenodo.org/record/7193436#.Y4XU3X1Bx_D

3.3 ETSI – European Telecommunications Standards Institute

3.3.1 Initiative's Profile

The European Telecommunications Standards Institute (ETSI[28]) is a not-for-profit institute with more than 900 members worldwide, including industry and academia representatives, as well as public organisations. ETSI is a European Standards Organisation (ESO), the recognized regional standards body dealing with telecommunications, broadcasting, and other electronic communications networks and services. Initially founded to support European regulations and legislation through the creation of Harmonised European Standards, nowadays ETSI follows a global perspective, with its standards being used all over the world.

3.3.2 Nature of Contribution

During 2020-2021, the ETSI BOARD TREND performed a thorough analysis to identify the most relevant future technology trends relating to the ICT sector. This work has provided as a primary result the ***"ETSI Technology Radar (ETR)"*** report[29]. The ETSI Technology Radar is updated at regular intervals, with the next edition being planned for the end of 2022. The intent of the ETR is to highlight probable technology trends for ICT that may impact ETSI's quest to remain at the forefront of ICT standardisation. More specifically, this initiative has as a goal a) to report the outcome of a thorough analysis that has considered publicly available technology reports, questionnaires and inputs from ETSI members on the major technology trends; b) to identify the major technology trends that could be of most concern/interest for ETSI; and c) to contribute, for each selected technology trend, to the identification of eventual gaps with respect to current ETSI activities. In December 2021, ETSI invited AIOTI to review the identified technological trends and to provide any observations, comments, and suggestions. ICCS, as a member of the AIOTI Standardisation WG, provided feedback on the ETR.

Moreover, Pledger was invited by the Programme Committee of ETSI IoT Conference 2022[30] (October 2022) to present the results of the *"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"* AIOTI report (see section 3.1). The results were discussed among various experts of the field in a panel discussion and are expected to be reused by various initiatives (Figure 3).

Figure 3: Pledger at ETSI IoT Conference 2022.

[28] https://www.etsi.org/about/about-us
[29] https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp45_ETSI_technology_radar.pdf
[30] https://www.etsi.org/events/past-events/2088-etsi-iot-conf-2022#pane-6/

3.3.3 Mapping to Pledger outputs

As in the case of the AIOTI and StandICT reports, the main Pledger-related material taken under consideration was that of the Pledger results, as reported in the Pledger deliverables *D2.1 "Pledger Detailed Use Cases"* and *D2.2 "Pledger Requirements Analysis"*.

3.3.4 Future Monitoring and Engagement Plan

Inside ETSI, there is a multitude of Industry Specification Groups (ISGs) on various topics related to Pledger. One of the best candidates for future monitoring and contributions from Pledger partners is the ISG on Multi-access Edge Computing (MEC). The group provides specifications to enable applications to be hosted in a multi-vendor multi-access edge computing environment. Under this context, the primary Pledger results of *WP3 "Performance, QoS and orchestration mechanisms"*, and *WP4 "Trust, Smart Contracts and Decision Support mechanisms"* can be the baseline for investigation of contribution to initiatives such as the ETSI "Multi-access Edge Computing (MEC); Framework and Reference Architecture" standard[31], updated in March 2022. In this context, a future initiative could also be the participation to the discussions on the MEC PoC Framework[32] , based on the Pledger UCs.

3.4 Hyperledger Foundation

3.4.1 Initiative's Profile

The Hyperledger Foundation[33] is a non-profit organisation, an open source community focused on developing a suite of stable frameworks, tools, and libraries for enterprise-grade blockchain projects. It serves as a neutral home for various DLT frameworks. The Hyperledger Foundation staff is part of a larger Linux Foundation team.

In the context of Pledger, several Hyperledger SIGs are of interest. Special attention has been given on the Hyperledger Telecom SIG[34], which is focused on technical and business conversations about appropriate use cases for blockchain technology in the Telecom industry.

3.4.2 Nature of Contribution

Pledger, represented by INNOV and ICCS, published a whitepaper titled ***"Self-Asssesing Service Level Agreements (SLAs) with Hyperledger Fabric"***, expecting official release within January 2023. The initial planned efforts were presented live and recorded in an official community meeting[35], while a draft version of the paper is already online[36] (Figure 4). The paper addresses the issues concerning the Self-Assessment of SLAs in Telecom by introducing a distributed alternative approach using Hyperledger Fabric[37] and Fabric Private Chaincode[38]. Towards that direction, the paper defines the appropriate **framework prototype**. The intended audience comprises of various organisation representatives, their developers, and their clientele, contracting with different SLA types. The proposed approach aims to cover dissimilar types of SLAs through a generic approach model where the requested actors' roles (e.g., service provider, application provider, end-user, etc.) and contract activity are defined and addressed completely inside the dedicated framework. The end result is a secure system that provides accuracy and computational fairness benefits to both the actors. In accordance to the underlying blockchain scalability, the suggested solution can scale for enterprise UCs with profitable and applied interest.

[31] https://standards.globalspec.com/std/14499252/GS%20MEC%20003
[32] https://www.etsi.org/technologies/multi-access-edge-computing/mec-poc
[33] https://www.hyperledger.org/
[34] https://wiki.hyperledger.org/display/TCSIG/Telecom+SIG+Charter
[35] https://www.youtube.com/watch?v=YcvUocJnY3Q
[36] https://wiki.hyperledger.org/pages/viewpage.action?pageId=6429512
[37] https://www.hyperledger.org/use/fabric
[38] https://github.com/hyperledger/fabric-private-chaincode

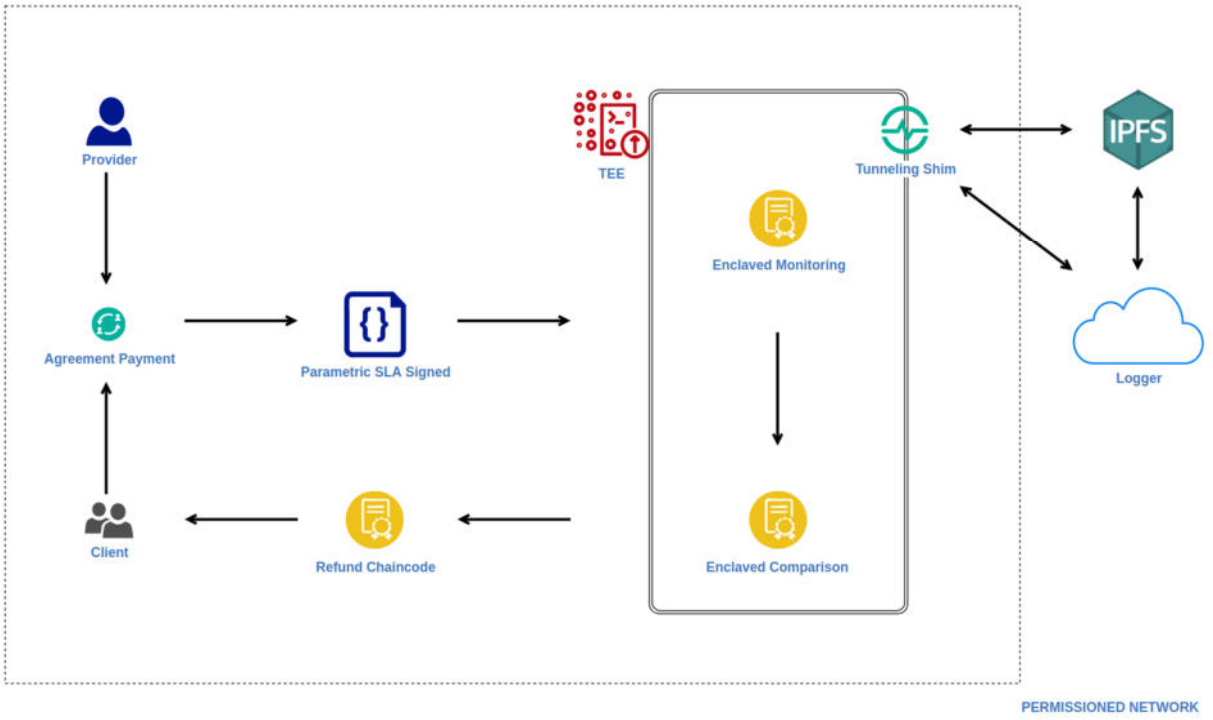

Figure 4: Blockchain SLA Self-Assessment Architecture.

3.4.3 Mapping to Pledger outputs

With regard to the Hyperledger umbrella specifically, Pledger has followed the Hyperledger specifications and standardisation of Fabric distributed ledger and Explorer Hyperledger tool, while the whole project efforts acquired a general Hyperledger logic. Pledger has embraced the fundamentals of open source, envisioning to support and extend the wider open source community. The project has built its decentralised solutions with regard to privacy while developing an enterprise-grade DLT. The produced whitepaper is directly linked to the Pledger activities and results of *WP3 "Performance, QoS and orchestration mechanisms"*, and *WP4 "Trust, Smart Contracts and Decision Support mechanisms"*, and is the outcome of the project's aspiration to provide a seemless solution connecting the Pledger SLAs-related tools with the corresponding Pledger-DLT approach.

3.4.4 Future Monitoring and Engagement Plan

Under the context of future OSC and standardisation activities, the Pledger partnerts will continue contributing to the Hyperledger Telecom SG and Hyperledger Fabric. Future work on the system's configuration will mostly be directed toward providing more violation-agreed actions, such as adding parties reputation management and SLA product scoring inside the workflow of SLA violation handling.

Other initiatives for potential future contributions include the Hyperledger Architecture WG and the Hyperledger Public Sector SIG. The Pledger partners will keep exploring and attempting improvements and contributions on the Hyperledger distributed ledger, supporting other Hyperledger projects as well.

3.5 FIWARE: The Open Source Platform for Our Smart Digital Future

3.5.1 Initiative's Profile

The FIWARE Foundation[39] is a non-profit organisation that drives the definition – and the Open Source implementation – of key open standards that enable the development of portable and interoperable smart solutions. The FIWARE Community is an independent Open Community whose members and partners contribute to a trusted brand and technology, and commit to the realization of FIWARE's mission, "building an open sustainable ecosystem around public, royalty-free, and implementation-driven software platform standards that ease the development of new Smart Applications in multiple sectors". FIWARE encourages the adoption of open standards for the development of "smart solutions" in different Domains.

Under the Pledger context, out of all the FIWARE Domains, the one of primary focus is that of Smart Cities.

3.5.2 Nature of Contribution

"Smart solutions" are considered as "Powered by FIWARE" if they include the context information management provided by the FIWARE Context Broker[40], which supports the data extraction, processing, and actuation, and relays on a suite of additional components for deployment and data management, as well as data manipulation known as "Generic Enablers". All the interactions between applications, Generic Enablers, and the Context Broker take place using the FIWARE Next Generation Service Interface (NGSI) RESTful API , an open standard designed to manage the entire lifecycle of context information, including updates, queries, registrations, and subscriptions. The NGSI API includes a) a data model for context information, b) a context data interface for exchanging information, and c) a context availability interface about how to obtain context information.

Pledger, represented by ENG, has introduced the definition of **new NGSI "smart data models"**[41], which are the key contribution of Pledger to FIWARE standardisation. To achieve that, ENG a) participated actively in the corresponding periodic technical steering committee calls[42] to check the advancements about the Context Broker, and b) identified the key parts of the data model exchanged among the DSS and the other Pledger core components that could be standardised. Following the FIWARE framework, a smart data model includes three elements: a) the schema, b) the specification of a written document for human readers, and c) the examples of the payloads for NGSI. All of these elements are presented in detail in the Annex of this document, as the corresponding information has not been made public yet (as of November 2022).

3.5.3 Mapping to Pledger outputs

The presented contribution is directly linked to specifc components under *WP3 "Performance, QoS and orchestration mechanisms"*, and *WP4 "Trust, Smart Contracts and Decision Support mechanisms"*. More specifically, the new NGSI "smart data models" are Pledger data models focusing on the design and implementation of the DSS tool of the project.

3.5.4 Future Monitoring and Engagement Plan

The adoption of a structured and documented NGSI data model in compliance with FIWARE standards facilitates the involvement of open source community and improve the project sustainability. Pledger partners will keep monitoring the evolution of FIWARE standards and the applicability of Pledger's major components in order to facilitate potential future integration and the development activities.

[39] https://www.fiware.org/
[40] https://www.fiware.org/2020/12/11/fiware-context-broker-the-engine-for-future-energy-systems/
[41] https://www.fiware.org/developers/data-models/
[42] https://www.fiware.org/foundation/technical-steering-committee/

4 Conclusions

This deliverable contains an overview of the standardisation bodies and initiatives followed by Pledger, together with the activities undertaken to ensure the project results sustainability by promoting the latter to the corresponding standardisation working groups.

Beyond the incidental contributions provided by the Pledger partners to SDOs, Alliances, and OSCs focused on standardisation and open-source activities, Pledger has managed by the end of its lifecycle to produce a solid list of concrete standardisation results. These results are:

- The *"High Priority Edge Computing Standardisation Gaps and Relevant SDOs"* AIOTI report[43].
- The *"Landscape of Internet of Things (IoT) Standards"* StandICT report[44] and the corresponding *"Landscape of Edge-Computing"* (to be published in December 2022).
- The *"ETSI Technology Radar (ETR) 2022"* report[45] (to be updated at the end of 2022).
- The *"Service Level Agreements Self-Assessment with Hyperledger Fabric"* Hyperledger whitepaper[46].
- A new NGSI "smart data model"[47] in the context of FIWARE.

Pledger has produced contributions related to **three standardisation landscape reports**, **one Open Source Framework whitepaper**, and **one Open Source guideline**, by being active in WGs of SDOs (ETSI), Alliances (AIOTI, StandICT), and OSCs (Hyperledger, FIWARE). Moreover, the project has managed to exploit results from all of its technical WPs, with *WP2 "Requirements Analysis and Architecture"* input being used for the standardisation landscape reports to SDOs and Alliances, and *WP3 "Performance, QoS and orchestration mechanisms"* and *WP4 "Trust, Smart Contracts and Decision Support mechanisms"* outcomes being used for Frameworks and Guidelines to OSCs.

To sum up, Pledger has successfully met its standardisation goal of contributing to at least 2 standards with relation to SLA metrics and orchestration languages, and has successfully established the baseline for future related activities extending beyond the official lifecycle of the project.

[43] https://aioti.eu/wp-content/uploads/2022/04/AIOTI-High-Priority-Edge-Computing-Gaps-Final.pdf
[44] https://zenodo.org/record/7193436#.Y4XU3X1Bx_D
[45] https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp45_ETSI_technology_radar.pdf
[46] https://wiki.hyperledger.org/pages/viewpage.action?pageId=6429512
[47] https://www.fiware.org/developers/data-models/

Annex: Pledger DSS NGSI Smart Data Model

The following guidelines and schema are provided to introduce a new NGSI Smart Data Model, as defined by FIWARE, focusing on one of the main tools of Pledger: the Pledger Decision Support System (DSS). The DSS is a new component developed in Pledger to support the service provider in taking optimal decisions about the allocation of resources for DApps while minimizing the number of SLA violations. The DSS acts autonomously trying to reduce the resources allocated to the edge, where they are scarce, whenever the Apps do not produce any warning, then increasing them when the opposite occurs. Eventually, the DSS offloads the Apps to the cloud if there are no more edge resources available, then back to the edge when possible.

The specific tool is an outcome of the project's *WP4 "Trust, Smart Contracts and Decision Support mechanisms"* and is extensively documented in *D4.6 "Decision Support tools II"*. Information included in D4.6 should also be taken under consideration to fully understand the following guidelines.

Guidelines

On the topic of **Context Broker** specifications, following the guidelines described in "Going through a Data Model" in FIWARE documentation[48], it was decided to use the "Simplified Entity Representation" in NGSIv2 specification in place of the "Normalised Entity Representation" to keep the description less redundant.

Using this representation we can have, for each entity, a simple JSON structure with specified type. For attributes, along with values, **type** might be specified if it refers to a well-known data model. For example:

```
{
  "id": "entityId",
  "type": "entityType",
  "attribute1_name": "attribute1_value",
  ..
  "attributeN_name": "attributeN_value"
}
```

or, in case of attributes referring to a **known type**:

```
{
   "id":"entityId",
   "type":"entityType",
   "attribute1_name":{
      "type":"attribute1_Type",
      "value":"attribute1_value"
   },
  ..
  "attributeN_name":{
      "type":"attributeN_Type",
      "value":"attributeN_value"
   }
}
```

[48] https://fiware-datamodels.readthedocs.io/en/stable/howto/index.html

This basic model must also include the **mandatory** fields required by NSGIv2 specifications:

- id: a unique identified of the entity modelled.
- type: the entity type, i.e., the type of data model.
- dateModified: last update timestamp of the entity.
- dateCreated: the entity's creation timestamp.

Then, it was chosen to enrich the model with **optional** fields to improve the traceability of the entities, adding recommended GSMA[49] common definitions:

- owner: an array of URIs or pointers to NGSI entities representing the owner(s) of the entity.
- source: a pointer (eventually a URI) to the service providing the data.
- name: a mnemonic name given to the entity.
- description: a textual description of the entity.
- dataProvider: a name identifying the entity providing the data.

This defines the basic structure to use in the modelling of the DSS messages described below.

As a next step, it was decided to focus on the messages exchanged by the DSS to the **Orchestrator** and the **SLA Manager** (other Pledger components), with the goal to support future extension on the DSS as an autonomous service that provides end-to-end monitoring and orchestration for the continuum based on FIWARE.

To achieve such goal, the **objectives** (and benefits) are to 1) adopt a common data format for the **control plane** to facilitate the integration with the other FIWARE components and to 2) limit the dependencies with the Pledger core components replacing closed-source components like the StreamHandler with opensource, context-aware alternatives, such as FIWARE Context Broker, using the mentioned NGSIv2 specifications[50] as a baseline.

Starting from what is already shown in *D4.6 "Decision Support tools II"*, Figure 5 highlights the **main DSS interactions** with the other Pledger core components and the two data models under analysis in this subsection that in Pledger are exchanged using the StreamHandler.

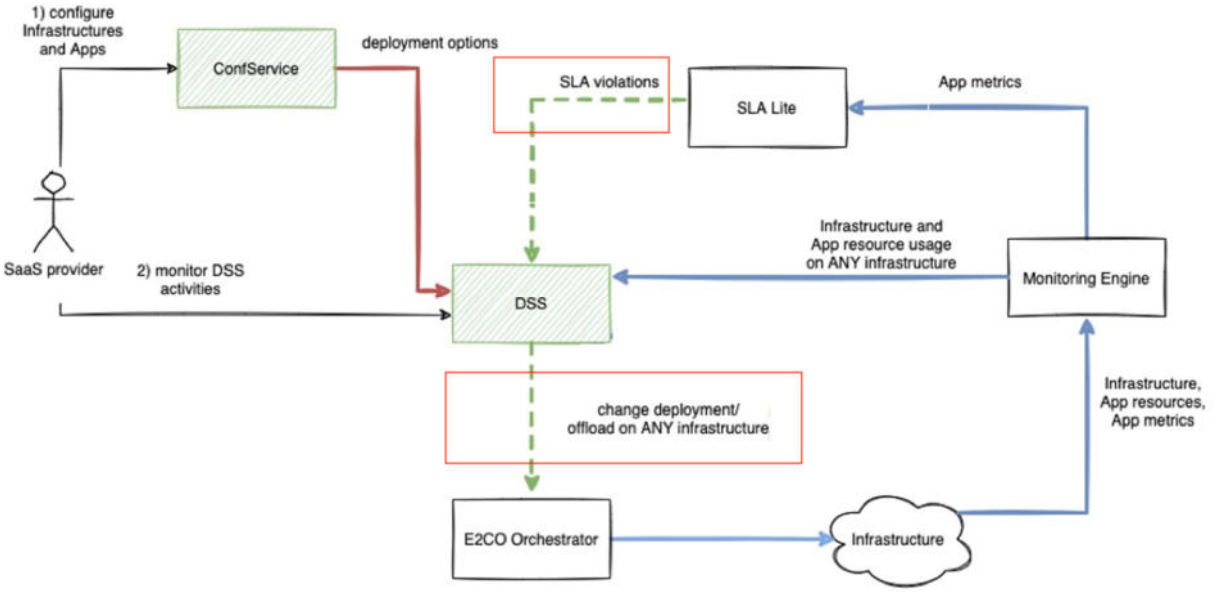

Figure 5: DSS interactions with the other Pledger core components.

[49] https://github.com/FIWARE/data-models/blob/master/specs/gsma.md
[50] http://fiware.github.io/specifications/ngsiv2/stable/

Other DSS interactions with Pledger core components are ignored because:

- ConfService → DSS interaction is done through an internal protocol, JDBC, which is not relying on StreamHandler, so no part of the objectives mentioned above.
- MonitoringEngine → DSS interaction is done through StreamHandler (and via direct API calls), but not control plane data are monitored (which is against the objective mentioned above).
- Other interactions with the DSS are considered minor, and as such they are ignored (for example, interactions related to the scenario of identifying which Node is better for a specific DApp, based on the AppProfiler tool), as the content is very specific and less relevant for a standardisation activity.

Having clarified the context, we can proceed with the analysis of the Orchestrator and the SLA Manager messages exchanged with the DSS.

For the **Orchestrator**, an example of data exchanged (later referred as "OrchestratorAction") is:

```
{
  "id": "SERVICE_ID",
  "entity": "service",
  "operation": "OPERATION",
  "target_infra_id": "INFRA_ ID",
  "placeholders": "PAYLOAD"
}
```

Such a general example reflects the data model exchanged in the message, containing:

- the **service** ("id") that is the objective of the DSS action.
- the **action** to take ("operation"), decided by the DSS, that can be:
  - start
  - stop
  - scale
  - offload
- the **infrastructure** that will host the service ("target_infra_id"), taken from the ConfService.
- the runtime **parameters** ("placeholders"), taken from the DSS, about:
  - number of replicas
  - reserved resources (CPU, memory)
  - infrastructure namespace where to run the service
  - infrastructure node where to run the service

A note about the **internal data model** referred by the structure above: This model refers to the internal ConfService data model which is described in D4.6 and that is based on the concept of a Service, which is the entity that receives the action, and the Infrastructure and Nodes, which host it, that are structured with a one-to-many relation.

Figure 6 shows an abstract of the ConfService data model focused on the entities mentioned and their relationships. This model is generic enough to be used also outside Pledger **without any change** and can be used as a baseline to convert it using FIWARE guidelines.

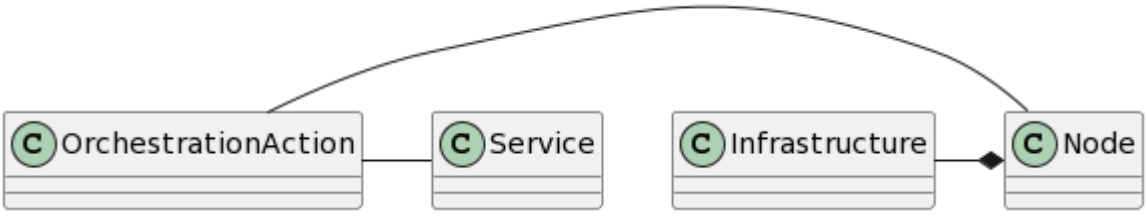

Figure 6: E-R model for OrchestrationAction, Service, Infrastructure and Nodes.

Following the design principles proposed by FIWARE for the creation of data models[51], for the Pledger entities mentioned there are no FIWARE types, the following convention is used:

- as **type**, the string "pledger:<PLEDGER_TYPE>"
- as **owner,** the string "urn:pledger:<PLEDGER_TYPE>:ID".
- as **dataProvider,** the string "DSS ConfService".

where PLEDGER_TYPE is a DSS class name according to D4.6, extended to have also OrchestratorAction with the model described above.

This leads to the following proposed model example for the **Orchestrator action (and related entities)** to scale service with ID 3 on infrastructure with ID 1 and node with ID 2:

```
{
   "id":1111,
   "type":"pledger:OrchestratorAction",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":" OrchestratorAction",
   "description":"a OrchestratorAction",

   "action":"scale",
   "replicas":2,
   "namespace":"my namespace",
   "cpu":{"value": 500, "type": "millicore"},
   "memory":{"value": 256, "type": "megabyte"}
}
```

```
{
   "id":1,
   "type":"pledger:Infrastructure",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":"Infrastructure",
   "description":"a Infrastructure",
   "dataProvider":"DSS ConfService"
}
{
   "id":2,
   "type":"pledger:Node",
   "dateCreated":{
```

[51] https://fiware-datamodels.readthedocs.io/en/stable/howto/index.html

```
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "owner":{
      "type":"URN",
      "value":"urn:pledger:DSS:Infrastructure:1"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":" Node",
   "description":"a Node",
   "dataProvider":"DSS ConfService"
}
```

```
{
   "id":3,
   "type":"pledger:Service",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":"Service",
   "description":"a Service ",
   "dataProvider":"DSS ConfService"
}
```


For the **SLA Manager**, an example of data exchanged is:


```
{
  "sla_id": "SLA_ID",
  "guarantee_id": "GUARANTEE_ID",
  "severity_name": "Serious",
  "value": "VALUE"
}
```


Such a general example reflects the data model exchanged in the message, containing:

- the **SLA** ("sla_id") that produced a violation.
- the **guarantee** ("guarantee_id") that, within the **SLA**, produced the violation.
- the **severity** of the SLA Violation ("severity"), that can be:
  - Warning
  - Mild
  - Serious
  - Severe
  - Catastrophic
- the **value** that generated the violation ("value"), as a number.

A note about the **internal data model** referred by the structure above: Also in this case, the model refers to the internal ConfService data model described in D4.6 and that is based on the concept of an SLA[52] which aggregates one or more Guarantees, each one describing a metric to monitor (in literature, also known as Service Level Indicators or SLI) and different thresholds (in literature, Service Level Objectives or SLO) with corresponding severities.

Figure 7 shows an abstract of the ConfService data model focused on the entities mentioned and their relationships. Again, we consider this model as generic enough to be used also outside Pledger **without any change** and can be used as a baseline to convert it using FIWARE guidelines.

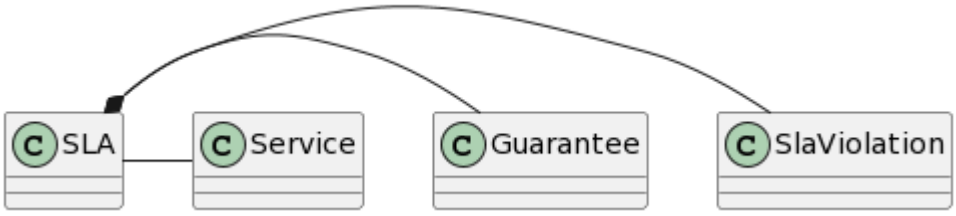

Figure 7: E-R model for Service, Sla, SlaViolations and Guarantees.

For the SLA Manager messages, the same convention is adopted for the **type**, **owner**, and **dataProvider**, as in the case of the Orchestrator.

This leads to the following proposed model example for the **SlaViolation (and related entities)** for SLA with ID 4, having a Guarantee with ID 5, with SLA attached to a Service with ID 3, all belonging to the Pledger platform published on URL http://192.168.70.13:30288:


```
{
   "id":2222,
   "type":"pledger:SlaViolation",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "owner":{
      "type":"URN",
      "value":"urn:pledger:DSS:Sla:4"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":" SlaViolation ",
   "description":"a SlaViolation ",
   "dataProvider":"DSS ConfService",

   "severity":"Mild",
   "value":777,
}
```


[52] https://www.atlassian.com/incident-management/kpis/sla-vs-slo-vs-sli

```
{
   "id":4,
   "type":"pledger:Sla",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "owner":{
      "type":"URN",
      "value":"urn:pledger:DSS:Service:3"
   },
   "source":{
      "type":"URL",
      "value":"http://192.168.70.13:30288/"
   },
   "name":"SLA",
   "description":"an SLA",
   "dataProvider":"DSS ConfService"
}
```



```
{
   "id":5,
   "type":"pledger:Guarantee",
   "dateCreated":{
      "type":"DateTime",
      "value":"2021-08-08T10:18:16Z"
   },
   "dateModified":{
      "type":"DateTime",
      "value":"2021-08-08T11:18:16Z"
   },
   "owner":{
      "type":"URN",
      "value":"urn:pledger:DSS:Sla:4"
   },
   "source":{
      "type":"URN",
      "value":"http://192.168.70.13:30288/"
   },
   "name":"Guarantee",
   "description":"a Guarantee",
   "dataProvider":"DSS ConfService",

   "thresholds": [
    {"severity": "warning", "value": 100},
    {"severity": "mild", "value": 500},
    {"severity": "serious", "value": 1000},
    {"severity": "severe", "value": 5000},
    {"severity": "catastrophic", "value": 10000},
   ]
}
```


To conclude, these two models have been validated against the respective JSON Schema reported in the next section.

We believe this work could be used as a baseline for future investigations and to extend Pledger DSS and make it “Powered by FIWARE”, so to be part of its ecosystem while reducing, at the same time, the dependencies on closed-source components.

JSON Schema

The JSON Schema part which is in common with all the entities mentioned in the previous sections is the following:

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "object",
  "properties": {
    "id": {
      "type": "integer"
    },
    "type": {
      "type": "string"
    },
    "dateCreated": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string"
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "type",
        "value"
      ]
    },
    "dateModified": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string"
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "type",
        "value"
      ]
    },
    "owner": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string"
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "type",
        "value"
      ]
    },
    "source": {
      "type": "object",
      "properties": {
        "type": {
          "type": "string"
```

```
        },
        "value": {
          "type": "string"
        }
      },
      "required": [
        "type",
        "value"
      ]
    },
    "name": {
      "type": "string"
    },
    "description": {
      "type": "string"
    },
    "dataProvider": {
      "type": "string"
    }
  },
  "required": [
    "id",
    "type",
    "dateCreated",
    "dateModified",
    "source",
    "name",
    "dataProvider"
  ]
}
```

Below, the JSON Schema part specific for **OrchestrationAction** is provided. All additional fields are "required".

```
{
    //please add here the common part above
    "action": {
      "type": "string"
    },
    "replicas": {
      "type": "integer"
    },
    "namespace": {
      "type": "string"
    },
    "cpu": {
      "type": "object",
      "properties": {
        "value": {
          "type": "integer"
        },
        "type": {
          "type": "string"
        }
      },
      "required": [
        "value",
        "type"
      ]
    },
    "memory": {
      "type": "object",
      "properties": {
        "value": {
```

```
          "type": "integer"
        },
        "type": {
          "type": "string"
        }
      },
      "required": [
        "value",
        "type"
      ]
    }
}
```

Below, the JSON Schema part specific for **Guarantee**. All additional fields are “required”.

```
{
    //please add here the common part above
    "thresholds": {
      "type": "array",
      "items": [
        {
          "type": "object",
          "properties": {
            "severity": {
              "type": "string",
              "enum": ["warning", "mild", "serious", "severe", "catastrophic"]
            },
            "value": {
              "type": "integer"
            }
          },
          "required": [
            "severity",
            "value"
          ]
        }
      ]
    }
}
```

Below, the JSON Schema part specific for **SlaViolation**. All additional fields are “required”.

```
{
    //please add here the common part above

    "severity": {
      "type": "string"
    },
    "value": {
      "type": "integer"
    }
}
```