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Executive Summary

This document is the final deliverable from WP8 – "Pilot Demonstrations and Overall Evaluation". It reports on the assessment criteria, evaluation process and the results of the evaluation of the VICINITY Framework, Pilot test sites, and Open Call trials. It should be read in conjunction with more detailed evaluation reports on the individual pilot trials: D8.2, D8.3, D8.4 and D8.5, and D6.4 which evaluates the key USP of providing security and privacy for the personal data of the end users, also D2.4 which evaluates the impact of VICINITY on standards and D9.14 that reports on commercialisation plans.

The four pilot projects were completed and operated correctly. In addition, there were two rounds of open-call projects, with four projects funded in each call these all completed satisfactorily and formed an independent review of the VICINITY Framework and the supporting documentation.

In this deliverable we first explain the approach that was taken to gather evidence in order to evaluate the effectiveness of the pilots, open call projects and the overall Framework. The evidence gathered from each pilot is then summarised with links to deliverables where more detailed information can be accessed.

The evaluation was based on evidence collected automatically and from stakeholder interviews and questionnaires. Several dashboards were created and used to track system-use and performance.

- bAvenir tracked usage and issues with the core VICINITY platform.
- The data from Pilot demonstration sites and the related value-added services were uploaded in real time to a central registry operated by UniKL. These activity measurements were fed into a dashboard that enabled trends to be observed graphically.
- In addition, some pilot sites used their own dashboard to monitor the performance of their systems.

Subjective evaluations were collected from various stakeholders who were using the VICINITY-based service either as service users or as service providers. Three metrics to evaluate the state of maturity were adopted. The metrics chosen necessarily cover the range of maturity that extends to the fully-commercialised status of being a fully proven, highly integrated system that uses VICINITY-compatible sensors available off the shelf. This approach is necessary to judge how far the project has advanced the concept and what remains to be done.

The effectiveness of the evaluation processes is also reviewed.

In combination, these evaluations revealed that the VICINITY concept delivers the intended benefits and is relatively easy to use. The level of maturity of the VICINITY Framework and the pilots was assessed using the Technology Readiness Level scale (TRL). This was originally proposed by NASA and adopted by the EU for H2020 projects. In addition to the TRLs , two new criteria were adopted that assess firstly the ease of integration of sensors into a VICINITY network; and secondly, for pilots, the level of integration that the pilot use-case had with the pre-existing IT systems that were in use.

Overall, it was concluded that the VICINITY framework had delivered the expected benefits. The teams implementing the Pilots and OpenCall experiments found the framework easy to use and concluded that it provided the intended services. The VICINITY concept has been proved to work well and its adoption is seen to offer benefits to the organisations using VICINITY. We have reached TRL 7, and have technical and some commercial justification to develop the capability to TRL 9

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List of Definitions & Abbreviations

Abbreviation	Definition
EC	European Commission
EU	European Union
GDPR	General Data Protection Regulation
IEQ	Internal Environment Quality
IFTTT	If True, Then This
IUS	(level of) Integration with User’s Systems
P2P	Peer to Peer
PV	(solar) Photo Voltaic (generation)
RES	Renewable Energy Systems
TRL	Technology Readiness Level
USP	Unique Selling Point
UV	Ultra-violet light
VAS	Value Added Service
VFC	VICINITY Framework Compliance

1. Introduction

1.1. Context within VICINITY

This document provides one of seven evaluation reports on the effectiveness and usability of the VICINITY Framework, as observed from the collective results from the four pilot trials and the eight Open Call trials. It should be read in conjunction with D6.4 that evaluates the overall security and privacy provided by VICINITY, and by the individual assessment reports on the four pilot trails D8.2 at Martim Longo, Portugal; D8.3 in Oslo, Norway; D8.4 in Tromsø, Norway; D8.5 at Pilea-Hortiatis, Greece, Most importantly the alignment of the VICINITY Framework with international standards is covered in D2.4. The scope of this document has been targeted to avoid unnecessary duplication of information that is best obtained from other documents. The next sub-section of this deliverable will explain the scope and boundaries for this report. The objectives for this document are defined under three headings: the original objectives as documented in the original project proposal; guidance from the project office at progress review meetings and a summary of the way that these broad objectives have been translated into specific objectives.

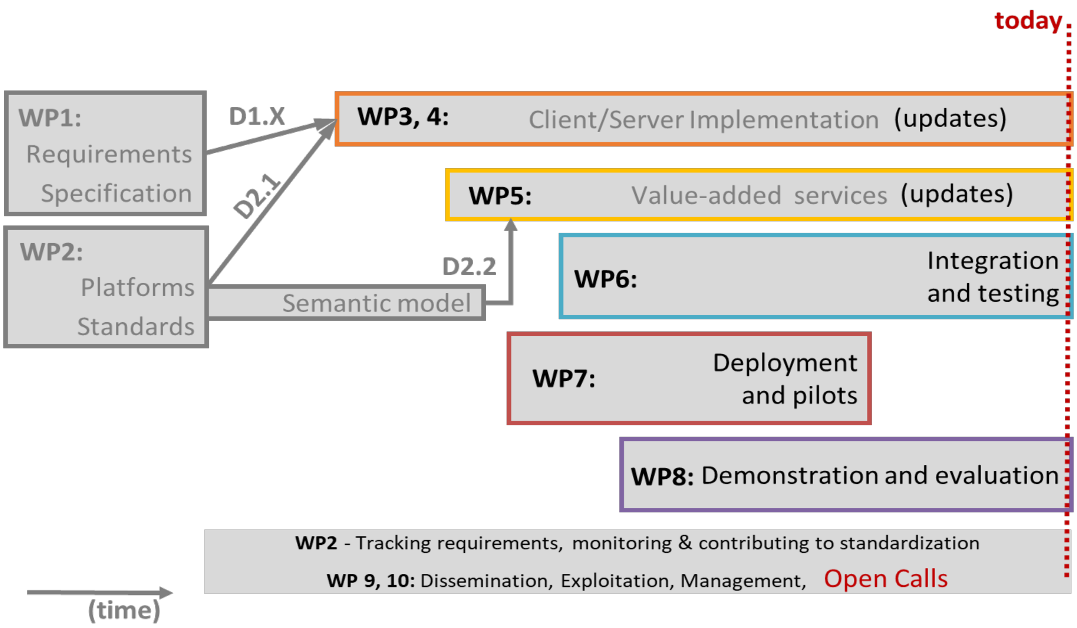

Figure 1: Relationship of this WP to the overall project plan

This report will describe the approach taken to evaluate the pilots and the VICINITY Framework. Subjective evaluation was collected from developers, users and other stakeholders, with objective, quantified evaluation based on the autonomously collected usage data that has been used to drive usage dashboards Section 2 also explains the three state of maturity scales that have been developed and adopted In order to evaluate the state of maturity of the developments from the project. TRL has been adopted along with two VICINITY-specific metrics have been created to assess the state of maturity of the Framework, pilots and the use-cases that were implemented.

Section 3 reviews the main conclusions and state of maturity of the four pilot trial sites.

The findings of the open call projects with regards to the evaluation of the VICINITY Framework are summarised in section 4. The developers of the eight open call projects were obliged to provide an assessment of their experiments, which included an assessment of the functionality of the VICINITY Framework, and its ease of use, including the quality of documentation.

An evaluation of the VICINITY Framework is developed from the feedback from the pilots and open call trials, as well as direct observations from the team that operated the VICINITY platform during the trials. The effectiveness of the evaluation tools is assessed before the final conclusions are presented.

1.2. Original Objectives from the Description of Work

The objectives of Work Package can be found in the original description of work that formed the contract for this project. Those descriptions are reproduced below, taken from the original Description of Work in the Grant Agreement. Additional requirements have been introduced during the project, together with consideration of where some of this scope has already been covered in other documents. The resulting clarified scope for this document is then presented, based on the above considerations.

WP & Tasks	Description
WP8	It is most important that the pilot evaluation framework is set up so that the use cases can be demonstrated and evaluated effectively. Therefore: Sufficient testing and measurement points must be put in place to ensure that the outcomes of the use cases can be determined unequivocally.- Evaluation criteria for the pilot systems will include the ability to be: self-adaptive, robust, safe, intuitive, affordable and interconnected smart network and service platforms. This includes the ability of the systems to dynamically access spectrum and the effectiveness of the network management. KPIs will be defined and, when applicable automated, to ensure that overall satisfaction is maintained. This will include energy efficiency metrics to ensure a long battery life for connected devices.
WP8.6	This task performs the overall evaluation of the VICINITY framework, considering User Experience (both end-users participating in the use-realisation and addressed stakeholders). In particular, an evaluation of the improvements brought by the overall VICINITY framework in terms of achieved ease of integration, semantic interoperability gained and overall improvements towards value-added services implementation. This task also serves for validating the degree of compliance of the VICINITY overall pilot operation results to the user, business and overall requirements identified in WP1.The final report will detail the performance evaluation of each use case, including autonomously gathered data, results of questionnaires and evaluations of the economic and environmental performance. A report will be written detailing the way in which the pilot system was evaluated, the evaluation criteria and the performance of each use case and application. This will include autonomously gathered data, results of questionnaires and evaluations of the economic and environmental performances. A rating system will be devised to show the relative maturity of the use case and the applications within it. The usefulness of the dashboard will be assessed and reported. A description of how performance indices may be updated over time so that year-on-year improvements (or issues) can be measured and tracked. Finally, ATOS will assist in the overall evaluation by bringing onboard third-party integrated infrastructures, performing the Open Calls foreseen in the project.
D8.6	The deliverable will provide a report on the results of the evaluation of the user experience and assess how well the VICINITY Framework performed against the expectations set up in D8.1. It will describe the way the pilot system was evaluated, the evaluation criteria and the performance of each use case and application. This will include autonomously gathered data, results of questionnaires and evaluations of the economic and environmental performances. A rating system will be included to show the relative maturity of the use case and the applications within it. The usefulness of the dashboard will also be assessed and reported including how performance indices may be updated over time so that year-on-year improvements can be measured and tracked.

Table 1: Work package descriptions

1.2.1. Comment and interpretation

Information on evaluation methods and a summary of findings for each pilot, with additional information derived from the dashboard that tracked autonomously created data, will be included. Additional metrics to evaluate the state of maturity of the pilots and of the VICINITY Framework will be described. This deliverable will also consider the effectiveness of the various evaluation tools that were used. Avoidance of overlap with other deliverables is considered in section 1.4 below.

1.3. Additional Objectives from the Project Office

The Project Officer's review team also provided guidance at the review in January 2019. This included: "It is not clear, how the pilots are evaluated beyond technical evaluation. The actual value of the pilot applications is limited. The evaluation should focus on the VICINITY based USPs, rather than the single pilots' applications and services which should be treated as test cases for the overall VICINITY platform, enablers and USPs."

1.3.1. Comment and interpretation

The evaluation of the VICINITY Framework has been given greater attention, taking input from the findings of the Pilot trials and the Open Call projects, where the developers were entirely independent from the VICINITY team.

The VICINITY USP as claimed in D5.1 and repeated in D8.1 is:

"VICINITY's USP is its ability to enable data to be shared between a wide variety of devices by ensuring semantic interoperability among them at the metadata level so that the contents of the data can follow a separate path from the VICINITY platform to ensure privacy".

The VICINITY Framework and Pilot Site use cases and applications need to be judged against this USP.

1.4. Avoidance of repetition and overlap with other VICINITY documents

Much of the information included in the definition of D8.6 above has already been written up in the individual pilot trial reports:

- D8.2: Pilot results of Smart Energy Micro-Grid Neighbourhood use-case;
- D8.3: Realisation and evaluation of Buildings for Assisted Living Neighbourhood Use Case;
- D8.4: Pilot results of Intelligent Transport and Parking use-case;
- D8.5: Pilot results of eHealth at Home use-case.

Other aspects of evaluation are covered by D6.4: VICINITY security and privacy evaluation report;

- D2.4: Report on Standards Involvement over life of project and conformance assessment, and
- D9.14: VICINITY exploitation and business plan.

1.5. Specific Objectives for the T8.6 evaluation exercise

- Determine the ease of use of the VICINITY platform, as experienced by developers.
- Monitor and interpret usage trends, as visualised on the dashboard.
- Devise an approach to assess the overall level of maturity of the Framework and the pilots
- Examine whether the Pilot use-cases worked as expected, delivering the stated USP.
- Review the findings from the open call trials in relation to the evaluation of the VICINITY Framework
- Review the usefulness of the evaluation tools used, automatically collected data and feedback from developers and other stakeholders.
- Conclusions on evaluation of the VICINITY Framework, the Pilots, other test sites and use cases trialled

2. Evaluation Methodology

Objective and subjective measurements have been made during the experimental phase of the project. It is necessary that the VICINITY Framework and the Value-Added Services (VASs) are shown to be operating correctly, but that is not the main purpose of the evaluation activity. The evaluation phase is to check that there are real benefits being delivered by the use of the VICINITY Framework and the Value-Added Services that are implemented at the pilot sites. The VICINITY Framework needs to be shown to be easy to use and effective in its operation. Objective measurements of the service operation are gathered by the real-time collection of usage statistics reported by the VAS. Subjective measurements are made by observation and questions asked of representatives of the stakeholders.

2.1. Objective Measurements

2.1.1. Usage tracking, displayed on the Performance Dashboard

Usage information is generated at each Pilot site. This is then uploaded to a central repository operated by UNIKL. The data collected is analysed by UNIKL and the analysis is presented on a Dashboard.

Ref No	Common KPI	Explanation	Static / Dynamic
1	Devices connected to the pilot site (Type and Number)	This is the total number of IoT devices (sensors, actuators etc) that are registered in VICINITY at a particular pilot site.	static
2	Number of Organizations, Devices, VASs, Friendships and Contracts per use case.	This is a description of the Pilot Site's Neighbourhood.	static
3	Participants per use case (Type, Number)	This relates to people who are users of the UIs of the VAS. Ideally everyone using the VAS will have a personal account.	static
4	Number of messages received by the Use Case VAS from IoT devices.	This includes routine messages „here I am", „I am still connected" and „the temperature is 39deg c" messages.	Dynamic
5	Number of maintenance alerts detected	Number of maintenance alerts produced by either the sensor or the logic of the VAS	Dynamic
6	Number of notifications by the Use Case VAS	Number of notifications produced by the VAS (e.g. regarding an alert)	Dynamic

Table 2: KPIs to be collected automatically

The Dashboard data repository does not receive information direct from sensors. Instead it receives suitably abstracted information from the VAS server. This avoids any GDPR problems and complies with the stated principles of VICINITY that VICINITY service only forwards sensor data to the VAS server.

Unfortunately, it was not possible to implement some of the more advanced automatically collected KPIs that were identified in D8.1.

Some VASs produce additional status reports that are fed to the Dashboard Repository, so that there is more clarity of the value being delivered by that VAS. Such additional information is detailed in section 3.

The Dashboard provides a plot of usage against time for each of the use-cases being operated at each Pilot. The Dashboard can provide various displays for each of KPIs 4, 5 & 6.

The VICINITY Pilot Dashboard is operated by UNIKL and is accessible at https://cpsgw.cs.uni-kl.de/vicinity-dashboard. The dashboard information is publicly available as there is no personal data reported to the dashboard tool.

All the usage data is statistical in nature and is generated on the pilot trial site: only non-private performance data is collected and reported to the dashboard. 39 shows the Landing Page of the Dashboard. The Landing Page summarizes the individual data about each pilot site to immediately give an impression of VICINITYs overall performance across all pilot use-cases.

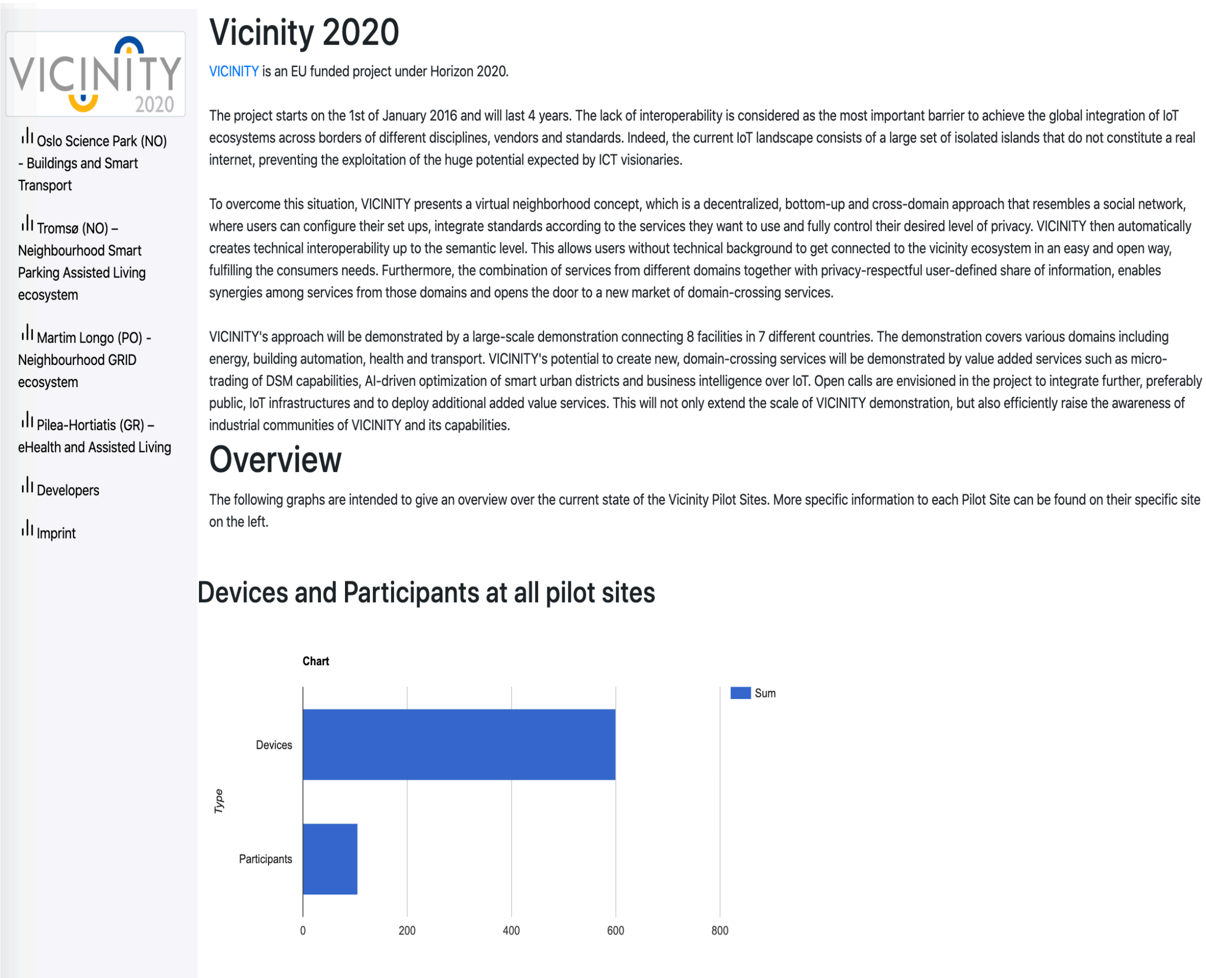

Figure 2: VICINITY Pilot Dashboard Landing Page

Further details can be displayed for each available Pilot Site: Oslo Science Park, Tromsø, Martim Longo and Pilea-Hortiatis. The Dashboard collects static (slow changing) and dynamic (day-by-day changes) KPIs for each Pilot (see table 2): KPIs 1-3 are represented as Bar Charts. Each of them will show the most recent data, which represents the current operational state of the pilot site. KPIs 4-6 are collected daily. The trend over the past week/month/year can be selected and shown. These give a good impression on the real benefit, brought to the pilot sites by utilizing VICINITY. Figure 3 shows KPIs 2, 3 and 4 of the Oslo Science Park as collected and shown by their operating Value-Added Services.

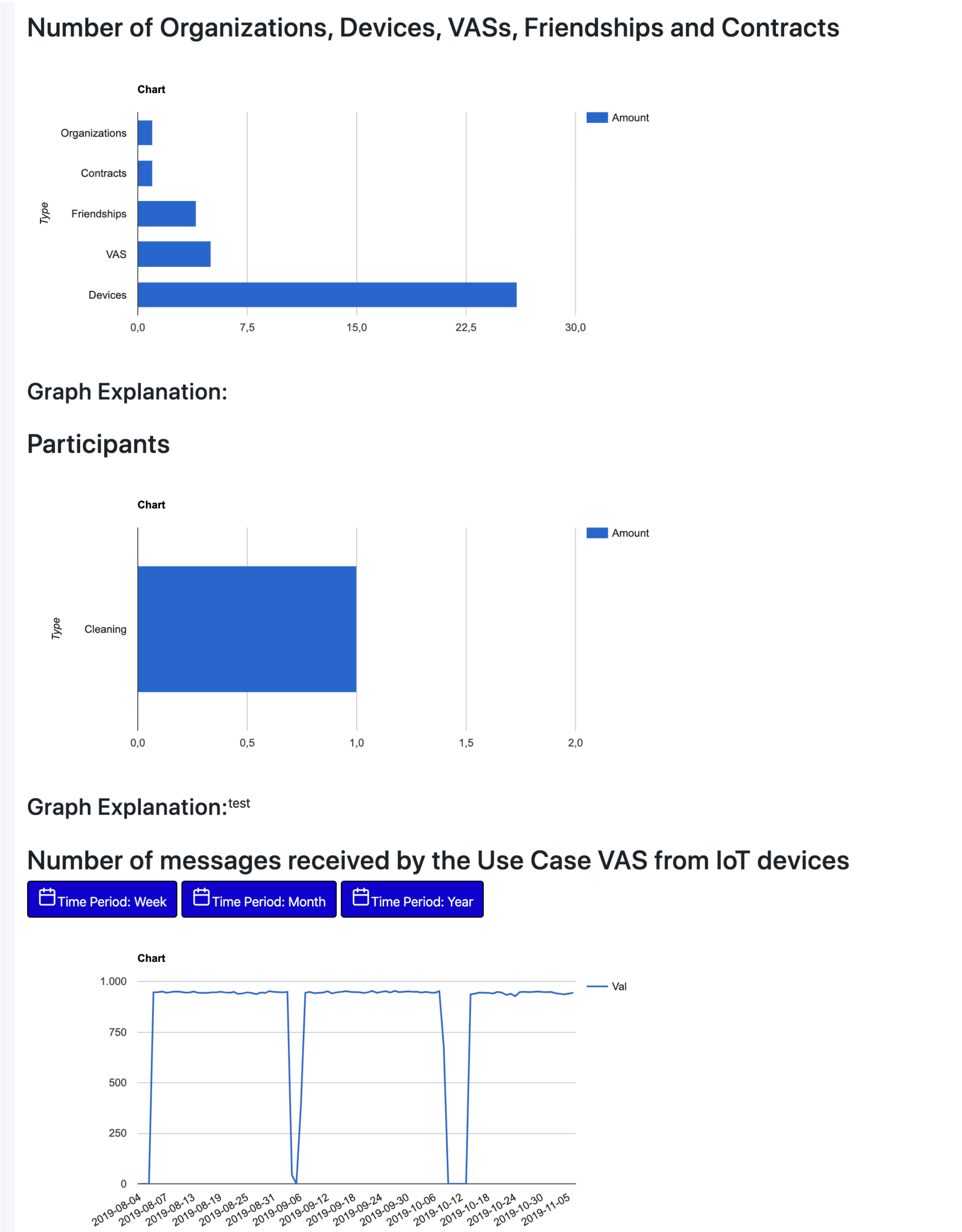

Figure 3: Example display of selected KPIs on Oslo Pilot Site

2.1.2. Dashboard relating to the overall performance of the VICINITY Framework

The operational management dashboards that were used by BVR to manage the operations of the core VICINITY Platform are described in Section 5 of this deliverable.

2.2. Subjective Measurements by questionnaire

There are many different types of stakeholders and beneficiaries for the provision and adoption of VICINITY and the value-added services using VICINITY. Their views have been captured using questionnaires and results reported in D8.2 to D8.5. A "developer's questionnaire" was used for the Pilot site and the Open Call developers.

2.3. Rating the State of Maturity of the use cases and applications within them

A further element of the evaluation is the Rating of the State of Maturity of the use cases and Value-Added Services within them, as well as the overall VICINITY Framework.

The well-established Technology Readiness Levels (TRL) is one classification of maturity. However, there are other factors that need to be considered and two new metrics have been created for this project. These include the level of VICINITY Framework Compliance (VFC) and the level of Integration with the User's Systems (IUS).

These metrics have been devised to enable progress to be judged against what will be required before VICINITY can be widely adopted as an industry preferred approach. This means that stages of maturity have been defined which are beyond the development stage that is appropriate for this project. Failure to reach the highest level of maturity does not in any way imply failure of the project to achieve its objectives.

2.3.1. Technology Readiness Level

Nine Technology Readiness Levels are defined below, using the wording in H2020 general annexes to 2016-17 Work Programme. [3]

TRL 1	basic principles observed
TRL 2	technology concept formulated
TRL 3	experimental proof of concept
TRL 4	technology validated in lab
TRL 5	technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
TRL 7	system prototype demonstration in operational environment
TRL 8	system complete and qualified
TRL 9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 3: Definition of Technology Readiness Levels (TRL)

2.3.2. VICINITY Framework Compliance

The objective of VICINITY is to move away from the current approach adopted for many IoT systems, which is to implement stove-piped systems, where sensors are used only to support the service that they were installed for. Interoperability can be implemented at various levels in the system.

The following classification has been developed within the VICINITY project.

Ideally, sensors should be developed to be able to connect directly to the VICINITY network with a local connection. That direct connectivity is classed as VFC 3 and will only be achieved once the VICINITY interface is adopted by sensor manufacturers. To achieve VFC 3 would be a stretch target and was not included within the specific objective to be achieved in this project but is an important to use this to assess the level of integration that has been implemented.

Where sensors do not have a VICINITY interface, direct local connection will need to be via a VICINITY adapter. Connection of a sensor or other device via a VICINITY adapter is considered to VFC 2.

Currently, many specialist sensors are only available as part of a stove-piped system, as mentioned above. Such systems will only allow access to information from individual sensors via their central service, which may be many thousands of km away. They will not allow direct access. This is classed as VFC 1 and is an approach that has had to be taken in several pilot implementations. This is considered to be a relatively low level of maturity.

score	criteria
VFC 1	Sensors use proprietary connections to a proprietary server which provides an interface that VICINITY can access.
VFC 2	Sensors and actuators connect directly to the VICINITY network via an adaptor.
VFC 3	Sensors / actuators have a VICINITY compliant interface and can be integrated with minimum cost and complexity

Table 4: Definition of scoring scheme for VICINITY Framework Compliance

2.3.3. Integration with User's System

The following classification has been developed within the VICINITY project. Four levels of integration with the service operator's management system have been identified.

- IUS 1: the lowest level the VICINITY VAS simply provides the service operator with an additional status report via an additional display in the control room.
- IUS 2: the VICINITY VAS adds more value by recommending that the service provider takes some specific action as a result of analysis work undertaken by the VAS. Any action taken will be by manual intervention by the service operator.
- IUS 3: introduces the ability of the VAS to take control of the situation and to automatically make interventions (for example: reducing power demand or calling a carer to attend someone that has been identified as having problems).
- IUS 4: is the highest level of integration envisaged: the status of the VICINITY sensors is passed to the operator's service management system. With this configuration the status of all sensors is monitored, and action is initiated by that service management system if a need for a maintenance action is identified.

The level of Integration of the VICINITY VAS with the User's Systems is an incremental addition of functionality

	IUSI1	IUS 2	IUS 3	IUS 4
Presentation of VICINITY VAS status reports into the service operators control room, with entirely manual intervention based on the operators' interpretation of VICINITY VAS status reports	*	*	*	*

VICINTY offers an analysis of the situation and advises the operator of the action that should be taken (manually).		*	*	*
Integration of VICINITY VAS with automated resource management systems: action is taken automatically based on the advice provided by the VICINITY VAS.			*	*
Integration of fault detection and reporting into the end user's fault management system.				*

Table 5: Definition of the extent of Integration with User Systems (IUS)

2.4. Experience of Open Call trial developers

The questions in the table below have been developed to gather information from the VAS developers and designers of the Open Call experiments funded by the VICINITY project.

The questionnaire for a VICINITY VAS Developer is given in table 6.

Memo: 1. Strongly disagree, 2. Disagree, 3. Undecided, 4. Agree, 5. Strongly agree		
VICINITY Documentation	Score	Comment
VICINITY Documentation		
documentation provided for VICINITY Gateway API		
documentation provided for VICINITY Agent		
documentation provided for VICINITY Adapter		
documentation provided for VICINITY Bavenir Platform		
Interaction with IoT Devices/Services		
Integrating IoT devices via the VICINITY Gateway is easy (1-5)		
Integrating IoT devices using the VICINITY Agent is easy (1-5)		
Integrating IoT devices using the VICINITY Adapter is easy (1-5)		
Integrating IoT devices using the VICINITY BAVENIR Platform is easy (1-5)		
Integrating VICINITY IoT services is easy to understand and use (1-5)		
VICINITY offers a good solution for sharing of data at a semantic level (1-5)		
VICINITY semantic discovery of IoT devices on a network is a useful feature (1-5)		
Privacy/Use of personal Data		
When using end-to-end encryption (if available on the IoT devices), VICINITY offers a secure connection between IoT devices (1-5)		
I agree that VICINITY is trustworthy regarding privacy of citizens' data collected from VICINITY IoT devices (1-5)		
I am confident that there is no disclosure of users' personal data collected from VICINITY IoT devices to third parties (1-5)		
I am confident that users' personal data collected from VICINITY IoT devices are stored in database compliant with GDPR (1-5)		
GitHub		

I think that the VICINITY presence on GitHub is a valuable open resource (1-5)		
I think that VICINITY documentation on GitHub is sufficient (1-5)		
What improvements would you like to see in the VICINITY ecosystem and/or resources on GitHub?		
General		
Satisfaction with the integration process with the VICINITY platform (1-5)		
I would choose to use VICINITY solution again if I had to implement a similar IoT solution (1-5)		
Can you name a competitor which offers a similar solution to VICINITY and if so which?		
I would recommend VICINITY solution to another person or organisation (1-5)		
Once you have understood the VICINITY architecture, how long does it take you to connect a new type of IoT device to the VICINITY platform? 1. More than a week 2. Around 4-5 days 3. Around 2-3 days 4. Less than a day 5. A few Hours		

Table 6: Questions for VAS developers

3. Pilot Evaluation Results

The results of each of the four Pilots sites will be reported in individual sections (3.1 to 3.4). In each case more detailed reports on the Pilot site are presented in D8.2 to D8.5.

3.1. Martim-Longo, Portugal

3.1.1. Brief overview of the Pilot trial

The ENERCOUTIM pilot site at Martim Longo has three sets of use cases and related VAS as described in D5.2 and D7.2: Municipality Energy Efficiency and Internal Environment Quality (IEQ) Services which include Dynamic Building Audit, Flexibility and Smart School; Services for Citizens (UV for Citizens); and Distributed Energy Assets Management (Platform Services).

Figure 4: Overview of buildings included in the Pilot Site at Martim Longo

Dynamic Building Audit, Flexibility and Smart School, allow the users, the building manager and the maintenance operators to know at any time the current state of the IEQ of the building, resources consumption and usage of the facility.

Municipality Energy Efficiency and IEQ Services are deployed at the municipality cluster of buildings (School, Retirement Home, Gym and Swimming Pool) and at SolarLab. Different types of sensor devices are used to collect real-time information from the buildings, specifically: temperature, CO2, humidity, luminosity, noise, motion and energy consumption.

"UV for Citizens" provides useful information for outdoor activities to the students, senior citizens and citizens in general about the UV level advisory limits. The "UV for Citizens" Value-Added Service, processes the real-time values of the UV sensor and displays the current UV index value and advisory information. The equipment is leveraged for the secondary use, since its primary use is for solar generation purposes.

Platform Services, Distributed Energy Resources, and Renewable Energy Systems all provide support information for the operation and maintenance of the Photo Voltaic production plant, specifically to plan cleaning of the photovoltaic modules to increase energy production, optimise operations and resources consumption.

3.1.2. The scale of operation

Martim Longo pilot site has 26 active devices from different types, each with a set of sensors specific to the functionality they provide, installed in six different buildings (Figure 5) and connected through the VICINITY platform.

Martim Longo pilot site has fifteen VAS registered end-users with access to specific application views according to their professional activities. Several beneficiaries are included, mainly the members of the local school and the retirement home communities.

3.1.3. Evaluation of the effectiveness of the trial

The results of the Use Case Pilot have been very encouraging, given the positive response the project has received from end-users. In fact, those involved in the demonstration considered their participation in the project as positive (over 60% of the main users strongly agreeing). The features and usability of the various Value-Added Services (VASs) implemented using the VICINITY platform has underlined the value of the technical and market viability of both the VICINITY platform and the VASs. Feedback from the end-users has allowed the ENERC team to address system reliability issues, make user-interface improvements, and analytics improvements. Strong emphasis was on creating opportunities for co-creation of additional VICINITY based solutions.

Within the pilot site implementation, the project has delivered the full operational solutions for the three VASs (Municipality Energy Efficiency and IEQ Services, Services for Citizens, and Distributed Energy Assets Management) and an additional feature set was co-created based on the market demand: IOT Inventory and the related performance monitoring of the systems. The VAS of UV for citizens evolved into a bigger scope for future development.

Data retrieved through the VICINITY platform from substantially diverse types and brands of devices has been correctly transformed in readily understandable and actionable information to the end-users, demonstrating the full functionality of both the VICINITY Unique Selling Point ‘Semantic interoperability as a service’ as well as the value of the VASs comprised in the VICINITY based ENERCOUTIM´s solutions.

End users have responded positively about their user experience and more importantly to the value of the VASs, indicating a clear interest to continue using the system, suggesting further ideas of expanded sensor data inclusion, and potential co-creation opportunities within Smart Building and Smart School solutions. Internally the ENERC team is interested in further developing the Smart Clean predictive services for systems maintenance within operations and management contracts. Showcasing the pilot to another municipality has led to an advanced discussion for future commercial pilot implementation. The international collaborations are under discussion.

3.1.4. Assessment of the level of maturity.

VICINITY based ENERCOUTIM solutions share several of components at various system layers: VICINITY device adapters; VICINITY cloud; and ENERCOUTIM services. Even so, the resulting VAS have achieved different levels of maturity. Energy Efficiency and IEQ Services (Figure 5) have evolved to a productization stage as a result of stakeholders' engagement and demand-oriented project dynamics while Services for Citizens and Distributed Energy Assets Management may be considered to require additional development and validation iterations.

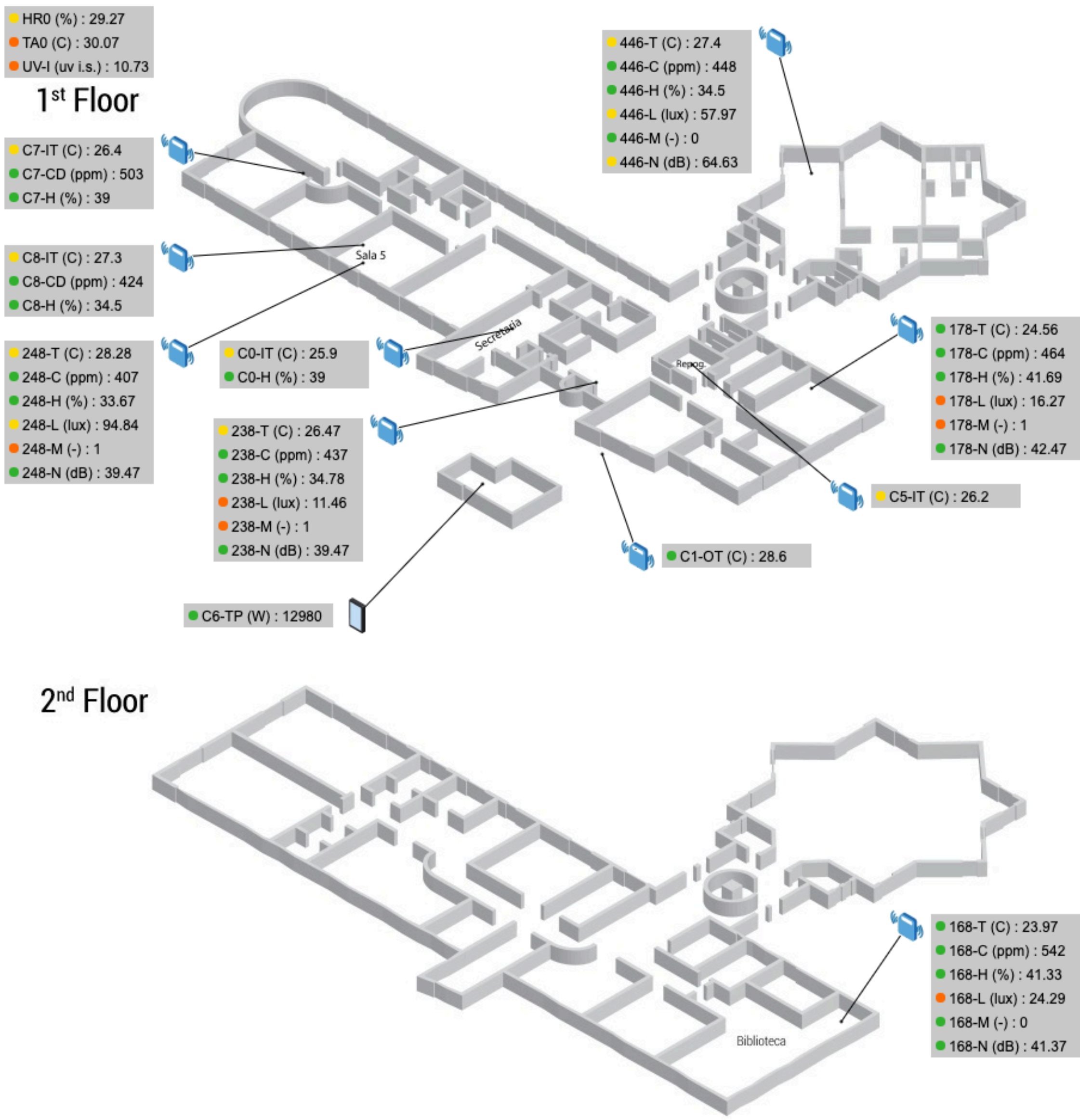

Figure 5: Dynamic Building Audit Application for the Martim Longo School (Value-Added Service 1)

Value Added Service	Use Cases	Technology Readiness Level	VICINITY Framework Compliance	Interoperability with User Systems
VAS1 - Municipality Energy Efficiency and IEQ Services	2.1, 2.2, 2.3, 2.4, 2.5, 2.8, 2.10, 2.11	TRL7	VFC 2	IUS 2
VAS2 - Services for Citizens	2.9	TRL6	VFC 2	IUS 2
VAS3 - Distributed Energy assets management	2.6, 2.7	TRL5	VFC 2	IUS 3

Table 7: State of maturity of Martim Longo use cases

3.1.5. Interpretation of the information from the dashboard

The VICINITY evaluation dashboard provides an overview of the scale and diversity of the IoT solution implemented in Martim Longo pilot site, comprising: four organizations (ENERCOUTIM, Martim Longo School, Martim Longo Retirement Home and Martim Longo Sports Facilities); twenty-six devices with multiple sensors specific to their functionality; and five VICINITY contracts.

Martim Longo pilot site has 26 active devices from different types, connected through the VICINITY platform: Weather Station; Power Meters; Renewable Energy Storage Unit; Indoor Environment Quality Sensor Devices; Photovoltaic Panels; and Gorenje Appliances. Each of these devices has a set of sensors specific to the functionality they provide, namely for most of the Indoor Environment Quality Sensor Devices: temperature; humidity; carbon dioxide concentration; luminosity; motion; and noise.

Martim Longo pilot site system has fifteen VAS registered end-users with access to specific application views according to their professional activities (teachers, infrastructure managers, caretakers, engineers and technicians).

Dynamic Building Audit, Smart School and RES Platform Services, require real time data for monitoring and extensive historical data series to provide information for IEQ analytics and PV efficiency assessment. The technical solution implemented in Martim Longo to enable simultaneously for monitoring and analytics features is based on sensor data pooling at regular intervals, therefore generating a large number of VICINITY messages. Sensor data is pooled at regular intervals of one to five minutes, depending on devices and overall system configuration and results in about 30,000 VICINITY messages per day under optimal condition, which demonstrates that the VICINITY platform is suitable for applications requiring a large volume of messages.

The number of maintenance alerts detected reflects the reported notifications related with sensors measurements that are outside of the expected physical values, requiring manual verification of the device. Maintenance alerts are based on an automated hourly analysis of the information retrieved from sensors.

The number of notifications reflects reported situations where the alert thresholds were reached or exceeded and tend to include a number of false positives as air conditioning or heating is turned off in unused rooms and results in alert thresholds being exceeded. Notifications are based on an automated hourly analysis of the information retrieved from sensors and further refinement of the analytics underlying alert notifications is being considered.

3.1.6. Overview of the feedback from stakeholders

Two different questionnaires were delivered to two different types of stakeholders, main users and potential users. The main users were the actual users of the Martim Longo pilot site while potential users were people with access to the SolarLab demonstration view of the ENERCOUTIM DBA application, enabling them to answer questions about the pilot site without being real users of the VICINITY platform.

The questionnaires delivered to the main users were important to evaluate the experience which was deemed to be positive. The users described the platform as useful and easy to use and pointed out benefits such as better resource consumption and having more knowledge of their buildings. The achieved unified IoT platform, able to connect different branded sensors, was considered the most innovative aspect of the VICINITY platform. These users also made suggestions regarding what could be improved, like the platform interface and further information processing in the form of warnings and suggested actions.

On the other hand, the questionnaires answered by the potential users provided these users' perception on the demonstration view of the ENERCOUTIM DBA application in the overall context of IoT enabled solutions. The answers were similar to the ones from the main users in regard to the innovative aspect of the VICINITY platform, which was the achieved unified IoT platform, permitting the monitoring of several different devices. Features that could be improved also coincided, with the mention of actionable suggestions being made from the information gathered.

Overall, the experience of the users was positive and the benefits that a unified IoT platform can deliver were recognized. The questionnaires were also effective in gathering feedback on what could be improved in future solutions.

The economic and environmental impact of the VAS1 must not be underestimated since it provides continuous monitoring of buildings performance, equipment efficiency and analytics on expected values, while also allowing for aggregated neighbourhood approach. Municipal stakeholders can access aggregated information of a cluster of municipal buildings that could scale up to the whole municipality. Aggregated savings are being analysed and assessed while keeping in mind energy consumption per square meter matrix and other related compliance parameters.

The solution provides an insightful opportunity for public sector facilities to create data lakes for further analytics and AI solutions creation. It is a building block towards data enabled decision-making and automation in buildings.

Among additional lessons learnt the heterogeneous selection of buildings beyond the original scope created an excellent comparative sample. The inclusion of SOLAR LAB facility in the trials was very helpful during the hackathons participation and additional experimentation that would have not been possible.

3.2. Oslo, Norway

3.2.1. Brief overview of the Pilot trial

The Pilot site was demonstrated at the M:6 co-working space in Norway. M:6 provides open plan co-working space as well as traditional office spaces. Their aim is to provide a unique environment where people from different companies can share knowledge and inspiration from each other. M:6 is operated and managed by CWI. They are eager to incorporate new technologies that can improve daily work and management of the building. The Pilot Site will also demonstrate how existing infrastructure can be integrated with VICINITY to combine information to improve quality of work and to be able to use information from smart devices to gain effectivity and customers satisfaction.

3.2.1.1. Use Case 1a.1 – Predictive Operations

This use case aims to assist cleaning staff in an office building to perform their work more efficiently. It does so by implementing a VAS for tracking room usage through door sensors placed on the doors and sending out alerts when a room had more visitors than a pre-defined threshold.

Door sensors are placed on 3 types of rooms. Common meeting rooms available to all tenants of CWI:Moss, select private offices and select toilets. This choice of rooms will allow to evaluate how well the VAS works for different use cases.

3.2.1.2. Use Case 1a.2 – Resource Management

TINYM receives utility consumption data from local partners (IWMAC) through an adapter on their network attached to VICINITY. Smart devices that can be accessed through VICINITY can then be manipulated to smooth out or lower the overall resource consumption curve for a location/site; in the case of energy tariffs, for example, this reduces costs by lowering resource consumption peaks by automatically responding to increases in utility usage. These same tools (provided by the VASs) can also be used to diagnose anomalies (like water leaks) and predict resource expenditure once baseline data has been gathered. The VAS includes setting up, communicating with, and regulating individual smart devices through VICINITY.

3.2.2. The scale of operation

The layout of the pilot service installation is shown in figure 6 below

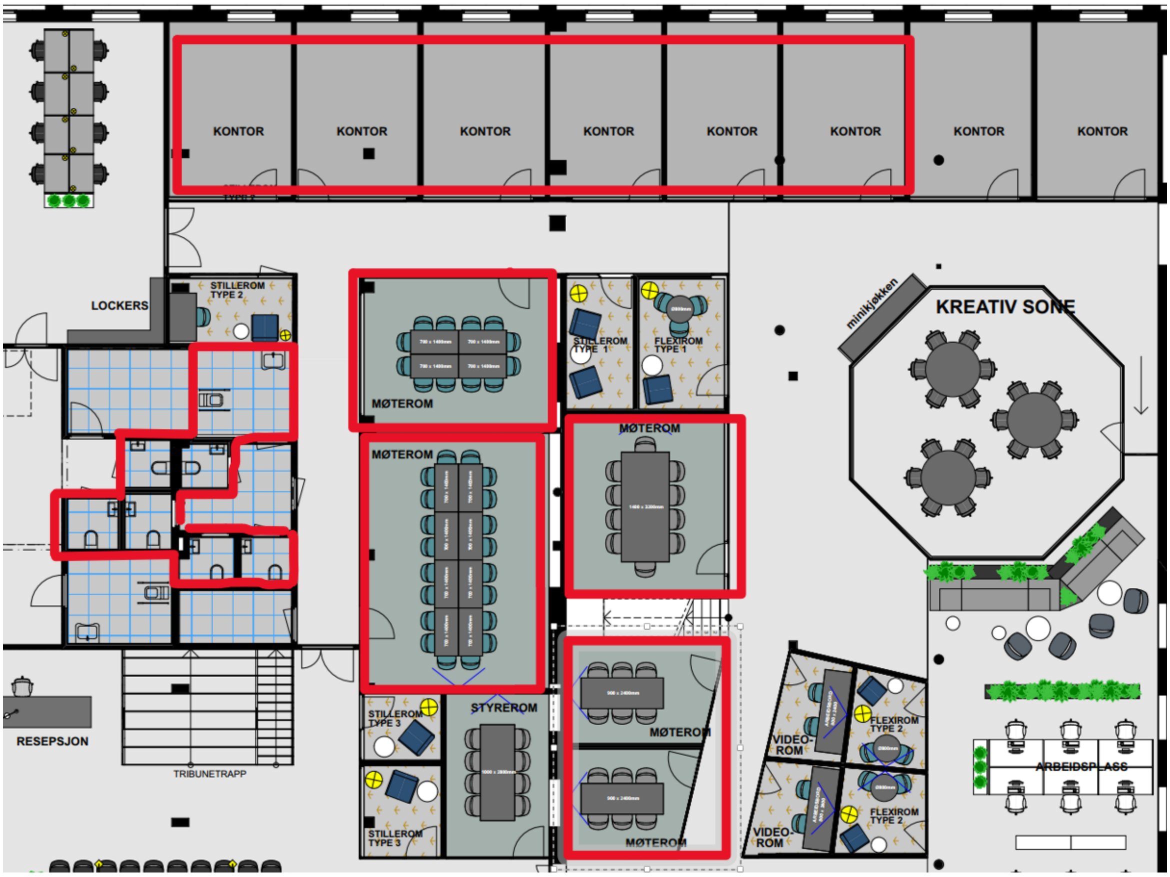

Figure 6: Picture showing which rooms in the office space have door sensors installed

The total installation included:

- 22 Door sensors
    - Some sensors were taken down and are not used currently, reason for this some of the tenants did not want to participate in the trial.
- 2 CO2 Sensors
- 3 Adapters, 2 adapters for door sensors from different suppliers and 1 adapter for CO2 sensors. 3 VAS – Main VAS tracking room usage and providing information to cleaning staff, another VAS to track CO2 values from the CO2 sensors and a separate VAS that tracks only room usage.

3.2.3. Evaluation of the effectiveness of the trial

- Key achievements.
    - Successfully launched and operate use case 1.
    - Successful technical demo of use case 2 – demonstrates integration of different IoT platforms in one use case.
    - Several minor VASs to provide various functionality for stakeholders are launched and operations.

- Delivery of the expected functionality?
    - All planned functionality was developed and delivered along with some additional features requested by stakeholders.

- Reliability issues.
    - There were no issues with VICINITY platform.
    - Some minor hardware-based issues with sensors from VITIR, the fault was faulty firmware of the sensors and issues were resolved by VITIR when they sent new sensors with updated firmware.

- Users' and operators' appreciation of the advantages of using the VAS
    - Described in D8.3, Use Case 1a.1 gave advantage to the stakeholders, optimized the work of cleaning staff.
    - Use Case 1a.2 was demonstrated on a technical level but was not set into operation.

- Service operator's appreciation of the advantages of using the VICINITY Framework
    - The developers of the pilot site appreciated how VICINITY allows the integration different devices and makes development of services easier.

- Delivery of the claimed USPs
    - USP for Use Case 1a.1 – Predictive operations is the possibility to integrate different sensors from different vendors into the same VAS. This has been demonstrated by implementing different door sensors, from 3 different vendors; Vitir, Tiny Mesh and CERTH.
    - USP for Use Case 1a.2 – Resource Management uses the opportunity to use VICINITY as a facilitator to integrate different infrastructures; existing infrastructure already implemented in the building and new infrastructure from new vendors/suppliers, in this case - Gorenje. This shows the ability of VICINITY and makes is possible for an existing building solution to integrate with new technology and be able to measure and save energy.

- Economic and environmental impact

- Sustainability is discussed in chapter 5 of D8.3. Use Cases promote responsible consumption of resources, encourages data sharing where it doesn't raise privacy concerns and improves the management of the building by providing actionable data to the management.

- Issues and learning points.
  - The issues and learning points have been identified and discussed in D8.3. The main points were
    - Agile Development approach was a good choice
    - Initial choice of Java as programming language was wrong, a switch to Python have been positive and simplified the development process and reduced the time needed to introduce changes.
    - Some instability with the VICINITY Agent and VICINITY gateway were encountered during development, but stable in operation.

3.2.4. Assessment of the level of maturity

Use Case	Technology Readiness Level	Vicinity Framework Compliance	Integration with User's System (IUS)
1a.1	TRL7	VFC 2	IUS 2
1a.2	TRL6	VFC 2	IUS 1

Table 8: Level of maturity of Oslo Pilot

3.2.5. Interpretation of the information from the dashboard

- We send following data to dashboard:
  - Number of messages received by VASs from devices
  - Number of devices/VAS/contracts/friendships
  - Number of participants in the use cases (actual users of use cases)
  - Number of Maintenance alerts
    - Not implemented and is always 0
  - Number of notifications sent to the users
    - The functionality of notifying users was disabled, because cleaning staff can't react to them in any useful way because of their work routine.
- Interpretation of the data
  - No significant trends can be noticed in the graphs. Because of the way we have implemented events for our devices the number of messages received by our VAS is roughly the same staying around 950 messages per day.
  - The graph showing notifications sent by the VAS is not particularly useful to analyse because notification system of the VAS was disabled. The notification system was disabled because stakeholders did not find it was useful, see D8.3 for detailed explanation.
  - The rest of the graphs are static and don't show any trends.

- Assessment of the usefulness of the dashboard information to evaluation of the pilot, and lessons learnt
  - Since we have not implemented any sort of maintenance alerts the information of how many messages are received by the VAS was useful to identify if something was wrong and needed attention.

3.2.6. Overview of the feedback from stakeholders

Assessment of the usefulness of the questionnaires, information missing, lessons learnt.

- We have identified that the way cleaning staff works needs to be changed in order for them to gain real value from the VAS, Hoegh Eindom (owners of the building) said that they are willing to accept new terms from cleaning company if the project is successful.
- Overall cleaning staff was very happy with the solution
- Several possible improvements were proposed by the cleaning staff in order to make the process of registering the room as cleaned more straight forward by utilizing physical button located in the actual space.
- Use Case 1a.1 could be a perfect fit for a building that has permanent cleaning staff.

3.3. Tromsø, Norway

3.3.1. Brief overview of the Pilot trial

The pilot took place at the "Teaterkvarteret 1. akt" in Tromsø. The site includes three 6-store buildings with a total of 38 apartments. The 38 apartments are either owned by or assigned to residents that are either elderly or disabled. The underground garage facility has 32 parking spaces, of which, 7 are allocated for larger vehicles, and 2 have electrical charger ports.

HITS visited the pilot site at least once a month to ensure the equipment was operating as expected and to answer questions from stakeholders that might arise or requests from technical personnel that needed to be addressed.

The use case had specific focus on managed healthcare apartments and demonstrated how transport information and building data could be integrated with assisted living through agreements with car space owners.

The pilot was based on two use cases:

- UC 1: Smart parking / priority parking – which opens the possibility for long-term and short-term contracts for both rental and renting parking space, as well as business models for handling transactions between owner and user. For the trial car park usage was limited to healthcare workers that had been called out to attend to a resident needing help.
- UC 2: Healthcare visit / Emergency parking – first responder – which offers an option for visiting addresses along a roundtrip with automatic allocation of best-option parking space based on cost, location and availability – especially in the case of an emergency which overrules all other contracts.

Both use cases offered a dedicated app for making necessary selections, as well as a backend system for simple data maintenance. Additionally, three value-added services were implemented that offered

- Real-time operation of shared/priority parking
- Administration of parking space
- Real time Information about parking space

For a more in-depth description of the actual pilot site and results, please read the annexes in D8.4: "Pilot results of Intelligent Transport and Parking use case". This document describes in more detail the setup of business logic, the hardware setup at the pilot sit, the devices that are registered through the VICINITY neighbourhood manager, user interface for the apps that has been developed – as well as other practical information on notification, subscription services, and business opportunities.

In the demonstrated solution, shared and priority parking were managed according to conditional rulesets. The smart parking sensors reported proximity and temperature, as well as the primary function of indicating the presence or absence of a vehicle. Booking, configuration and status of parking space were managed partly server side and partly by use of mobile apps.

More detailed information about the pilot trial can be found among other places in deliverable 8.4: "Pilot results of Intelligent Transport and Parking use case" and deliverable 5.3: "VICINITY value- added services deployment, validation, upgrade and evaluation"

3.3.2. The scale of operation

The following devices are the basis of the use cases demonstrated at the Tromsø pilot site.

Details regarding equipment, solutions and system integration have been identified and documented in Chapter 8 of D7.1 *"Pilot area installation methodology and planning"* (M31). Value-Added Services Offline management and Real-time operation for shared/priority Parking and Emergency Parking have been developed within Task 5.2. The details of the implementation are specified in the Annex to Pilot site Tromsø in D5.2 *"VICINITY Value Added Services Implementation Framework"* (M33).

There were nine users of the integrated solution of whom 2 were residents at the pilot site, while the rest where either carers or employees in the municipality.

Device type and vendor	*Functionality*	*Installed units*	*Use Case*	*Location*	*Deviations*
Parking Sensor PlacePod, PNI	Register occupancy and temperature	3	1, 2	Parking space	Hardware upgraded
IKEA smart light TRÅDFRI LED bulb E26 980 lumen IKEA	Display occupancy status	1	1, 2	Parking space	
Smart oven ATAG Magna CS4574M1C Gorenje	Heat food and register usage	1	2	Apartment	
Smart refrigerator with freezer ATAG Magna KD84178BFC Gorenje	Cool food and register usage	1	2	Apartment	
Motion sensors FGMS-001 Fibaro	Triggered when a motion is detected in the room	1	-	Apartment	
Door Sensors FGDW-002 Fibaro	Triggered when a door is opened or closed	1	-	Apartment	
Trådfri Gateway IKEA	Wireless connection (NEST)	1	1, 2	Office	
RF GATEWAY LORA ETHERNET/USB 881-1302-ND Multi-tech Systems Inc.	Wireless connection (LoRa)	1	1, 2	Office	
Raspberry Pi Model B+ V1.2 Raspberry Pi Foundation	Gateway for devices and sensors	1	-	Office	
Routers D-Link DWR-921 Wireless N 4G LTE Router, Huawei, OTE	Wireless Internet connection	1	1, 2	Office	

Table 9: Scale of the pilot installation in Tromso

3.3.3. Challenges faced by the Tromsø Pilot

The test pilot was originally proposed to take place at Tyska in Halden, Norway under the guidance of TINYM. Due to several changes in original plans, the Tyska project was postponed, and HITS had to re-evaluate where the test pilot was conducted. This change of pilot site was described in the first amendments to the VICINITY project and led to changes in stakeholders, location and scale of operations. This also opened for new opportunities, and in retrospect there may have been benefits from a redefinition of the uses cases to be implemented, but with the delay accumulated to that point there was not time to re-plan the entire scope of the trial.

In preparing the project proposal assumptions were made about the responsibility for developing the use cases for the pilot trials. As a result, there was a lack of PMs allocated to development, and HITS did not have the opportunity to get involved in any in-depth research activities. HITS concentrated on testing and spent a lot of resources on adapting adapters and business logic. The stakeholders at the Tromsø pilot provided HITS with input on needs, but we later learned that the workflow was quite different than originally anticipated. For example: although caretakers are visiting addresses for home visits, there is not a standard roundtrip. These trips differ from day to day. Furthermore, there is a limited set of resources that can be allocated to each address. These resources are managed through a proprietary CRM solution offered by company VISMA Logistics. To be fully effective the Tromsø pilot should offer a seamless user experience, but this would require full integration of VICINITY with VISMA – which was outside the bounds of the project. Late in the project we therefore had to create support for importing addresses from XML-files that are in turn exported from VISMA. All of this took place at the back-office system, and did not affect the workflow for the users, but reduced the number of real test runs. Out of 30 registered roundtrips with the mobile app allocated for use case 2: healthcare visit/first responder, currently only 2 (at the time of this report) were used in live home visits. A very practical limitation was that the carers were so busy that really did not have time to learn how to gain maximum use from the service that had been developed.
There were also some challenging situations that affected the time and resources that were invested in configuring the pilot site and later maintenance.

- One notable challenge was the challenge of coordinating attendance at the pilot site by support personnel from Gorenje and HITS people. At times it also could take a day or two before a request for information was replied to. A more formal service level agreement was needed.
- Another challenge was that the developers that HITS contracted did not have access to tools for monitoring real-time data exchange by sensors, devices and subscriptions. The workflow of VICINITY would benefit greatly from introducing an IFTTT [4] supported editor equipped with breakpoints and automatic alerts when conditions are met
- HITS did not have internal resources for handling the necessary degree of integration, and therefore used external developers for implementing VICINITY within the IoT ecosystem established at the pilot site.

3.3.4. Evaluation of the effectiveness of the trial

The pilot itself was conducted over a period of two years, with the VICINITY gateway and total integration of the parking sensors and subscription services to the Gorenje smart appliances becoming operational from December 2018. The pilot received too few data entries from actual field test to provide a proper long-term profile with usage rates.

The trial period confirmed that the VICINITY architecture delivered as promised in terms of privacy, interoperability and standardisation. Through the auto discovery service, VICINITY also offer faster registration and configuration of smart devices. The pilot also ascertains that the methodology for including value-added services in the same framework as smart devices, produce the expected results. This allows for new opportunities to arise within product development and business models.

VICINITY has introduced several new concepts and new ideas which enable sharing of segments of data to trusted groups, proper secure communication supported through homomorphic encryption, as well as proper management of devices through the VICINITY neighbourhood manager. The framework that is made available for further extending functionality through adapters and building and sharing new value-added services, seems to be robust and offer good groundwork for future development.

HITS did not experience any major issues with reliability or response time during the last year that VICINITY was operational. There was the occasional downtime during planned maintenance – with one notable outage during a weekend. The reliability issues we experienced all stemmed from the setup at the Tromsø pilot site and were analysed and found to be caused by poor LoRaWan radio reception quality. The buildings where the pilot site was conducted were built following all the latest standard relating to materials, insulation and electromagnetic shielding, which introduced several challenges when it came to communication with parking sensors using LoRaWan. The same applied partly to the Gorenje smart appliances that are installed at the pilot site since these were connected to a 4G network, which had poor coverage indoors. When these issues were sorted out, the setup were stable.

3.3.5. Assessment of the level of maturity

TRL: Whilst the use cases were trialled in a real-world situation, VICINITY will need considerably more development before they can be offered commercially.

VFC: all the sensors that were used were connected back to proprietary sensors. For example, there was no interface directly to the parking sensors which use a proprietary communications system back to a central server. Their status information is accessed via a VICINITY gateway that provides connection to that central server. The same is true for the communication with the Gorenje smart appliances.

IUS: UC 1: The users accessed parking information and guidance using an app on their mobile 'phone, but the information was not integrated into any other operational systems.
UC 2: there was no direct connection between the VICINITY system that provided healthcare alerts and existing healthcare management software and systems.

Use Case	Technology Readiness Level	Vicinity Framework Compliance	Integration with User's System (IUS)
UC 1: Parking	TRL 5	VFC 1	IUS 2
UC 2: Healthcare	TRL 5	VFC 1	IUS 1

Table 10: State of maturity of the Tromso use cases

The perceived maturity level was influenced by the fact that much of the technology being connected by VICINITY was immature and introduced its own problems. The challenges experienced at the pilot site with the refrigerator that regularly went offline, the poor connection to the parking sensors, and upgrade of firmware were examples of this. At the end of the trial runs HITS did however learn that the LoRa gateway may have had some influence. When the gateway was disconnected, the wifi-network grew a lot more stable, and it took less time getting the refrigerator online again after it disconnected. HITS therefore have reason to believe there may have been a fault in the LoRa gateway, as well as adjustments needed on the refrigerator.

3.3.6. Interpretation of the information from the dashboard

The dashboard offered by UNIKL for monitoring packages and origins of data traffic serve as a good way of documenting the usage and provide an overview of issues that may arise. The results can be found here: https://cpsgw.cs.uni-kl.de/vicinity-dashboard/Pilot/Troms%C3%B8

After the dashboard was updated with a new set of keys, HITS lost all the information that had been stored and the new configuration was not properly registered. All remaining efforts have been centred on assuring apps and backend solutions were fully operational and providing benefits for the limited number of people trained to use the service. However, the dashboard remains a tool HITS want to bring into future implementation activities, and which we recommend will be integrated in future version as part of a VCIINITY installation.

3.3.7. Overview of the feedback from stakeholders

In general, there will be three main type of target groups when communicating VICINITY and USP (ref. D9.7: "Dissemination and Communication Plan, year 4"); integrators, end users, decision makers. All have their own set of needs and expectations. Integrators are the main focus of VICINITY since they are providing the technological input when testing usability and scalability. Their expectation of security and privacy regulations related to encryption and storage will necessarily differ from operational personnel/end users with a more juridical approach focused on consent and availability.

HITS did receive feedback through stakeholder involvement throughout the course of the project which provided information that was used to adjust functionality specifications and expectations. This was considered a necessary approach, as some of the physical arrangements were changed on several occasions. This affected the location of the parking space, which was moved between three different sites, the apps which started out as a purely shared parking project for different actors, but later evolved into more specific solutions tailored for parking and for travelling. And finally, HITS and the stakeholders learned and understood more about the potential of VICINITY as the project evolved and stakeholders came up with ideas and input – which led to the First Responder functionality, which is based on subscriptions to alerts from a Value-Added Service tied to the smart appliances.

Due to the nature of the dynamic communication and unavailability of all stakeholders at any given time, questionnaires were not used. Instead a final meeting was conducted where the input and changes gathered were discussed. Considering the lack of significant real-life use of the results, there was not much practical information to gather from system usage by carers. The same applied to the shared parking option, since the parking spaces in question were located in an underground garage facility, which demanded authorisation to access. This provided VICINITY with a controlled physical environment, but reduced the number of actual, relevant users to a rather small set.

HITS acknowledges the help of all the stakeholders – in particular the carers that set aside time to provide feedback and share ideas, even in the midst of a busy workday. Although the carers did not have the opportunity to conduct proper in-depth tests due to the nature of their work visiting patients and elderly in need of assistance, the project received both interest and support from all parties involved.

3.3.8. Moving Forward

HITS concluded that VICINITY delivers as promised when it comes to integration and the strength being offered by extending functionality through the neighbourhood manager. This is best demonstrated through the integration of smart appliances where the Tromsø pilot site was subscribing to alerts generated by the

Gorenje VAS. HITS is planning to continue exploring business opportunities based on VICINITY while being aware that VICINITY is still a solution that will be in development for a long time to come.

Although VICINITY has a strong technical foundation, the user interfaces for management of the devices are still lacking in terms of usability and interaction. A common approach when managing larger, complex data sets are using node editors. Such editors enhance the workflow, as demonstrated in Figure 7 This approach would work well in the context of VICINITY, as it allows for smart handling of larger groups of IoT devices, assigning/linking gateways, and visualizing relations between private and public devices, as adding context to value-added services and subscriptions. The Node editor enhances workflow. Examples of tools that would support this approach can be found on the website "My sensors" (https://www.mysensors.org/controller/mynodesnet).

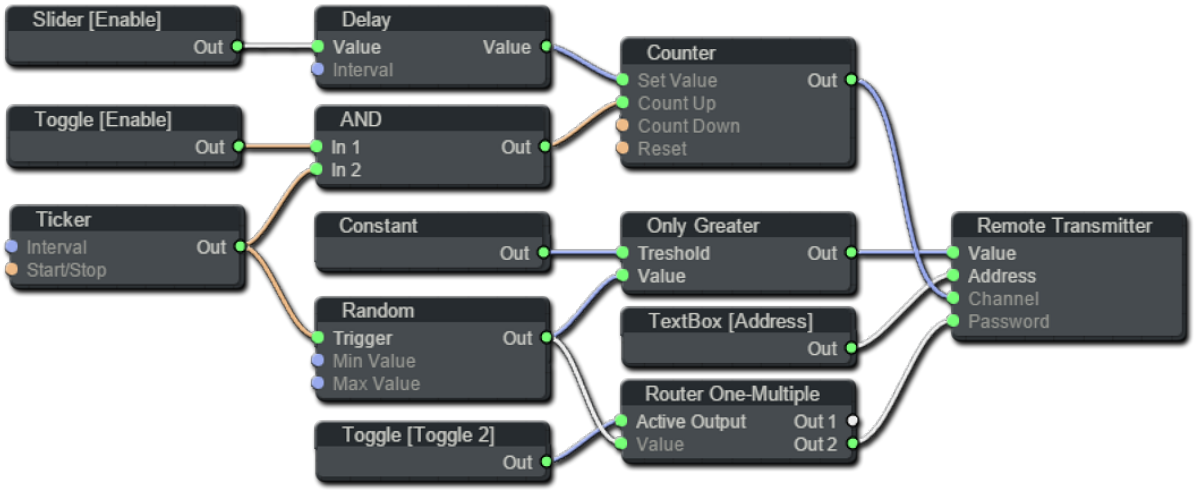

Figure 7: Example of node editing

The strength of VICINITY is its price – it is currently free and readily available to all, making the transition simpler, and enables adaption from a larger set of integrators without concern about hidden costs. The only potential costs existing would stem from the vendors of the devices. Furthermore, there is no upper limit of the number of devices and messages that VICINITY can be scaled up to handle. This is because VICINITY function as a service broker, but do not create or maintain any streams – it operates more as a facilitator.

However, management of VICINITY can learn from other similar service providers such as IoT Hub and IoT Suite, Azure Event Hub. Even if these are not directly comparable, there are concepts that serve as reference points for improvement – notably stream analytics, quick start template codes in the admin interface for quick prototyping and a more integrated and intuitive library of devices and adapters.
VICINITY represents an approach that is more relevant to integrators than to operators/end users. What VICINITY offers is the opportunity to tie together IoT ecosystems while retaining control of the data flow with accessibility and visibility. VICINITY does not necessarily make these processes any simpler, and new adapters and Value-Added Services will have to be developed. This process is so far not yet streamlined. A future version of VICINITY would probably benefit from having a tool similar to JSfiddle (https://jsfiddle.net/) that offer a boilerplate for adapters or VAS, and which then could be stored directly in the cloud as resource for others users to either link to or make changes to.

The opinion of HITS is that if we had started the implementation of the pilot site today, it would have been more cost efficient than to develop proprietary solutions from scratch.

3.4. Pilea-Hortiatis, Greece

3.4.1. Brief overview of the Pilot trial

Pilea-Hortiatis Pilot demonstrated two e-Health use cases with beneficiaries from the Municipality. A total of 38 private homes of elderly citizens' have been utilised for the deployment of the VICINITY infrastructure and related Value-Added services and are currently participating in the demonstration of the respective use case.

In the first use case, private homes of elderly citizens were equipped with IoT sensors, in order to remotely monitor everyday activities and medical data, so as to implement assisted living for them. This has been achieved with a variety of sensors like motion/door sensors, pressure mat sensor, smart appliances, panic buttons, blood pressure and weight scale devices. Doctors can track their patients' progress, abnormal detection in home and unusual behavioural events through a mobile application.

In the second use case, beneficiaries from the municipality of Pilea-Hortiatis participated in an Urban Marathon where a gamification system is developed. A total of 50 middle-aged citizens participated in the second use case. Citizens gained points from walking, visiting municipal athletic centres and by losing weight and could track their progress through a mobile application. These activities were tracked through IoT devices like wearables, beacons deployed in the sport centres and weight scales.

Personal medical data from both use cases have been securely stored in a GDPR compliant database on the municipality premises. Taking advantage of the VICINITY architecture, the communication between the VICINITY nodes using the VAS and the VAS itself were accomplished via VICINITY P2P (Peer-to-Peer) network.

3.4.2. The scale of operation

The number of installed IoT devices in the Pilea-Hortiatis pilot site was reported in D7.5. During the realization of the pilot (T8.5), maintenance, re-location, equipment removal and new installations have taken place. Overall, the pilot site installations have slightly increased, since the submission of D7.5 in March 2019 and the performed work is reported in D5.3. Numbers of connected devices are given in Table 11:

Device type	***Functionality***	***Number of installed units***
Blood pressure monitor	Measures systolic, diastolic blood pressure and heart rate	16
Weight scale	Measures weight	10
Panic Button	When pressed or detects fall it makes a call to inform a 24-7 call centre	12
Motion sensors	Triggered when a motion is detected in the room	40
Door Sensors	Triggered when a door is opened or closed	10
Pressure sensor	Triggered when a person lies on the bed	1
Gorenje refrigerator	Refrigeration	1
Gorenje oven	Cooking	1
Wearable fitness trackers	Measures human activity by measuring steps	50
Beacons	Transmits a BT signal with certain power which alternates when other BT devices are close.	10

Table 11: Scale of operation of the Pilea-Hortiatis pilot

3.4.3. Evaluation of the effectiveness of the trial

Context

The two use cases were demonstrated in the municipality of Pilea-Hortiatis and validation of this demonstration was described in D8.5 "Pilot results of eHealth at Home use-case". From a technical perspective, the functionalities that were first proposed in D5.1 were successfully delivered for both use cases. Minor deviations from the initial plan were reported in D5.2. As analysed in D8.5 in the Technical Evaluation section, since M37 beneficiaries have been using the medical devices on a regular basis whereby data has been transmitted through VICINITY P2P network to the GDPR compliant database and dispatched to health professionals' mobile applications. The same procedure has been followed for the data gathered from building sensors whereby abnormal activity of the elderly is detected.

Effectiveness

From the effectiveness perspective, users were generally satisfied with the interaction with the VICINITY Value-Added Services and the usage of the IoT devices and sensors. An important result of the first use case is that most of the elderly users feel more confident living alone than before the VICINITY services were offered. Regarding the users of the second use case, the gamification system was efficient, due to the system of points, and users of the wearable devices increased their daily walking and lost weight. Generally, over 80% of the participants believe that by VICINITY program can lead to a healthier lifestyle.

Business Perspectives

The unique selling points of VICINITY for the Greek pilot site were described thoroughly in D8.5 where stakeholders evaluated them through the questionnaire. The VICINITY Platform benefits the pilot site by enabling sharing of data at semantic level and giving the possibility to integrate different sensors from different vendors into the same VAS. Moreover, it offers security and data privacy in all transactions, an aspect, which is very important especially in the health domain. Most important is that elderly people, their relatives and middle-aged people are generally confident that their medical personal data won't be shared with third parties and that they are safe. Evaluation was focused also in brand perception manner and the results are that the users would recommend VICINITY as a platform and its application to other people or organisations. The Municipality is a key stakeholder for the Greek pilot site and their opinion plays a valuable role in the evaluation. MPH in close cooperation with health experts is fully aware of its citizens' needs and believe that through VICINITY program elderly people could have the chance to live alone more independently than before and middle-aged people to have a healthier life and routine. From a brand-awareness perspective, municipality employees would recommend the VICINITY program and its applications to other municipalities and stakeholders. A business plan for offering eHealth services through VICINITY platform has been developed in cooperation with the involved partners of the Greek pilot site and is presented in detail, in D9.14.

Lessons learnt

Lessons from the whole process of deployment in real life demonstrators is that the solution that VICINITY provides is useful and important for the users and the stakeholders. However, many barriers may arise during the whole procedure. For example, installing devices and sensors to private homes is a challenging procedure and also requires careful handling by the technical representatives and the doctors. In both use cases medical data are involved so it is essential to inform the relevant stakeholders for the handling of their personal data explaining the VICINITY features regarding privacy as well as the GDPR compliant database that was developed. This is achieved through informative events and by close communication of the stakeholders with representatives of the VICINITY program. To overcome these barriers and problems, close cooperation and frequent meetings with the relevant stakeholders is required where each partner involved in all the phases of the Greek pilot site exchange opinions and share their experience and knowledge to achieve better results.

3.4.4. Assessment of the level of maturity

Use Case	***Value-Added Services***	***Technology Readiness Level (TRL)***	***Level of Integration with User's Systems (IUS)***
eHealth and Assisted Living for elderly people at home	Privacy-preserving Data Gathering and Storage. GDPR data auditing	**TRL 6** Technology demonstrated in industrially relevant environment	***IUS 1***
	Analysis and clustering of elderly's people medical data to detect unusual behavioural events	**TRL 6**	**IUS 2**
	Triggering abnormal detection in homes	**TRL 6**	**IUS 2**
Health improvement for the middle-aged persons	Privacy-preserving Data Gathering and Storage. GDPR data auditing	**TRL 6**	**IUS 1**
	Individual Statistical Analysis of data from wearables, medical devices, beacons	**TRL 6**	**IUS 2**
	Aggregated Statistical Analysis of data from wearables, medical devices, beacons	**TRL 6**	**IUS 1**

Table 12: Technology Readiness Levels (TRL) and Integration with User Systems (IUS) of the VASs

Device type	***VICINITY Framework Compliance***
Blood Pressure monitor	VFC2
Weight monitoring device	VFC2
Panic button	VFC2
Motion sensors	VFC2
Pressure Mat	VFC2
Door Sensors	VFC2
Gorenje refrigerator	VFC2
Gorenje oven	VFC2
Wearable fitness trackers	VFC2
Beacons	VFC2

Table 13: Scoring scheme for VICINITY Framework Compliance

3.4.5. Interpretation of the information from the dashboard

All pilot sites use six commonly defined KPIs to be measured and presented in the evaluation dashboard. Pilea-Hortiatis pilot site implemented the respective services for collecting the required data, calculate the KPI values and forward them to the dashboard. The values for the 6 KPIs for Pilea-Hortiatis pilot site can be monitored at https://cpsgw.cs.uni-kl.de/vicinity-dashboard/Pilot/Pilea-Hortiatis.

The first KPI "Devices connected to the pilot site" gives an overview of the sensors that are registered in VICINITY platform for the Pilea-Hortiatis pilot site. Their amount as well as their ontology device type is displayed in the graph. Medical devices, building sensors and smart appliances consist the IoT infrastructure of the site.

The "Number of Organizations, Devices, VASs, Friendships and Contracts" gives an overview of the VICINITY entities that are included at the Pilea-Hortiatis pilot site. The pilot site consists of 93 Organizations, 151 devices, 5 VASs, 92 Friendships and 259 Contracts. In this way, the VICINITY Neighborhood of Pilea-Hortiatis is simply presented through a bar chart.

Another way to look at the pilot site is to observe the amount and the categories of the "Participants" of the use cases, which are the elder and middle-aged citizens that participate in the two use cases and the doctor, psychologists and dietician that monitored the citizens throughout the realization of the pilot. By comparing the two latter KPIs, we can easily observe that a separate Organization was created per elder and middle-aged citizen and per health professional, while the additional Organization belongs to the service provider of the VASs, the MPH Organization.

The next KPI, "Number of messages received by the Use Case VAS from IoT devices", shows in a dynamic way the usage of VICINITY platform, which for the Pilea-Hortiatis pilot site moves around 1.5-3.9k messages per day, traffic which is mostly caused by the motion sensors. The measurements coming from the medical device, as they have been presented in D8.5 are much less frequent (few times a week), comparing to the motion sensor measurements (few times per minute). In the graph we can also observe some zero values, which are due to either related to a problem on the server or on the client side.

The "Number of maintenance alerts detected" KPI shows in a brief way maintenance alerts coming from the VASs, which could be related to fault equipment, internet connection problems or downtime of the server, while the "Number of notifications" KPI, shows the notifications that were produced by the VASs in cases of abnormal detection either in medical measurements (blood-pressure) or in deviations from the usual movement behavior detected at home. This KPI shows that the load of notifications decreased, which is related to the upgrade of the VAS 3.1.3 for Abnormal Behavior Detection, as described in D5.3.

3.4.6. Overview of the feedback from stakeholders

Interaction with IoT devices / sensors

Developers from the two technical partners of the Greek pilot site GNOMON and CERTH, believe that VICINITY offers a good solution for sharing data at a semantic level and that semantic discovery of IoT devices is a useful feature for the platform, as shown in Figure 8. However, they have doubts on how easy and understandable it is to integrate IoT devices and services to VICINITY as they have faced difficulties probably due to the immaturity of the VICINITY platform in the initial stages of the development.

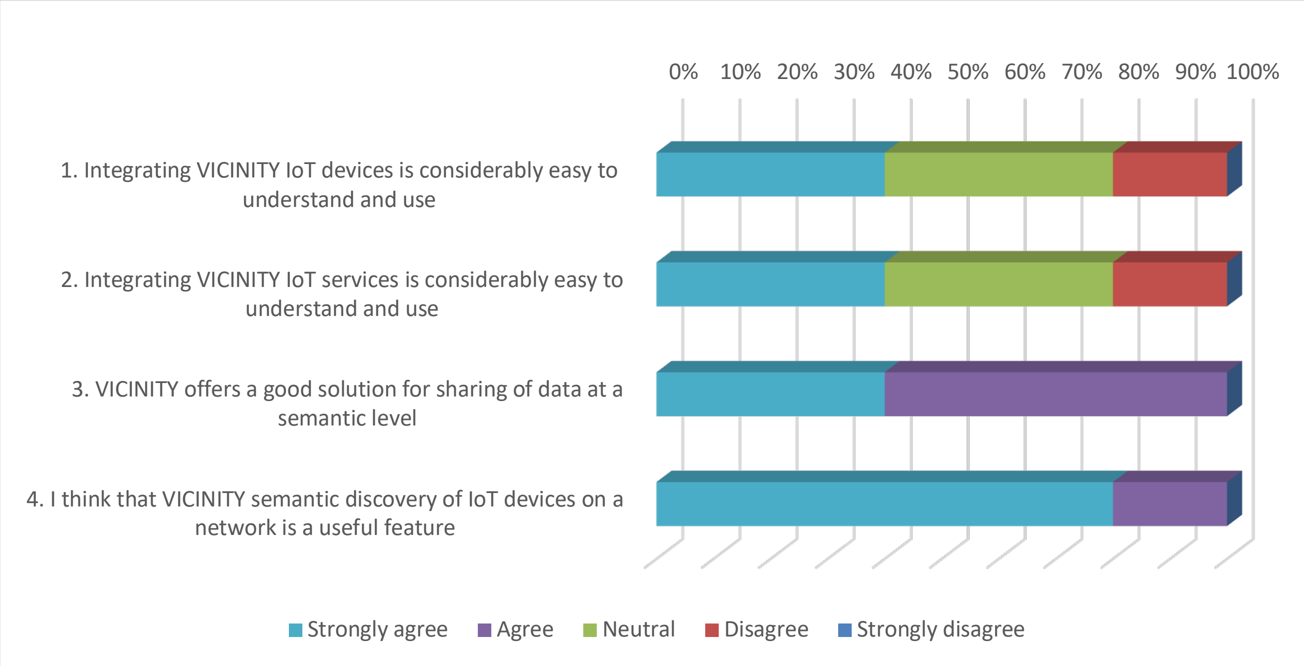

Figure 8: Interaction with IoT devices/sensors – Developers

Privacy / Personal Data usage

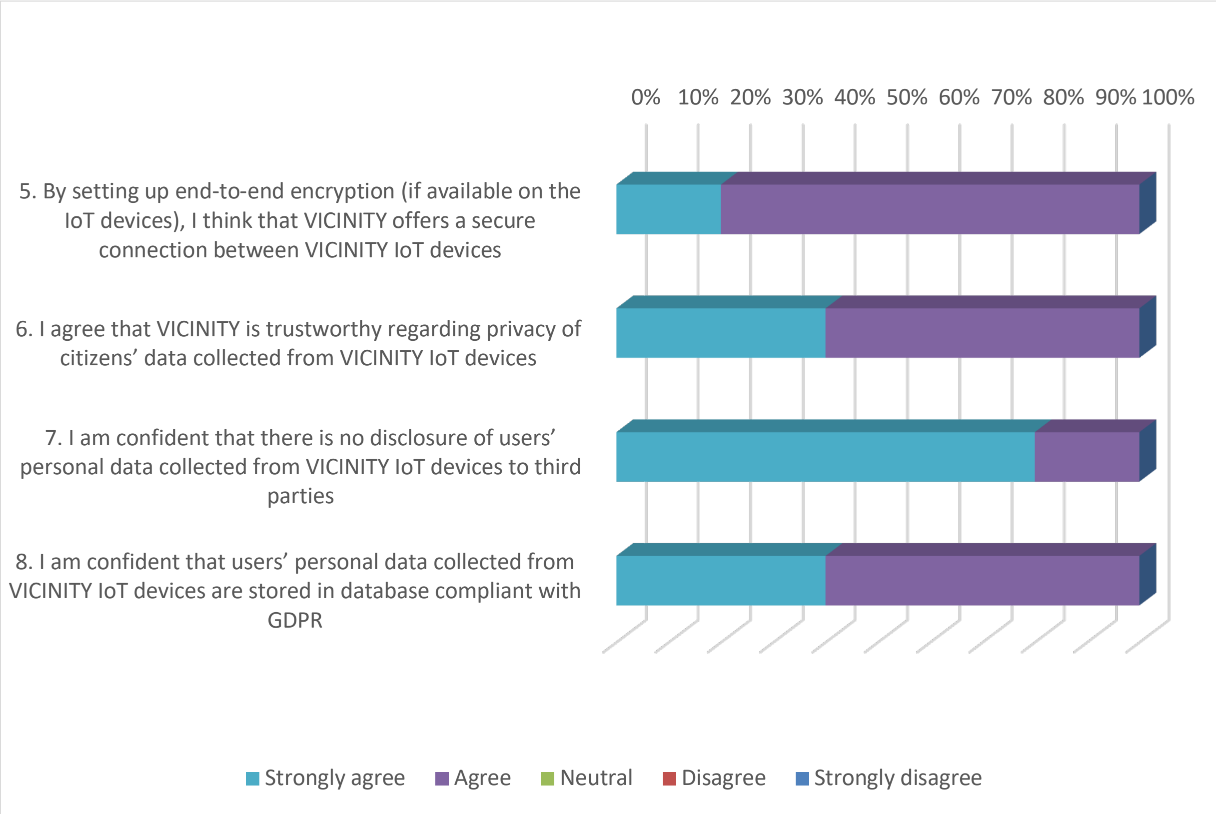

Figure 9: Perception of privacy and personal data usage

A GDPR compliant database was developed in order to store citizens' medical and building data that will be further evaluated in *D6.4 Security and Privacy evaluation report*. As shown in Figure 9, 100% of the developers are confident about the privacy and the personal data usage of the participants and agree that VICINITY solution offers a secure connection between IoT devices and that is trustworthy regarding privacy of citizens' data. There is no disclosure of users' personal data collected from VICINITY IoT devices to third parties. All the above is achieved through the GDPR compliant database together the VICINITY digital sovereignty that was developed by design. Users maintain ultimate control of their data.

GitHub

The GitHub community is an essential part of an open source platform like VICINITY. Therefore, it is essential to have a valuable presence in this community. As shown in Figure 10, over 70% of the developers of GNOMON and CERTH think that the VICINITY presence on GitHub is a valuable open source and over 50% consider that the VICINITY documentation is sufficient whereas a small percent has doubts over these issues.

One improvement has been suggested: the provision of a "Get Started" page). This document would include description of the steps for the whole procedure in one place, instead of separate documentation per component

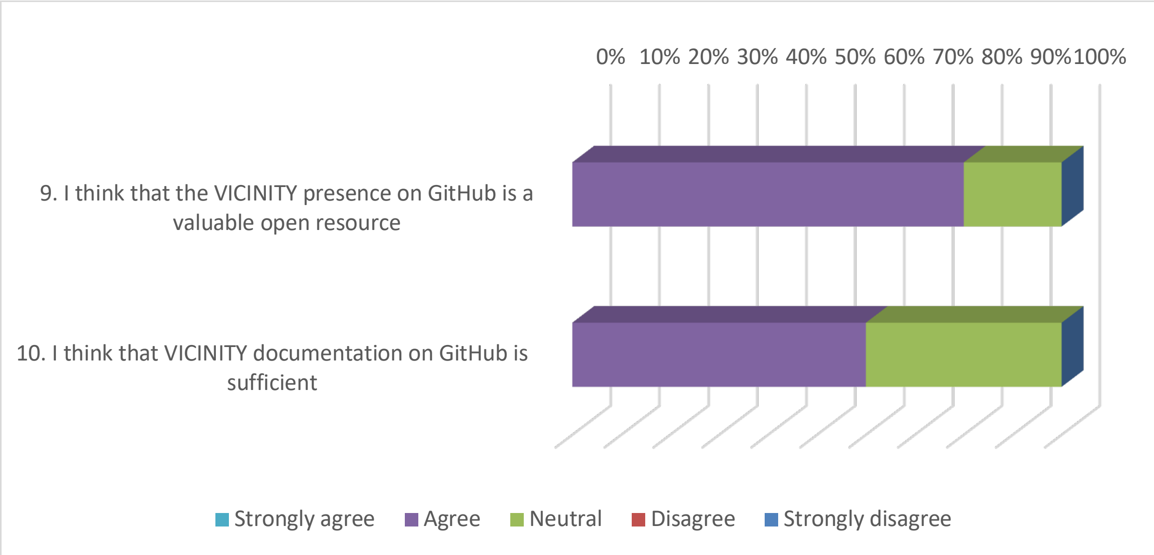

Figure 10: Opinion for GitHub – Developers

General

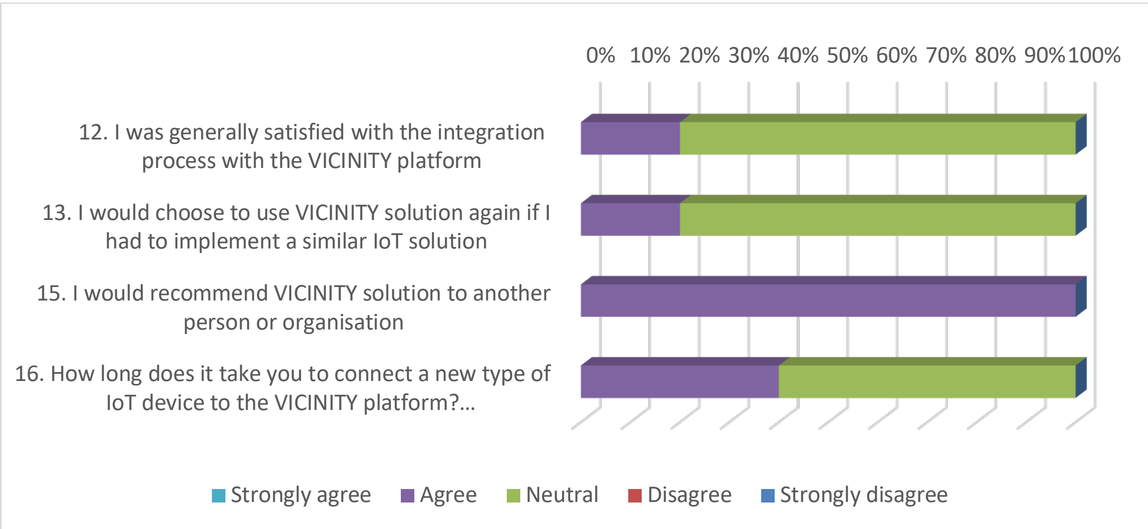

Figure 11: General from VICINITY program – Developers

4. Open Call Evaluation Results

This section provides the Open Call participant's evaluation. The first sub-section collects the opinion of the all Open Call Participants (45 in the First Open Call and 23 in the Second one) with regard to VICINITY documentation. The second sub-section provides the open call winners vision (4 participants in the First Open Call and 4 participants in the Second Open Call) about VICINITY Tech components and the VICINITY documentation, this provide the vision of these external users of the platform, which is considered very valuable for the VICINITY consortium. The section finalizes summarises the business evaluation of the open Call winners.

4.1. Quantified assessment of the VICINITY Documentation

The information in the following section has been provided by all participants in the VICINITY open calls. It provides a summary of the answers to the questionnaires provided in the VICINITY Open Calls application forms. The subsection has been divided into two sections, one per each open call.

4.1.1. First Open Call

The First Open Call was held between 1 March 2018 to 31 May 2018.

The Open Call received 45 proposals.

When the participants where asked about the VICINITY documentation, they answered as follows:

- **Question 1 We would like to know your opinion about VICINITY documentation:**

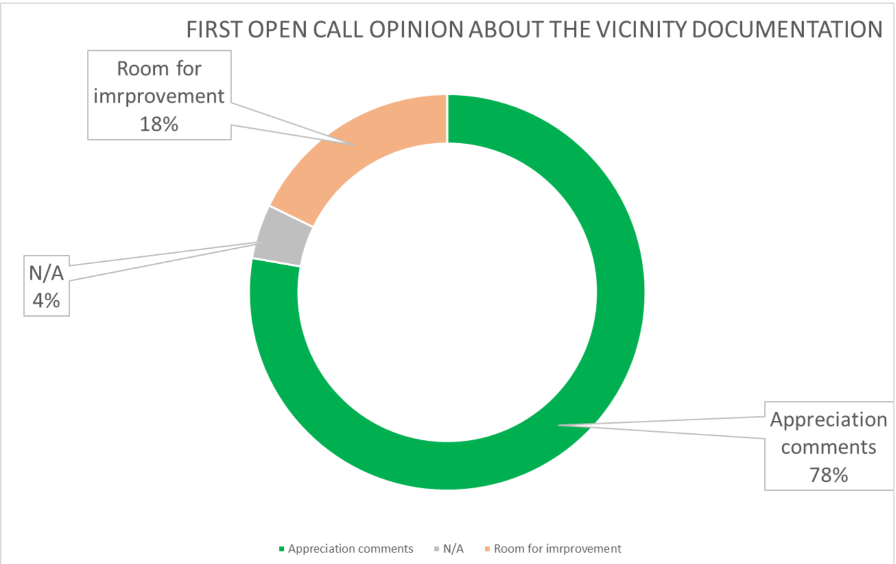

Figure 12: Open Call 2 participants' opinion about VICINITY Documentation

78% of Open Call participants considered the VICINITY documentation satisfactory.

The table below shows the list of explanations from the participants who responded to the question where comments about "room for improvement" were invited.

Question 30: We would like to know your opinion about VICINITY documentation?
VICINITY provides a wide range of documentation that helped us to comprehend the project. In particular, the technical guidelines are very clarifying. On the other hand, the F6S walkthrough document should be more detailed on what is required for each question.
In general, the documentation provides enough detail to understand the VICINITY concepts, architecture. Nevertheless, some links appear to be not working, such as the link into the technical details document for further details on the VICINITY architecture (http://vicinity2020.eu/vicinity/content/d
Would love to see more extensive IoT use case examples
Could have been better
Documentation is easy to read and quite direct towards what need to be achieved by the OC extension. However, some of concepts are not fully explained and delve into deliverables trying to find specific aspects.
Since there are four demo sites in the VICINITY platform, a case study on how to connect IoT devices into VICINITY —exemplifying the connection process step-by-step— would improve the understanding of the VICINITY universe and accelerate its implementation.
The documentation provided about the open call in the guide for applicants was complete and consistent. The technical documentation (we focused mostly on the Adapter APIs) is complete and comprehensive. One things we would suggest would be to provide developers and partners with an API sandbox.
We found the documentation quite helpful and well written. We'd like more detailed description of the several use cases.

Table 14: Open Call participants' opinions about "Room for Improvement" in the Documentation

<u>VICINITY's Actions resulting from comments on the documentation:</u>

Based on the Open caller's feedback on the Documentation, the VICINITY Gateway API, VICNITY Agent documents were reviewed and inconsistencies where removed. The documentation was restructured in terms of the short stories using Medium blog platform. The stories help to guide developers through particular development task. The end-to-end stories were created to cover the most important parts of every integration process. The canonical adapter was implemented which can be used to create virtual simulated infrastructure and test the value-added services.

4.1.2. Second Open Call

The second open call was launched on December 15, 2018 and ended on March 15, 2019.

4 projects were selected, and they carried out the work from June 2019 to November 2019.

23 proposal were received, Participants had to fill 3 questions with regard to VICINITY in order to provide feedback. Questions were asked in the applicant form in order to obtain feedback from the participants.

- **Question 1 We would like to know your opinion about VICINITY documentation:**

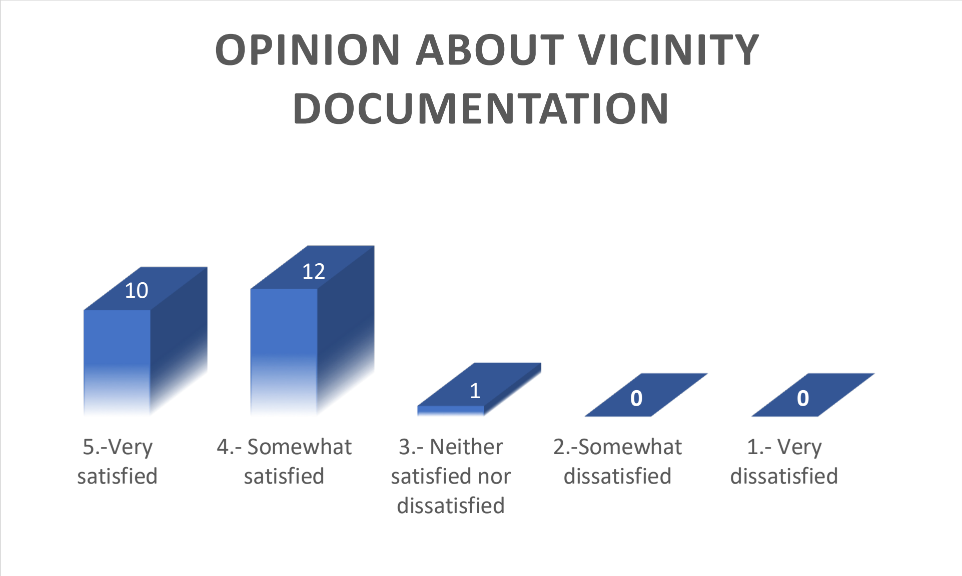

Figure 13: Open Call 2 participants' opinion about VICINITY Documentation

The average score for VICINITY documentaion was 4.4

- **Question 2. We would like to know your opinion about VICINITY GitHub ***

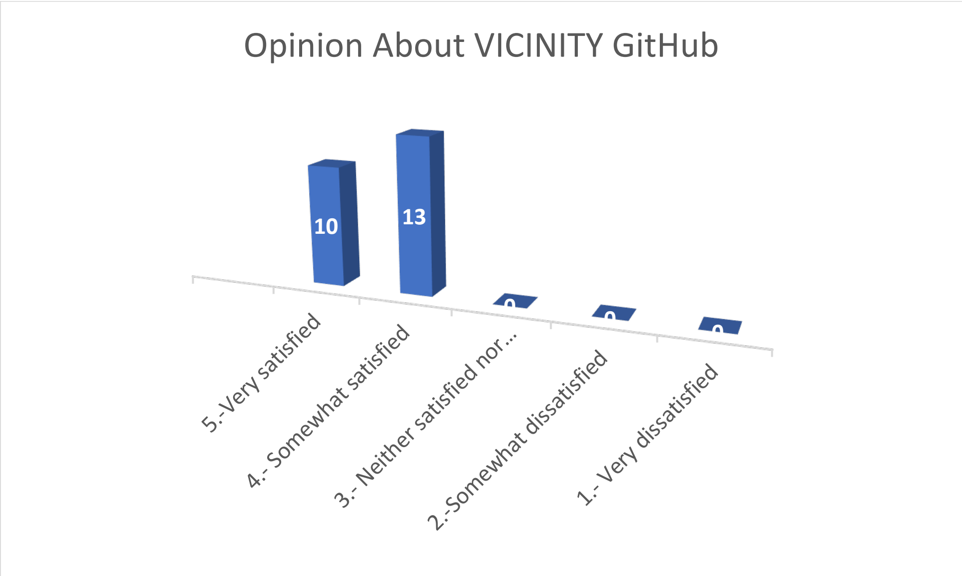

Figure 14: Open Call 2 Opinion about VICINITY Github

The average score for VICINITY documentaion was 4.3

Question 3. We want to know your recommendations

As this question was a free question, different answers were received, find below a summary of the answers.

Relevant answers	Category
The getting started guide is a good starting point for understanding how the VICINITY framework works, although some technical passages may be better detailed and clearly explained (e.g., device authentication).	Room for Improvement
It would be great if the documentation provided a complete end-to-end example about how to integrate a custom service and IoT device with the VICINITY platform. This would include: sign-up process in the platform; generation of all required credentials and entities, including at least one contract with another organization; deployment and configuration of a VICINITY OG and VICINITY Agent; low-level description of a minimal proof-of-concept VICINITY adapter; and some example requests and interactions. Most of these points are already covered in the "VICINITY Get Started" article in the documentation. G hbh from some extended sections and commentaries. This article should serve as an standalone introduction for developers, so newcomers to the platform are able to get the gist of the integration process without having to check other articles.	Room for Improvement
We are greatly satisfied with the VICINITY structure of documentation. Both in terms of technical reports and software at Github. We can see that there has been a great effort to ease the accessibility of newcomers to the VICINITY project. There is a lot of information available and we also like the fact that the software developed during the project is open source	Appreciation comment
The website documentation is very encapsulated in small proportions.	Neutral comment
Great project. We do share your vision of an open ecosystem, aiming to improve the citizens' life. It will be a great pleasure to contribute.	Appreciation comment
The preparation of the submission proposal was a good opportunity to get aware of the details of the VICINITY project. In particular, we would like to have more information about pilot site technical details and interoperability standards, even though both are presented in some of your public deliverables.	Appreciation comment
The overall concept of IoT interoperability as a service is definitely something the market is requiring and looking for. Given our experience in the IoT, which is characterised by a high degree of fragmentation and where each vendor is basically providing their own interfaces (with their own data model), an approach like the VICINITY one would have the potential to enormously speed up the development and integration process, as well as lowering the barrier for high-tech startups and innovative SMEs to enter the market. This can definitely have a major impact on smart buildings and facilities management, where not always is possible to fully install new home automation systems, but rather it is an incremental approach where	Appreciation comment

sensors and IoT devices are introduced where (and if) needed and services build over time. We do believe that VICINITY will be a perfect fit for such market need and requirement.	
The project has overall been very visible and Active, for instance through contributions to AIOTI (Keith Dickerson) which resulted in the publication of one AIOTI deliverable on cross domain use cases, that is highly visible and appreciated. Overall while we do not have deep insights about the project, we get enough information about the pilot and the open calls of the project. This is positive for dissemination and also providing equal opportunities for the startups to participate in the open calls.	Appreciation comment
A workshop for interested parties would be beneficial in understanding the technical opportunities of the project.	Suggestion
Use case scenarios are very well described. However it was not clear what is implemented using the Platform, so it was difficult to reflect on new, planned use cases.	Room for Improvement
The Github documentation is inconsistent. Some projects are well documented, while others are not. We recommend putting standard sections for documentation so that every contributor gives the same level of information for their project.	Room for Improvement
It would be a great idea to generate an ecosystem with Small Companies interested in IoT, Vicinity, etc and if VICINITY also shared data that would also be good.	Appreciation comment

Table 15: Open Call 2 free format feedback

<u>VICINITY's Actions in response to the comments on Documentation</u>

During the Second open call the stories documentation were update based on requests on more detailed information and technical aspects. The Github documentation was reviewed for the VICINITY core components. The VICINITY Videos guides were recorded to supplement user documentation about usage of the platform.

4.2. Quantified assessment of the usability of the VICINITY Framework

All open call projects were invited to provide an evaluation of the VICINITY Framework, its documentation and the support received from VICINITY project partners. In each case this included completing a quantified assessment of the usability of the VICINITY Framework, and separately the adequacy of the documentation for four key VICINITY components. In addition, free format comments were invited.

4.2.1. Open Call I Results

The First Open Call projects were:

- SAMMY by OptionsNet (Greece)
- Incant by Thinkinside Srl (Italy)
- RTNRG Real Time EneRGy management by PilotThings (France)
- Safety and Health Intelligence WearHealth (Germany)

Open Call I projects were carried out from October 2018 to March 2019.

This section of the questionnaire required respondents to give information on the VICINITY Framework, see the questionnaire table below.

Overall, how satisfied were you with the VICINITY ->	Gateway API	Agent	Adapter	Platform
Very satisfied				
Somewhat satisfied				
Neither satisfied nor dissatisfied				
Somewhat dissatisfied				
Very dissatisfied				

Table 16: Open call evaluation of VICINITY Framework

The figure below shows the summary of the VICINITY Technical components' statistics. It is apparent from this table that the majority of the technical components (Gateway, Agent and Platform) obtained a positive evaluation, however the Adapter component obtained a slightly lower evaluation.

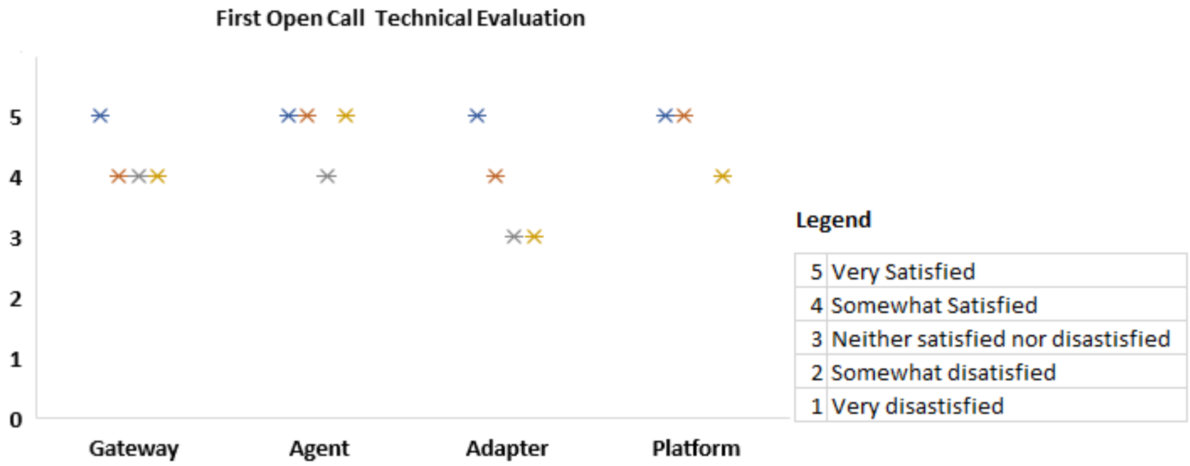

Figure 15: Open Call I Tech Evaluation

How adequate is the documentation provided by the VICINITY ->	Gateway API	Agent	Adapter	Platform
Totally Adequate				
Very adequate				
Somewhat adequate				
Needs improvement in some areas				
Not at all adequate				

Table 17: Open Call Evaluation of VICINITY Documentation

The figure below shows the summary of the VICINITY Documentation components' statistics. From the Figure, it can be seen that the Open Call participants are generally satisfied with the components' documentation, nevertheless the Adapter component obtained a lower evaluation which suggest the more attentions should be put in the improvement of the Adapter documentation.

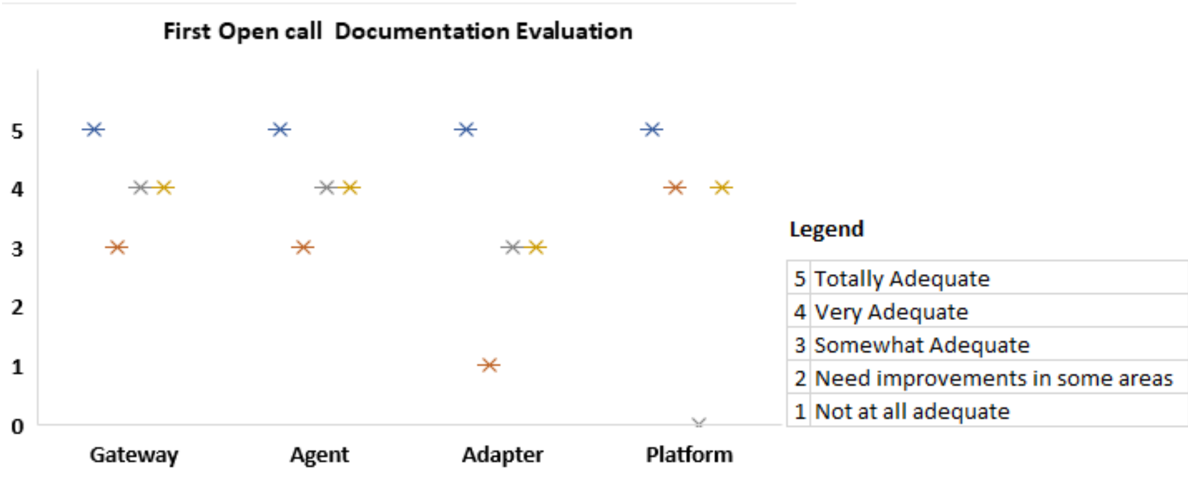

Figure 16: Open Call I Documentation Evaluation

4.2.2. Open Call II Results

The Second Open Call projects were:

- BARTER by Vizlore Labs (Serbia)
- By Nissatech (Serbia)
- F2IVAS by SENSINOV (France)
- drEven by UbiWhere (Portugal)

The Second Open Call projects were carried out from June 2019 to November 2019. For this part of the questionnaire respondents were required to give information on the VICINITY Framework, using the same questionnaire as that used for the First Open Call.

The figure below shows the summary of the VICINITY Technical components' evaluation statistics. It is shown from this table that the majority of the technical components (Gateway, Agent, Adapter, Neighbourhood Manager, Ontologies and Semantic and Discovery platform) obtained a positive evaluation, in the Second Open call more components were used by the Open Call Partners during the Second Open Call than during the First one, due to the nature of the Second Open Call projects.

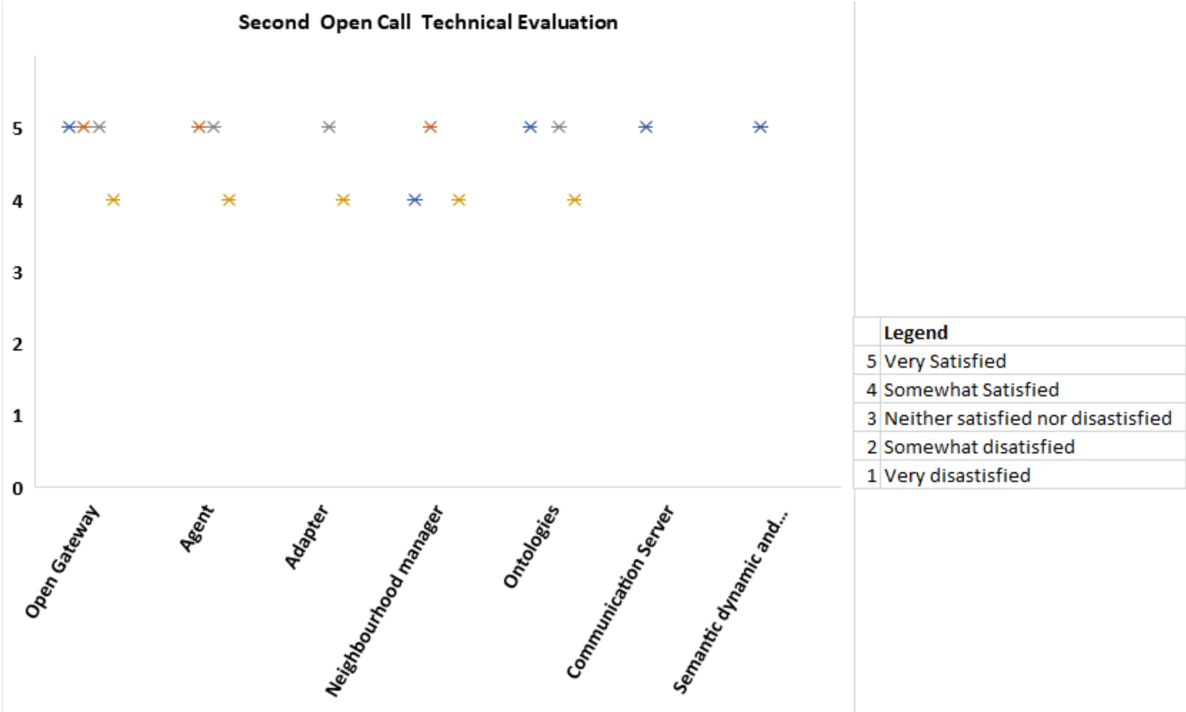

Figure 17: Open Call II Tech Evaluation

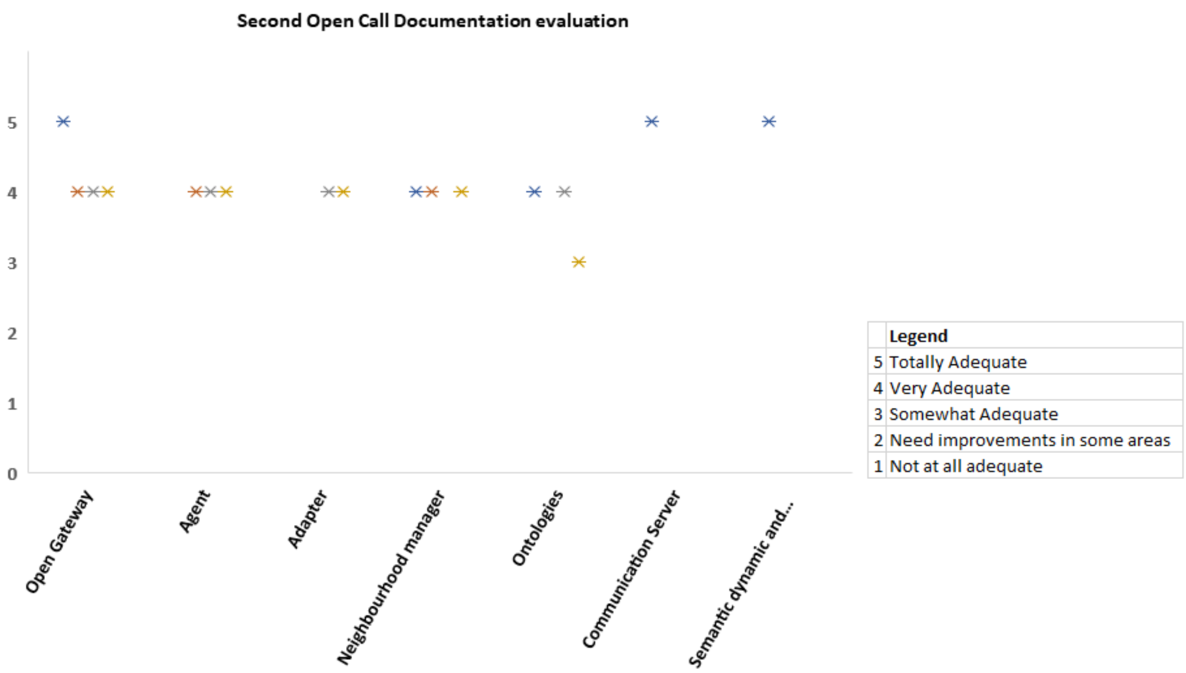

Figure 18: Open Call II Documentation Evaluation

Also, the documentation's evaluation was much more positive. It is clear that components and the documentation for poorly marker sub-systems have been improved since the previous Open Call (e.g. Adapter).

4.3. Business Evaluation

A summary of the Business Evaluation is provided in this section. As “first users” and potentially “first customers”, the Open Call partners’ opinion is very valuable for the VICINITY Consortium.

4.3.1. First Open Call Business Evaluation summary

Open Call I partners highlighted the following VICINITY features as very important for them:

Organizations considered that the VICINITY **open** approach has strengthened their position in the **IoT ecosystem**, as it **facilitates the integration** of third parties’ services and technologies. This approach allows organizations to use a plethora of potential services (e.g. indoor location-based). Besides, it favours that organizations obtain more **visibility** for their applications and **reach a wider community of potential** users for their technologies.

VICINTY has extended the **interoperability** of the Open Call partners’ solutions. The Platform has accelerated the interchange of data between different IoT systems, which in turn, has allowed them to provide **new value-added services** to their customers.

Also, the **International presence** of the companies has been reinforced thanks to the participation in the project.

In addition, VICINITY has **improved participants’ IoT skills**, attaining a more competitive position in the IoT market.

Apart from this, the Platform has reinforced the **data privacy and transparency** of the partners solutions.

Therefore, first Open call participants have evaluated their participation as being very satisfactory.

4.3.2. Second Open Call Business Evaluation summary

The VICINITY Platforms allows the participants to **validate** the **value** and the **interoperability** of their solutions, e.g. combining blockchain and IoT components showing the possibility of new business models.

Open Call partners report that VICINITY has allowed them to create **Proof of Concepts agilely**, this feature should be considered very relevant in the technological moment when act fast is very important.

The platform allowed them the use of **different sensors** with the same service. This supplier independence provides more value to their service proposition.

VICINITY has provided the availability to test decentralised EV charging solutions. Open Call has been crucial to provide the open call winners with the foundations to test how **viable** and **feasible** their systems may be when deployed and scaled.

5. Evaluation of the VICINITY Framework

The evaluation of the VICINITY Framework has been divided in the following sections:

- Community tools evaluation – explains the usage of the tools supporting the community building;
- Pilot-site evaluation of VICINITY USP – discussion the VICINITY USP benefits for the pilot site;
- Operational evaluation – reviews the VICINITY Platform operational stability, code quality and infrastructure deployment.

5.1. Community tools evaluation

The VICINITY Community building approach has the following key components: supporting the community with the documentation material, tools to interact with the community and engaging the community through the webinars, meet-ups and hackathons. The impact of interaction of the community has been measured through statistics about the documentation and tools usage.

5.1.1. Documentation material

"Medium" has been used as a documentation tool to create blogs. It is a simple and effective tool which allows creation of blogs and encourages people to contribute. Seven blogs were written about key features of the platform (https://medium.com/vicinity-h2020). The Medium provides the statistics on number of views and readings (Table 18)

Exposing and reading properties in VICINITY 1 min read · In VICINITY H2020 · View story · Details	8	2	25%
Lesson 2: Register service in VICINITY Platfo... 5 min read · In VICINITY H2020 · View story · Details	60	18	30%
Lesson 1: Building your first infrastructure c... 6 min read · In VICINITY H2020 · View story · Details	69	26	38%
What are the differences between VICINITY ... 2 min read · View story · Details	1	1	100%
How-to register device or service in VICINITY 4 min read · In VICINITY H2020 · View story · Details	14	6	43%
Docker VICINITY Gateway API tutorial 3 min read · In VICINITY H2020 · View story · Details	46	21	46%

Table 18: VICINITY Medium stories statistic

According the statistics the most useful story is "Lesson 1: Building your first infrastructure" with 69 visits and 26 complete reads. That document describe how easy is to create simple simulated infrastructure with a VICNITY Gateway API, sample adapter and simulated devices. This story was produced following feedback from the organisations who prepared bids for the open calls.

Information on the use of the blogs was collected over a 90-day period. The statistics show reading peaks of the stories, these are more focused in late September, early October and November (figure 16). This draws the hypothesis that reading of the Medium stories is dependent on the community activities.

Figure 19: VICINITY Medium stories 90 days statistics

5.1.2. GituHb statistics

The GitHub is used for software control for all components of the VICINITY platform including value-added services and adapters. This tool provides the basic traffic monitoring statistics for the last 14 days, thus regular manual downloading of the statistics is needed. There are two principal statistics “Views” and “Clones” of the source code repository. From the community building measurement, the most important repositories are VICINITY Gateway API and VICINITY Agent, because these components need to be used during any integration activities. The statistics show the activity peaks in late April 2019, late October and early November 2019 (Figure 20). (These statistics correspond to the Open call activities in April 2019 and Hackathon activities in October and November 2019.

Figure 20: VICINIT GitHub statistics of VICNITY Gateway API repository

5.1.3. Docker statistics

Each version of the VICINITY Gateway API is bundled in Docker image for simple and quick deployments. The VICNITY Gateway API docker image is accessible through https://hub.docker.com/r/bavenir/vicinity-gateway-api . The docker hub provides statistics of 160 cumulative downloads of the image since May 2019 (thus for 6 months) (Figure 21)

Figure 21: VICINITY Gateway API Docker image statistics

5.2. Pilot-site evaluation of VICINITY USP's

D9.13 VICINITY Exploitation plan defines the following unique selling points of the VICINITY Platform evaluated in pilot-sites:

- Enable **sharing of data at semantic level**
- **Digital sovereignty by design. Users maintain ultimate control** of their data, no disclosure to 3rd party.
- **GDPR-ready architecture**
- Edge-computing approach / P2P yields **higher scalability, dependability.**

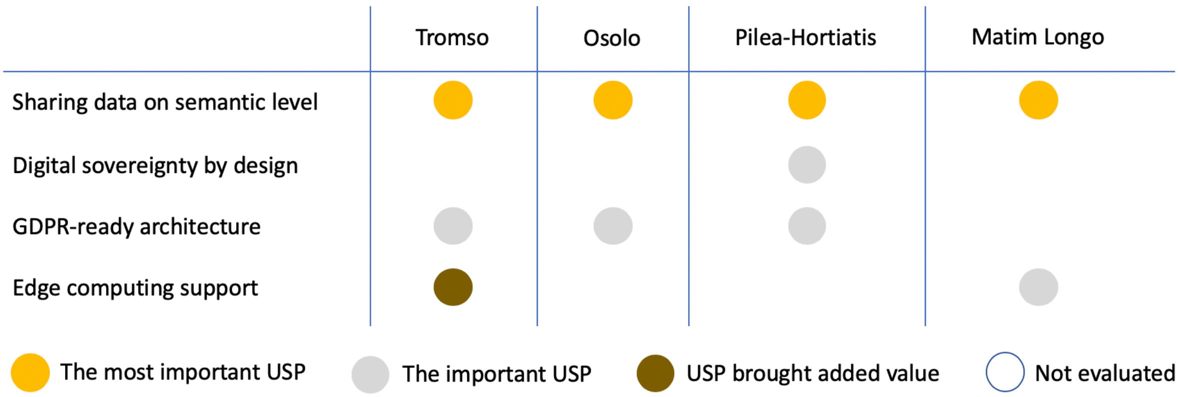

Figure 22: USP Coverage in VICINITY Pilot sites

The pilot site in Martim-Longo involved data sharing at the semantic level, where system integrators could use a wide range of devices and services without relying on one vendor. The flexible approach enabled by the architecture and generic VICINITY Gateway API, allows integration of VICINITY with complementary solutions for building management and supply and demand management tools as edges of the P2P network, which scales up the impact of the whole platform [D8.2].

The Pilot Site in Oslo implemented smart building solutions using the VICINITY platform to integrate devices and infrastructures. An interview with the stakeholders and collaborating with a possible partner revealed that sharing data on a semantic level and digital sovereignty by design were key USPs for the Oslo Pilot. Smart Building Domain and Building Domain in general have a strong need for easily integrating and communicating building information, such as energy consumptions and status of IOT devices, in order to be able to control and optimize building performance. In the Pilot site, there are several suppliers in this domain with proprietary solutions and the Building Owners are looking for possible solutions to be able to choose from several suppliers for infrastructures, IOT devices and end solutions. Data sharing at the semantic level, whilst keeping control of data, is a key component in a Smart Building. This gives the building owners the possibility of easy collaborate between different stakeholders, ecosystem and IT solutions.

The pilot site in Tromsø involved sharing data at the semantic level with an auto discovery feature which enables value-added service to discover new device continuously without actual service reconfiguration.

Moreover, end-to-end encrypted communication between peers and support for pilot site privacy is beneficial. Demonstrating the homomorphic encryption features at the P2P network edges decreases risks of privacy data leakage in VICINITY [D8.4].

The most important USP of the VICINITY Platform for the pilot site of Pilea-Hortiatis, was the GDPR-ready compliant architecture it provides. Since the pilot site is dealing with medical data and privacy is a very important aspect. Features, such as Friendships between Organizations and Contracts between IoT devices to VAS, as well as VAS to VAS, have allowed design of a GDPR-compliant use case, where data are securely transferred only to the authorized parties. The privacy aspect of VICINITY was evaluated positively by the use case participants, more than 90% of whom claimed that they trust their data in VICINITY platform and feel confident that it won't be shared to third parties, as described in D8.5. Moreover, interoperability at the semantic level, allows the municipality to integrate previous IoT solutions, with existing ones, as well as, select from a wide variety of VICINITY supported IoT platforms, as it was highlighted in D5.2.

5.3. Operational evaluation

5.3.1. Stability of solution

The VICINITY infrastructure is monitored with Nagios and Elasticsearch tools to check the health status of the VICINITY Core components. The core components are running to close 99.99% availability (Table 19).

iot_development	CPU Load	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	CPU Stats	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	DISK stats	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	HTTP	99.996% (99.996%)	0.004% (0.004%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	HTTP Comm Server API	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	HTTP Manager API	99.996% (99.996%)	0.004% (0.004%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Memory check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	MySQL Process Check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Network connections	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Network connections nowarnings	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Processes	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	XMPP Process Check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
iot_staging	CPU Load	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	CPU Stats	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	DISK stats	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	HTTP	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	100.000% (100.000%)	0.000%
	HTTP Comm Server API	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	HTTP Neighbourhood Manager API	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	100.000% (100.000%)	0.000%
	Memory check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	MySQL Process Check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Network connections	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Network connections nowarnings	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	Processes	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%
	XMPP Process Check	100.000% (100.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000% (0.000%)	0.000%

Table 19: VICINITY Core components monitoring

Elasticsearch's user interface, Kibana, displays VICINITY Core components containers in more details, all together 7 main containers are monitored.

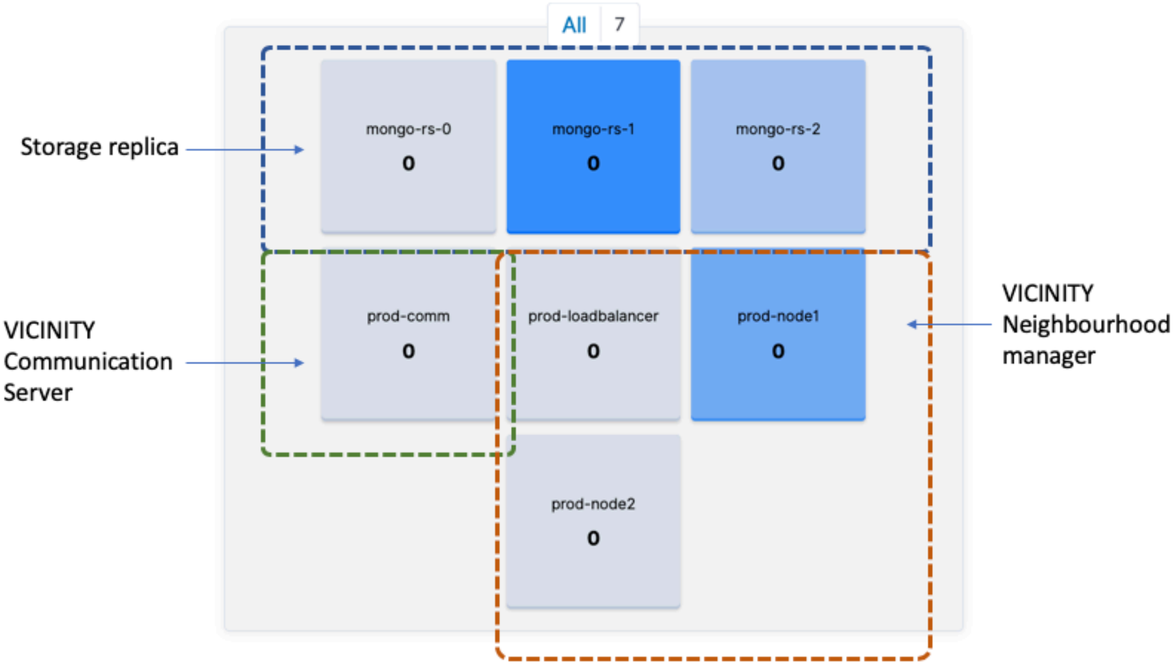

Figure 23: Kibana tool applied to VICINITY

Looking in deep on the VICINITY Communication Server quality parameters the load of the component varied around 0.1 – 0.2 which is a fairly low load. However, more interesting is the network traffic on the communication server which is higher, because the communication server is keeping the opened sessions with each connected IoT object and VICINITY Gateway API (Figfure 24)

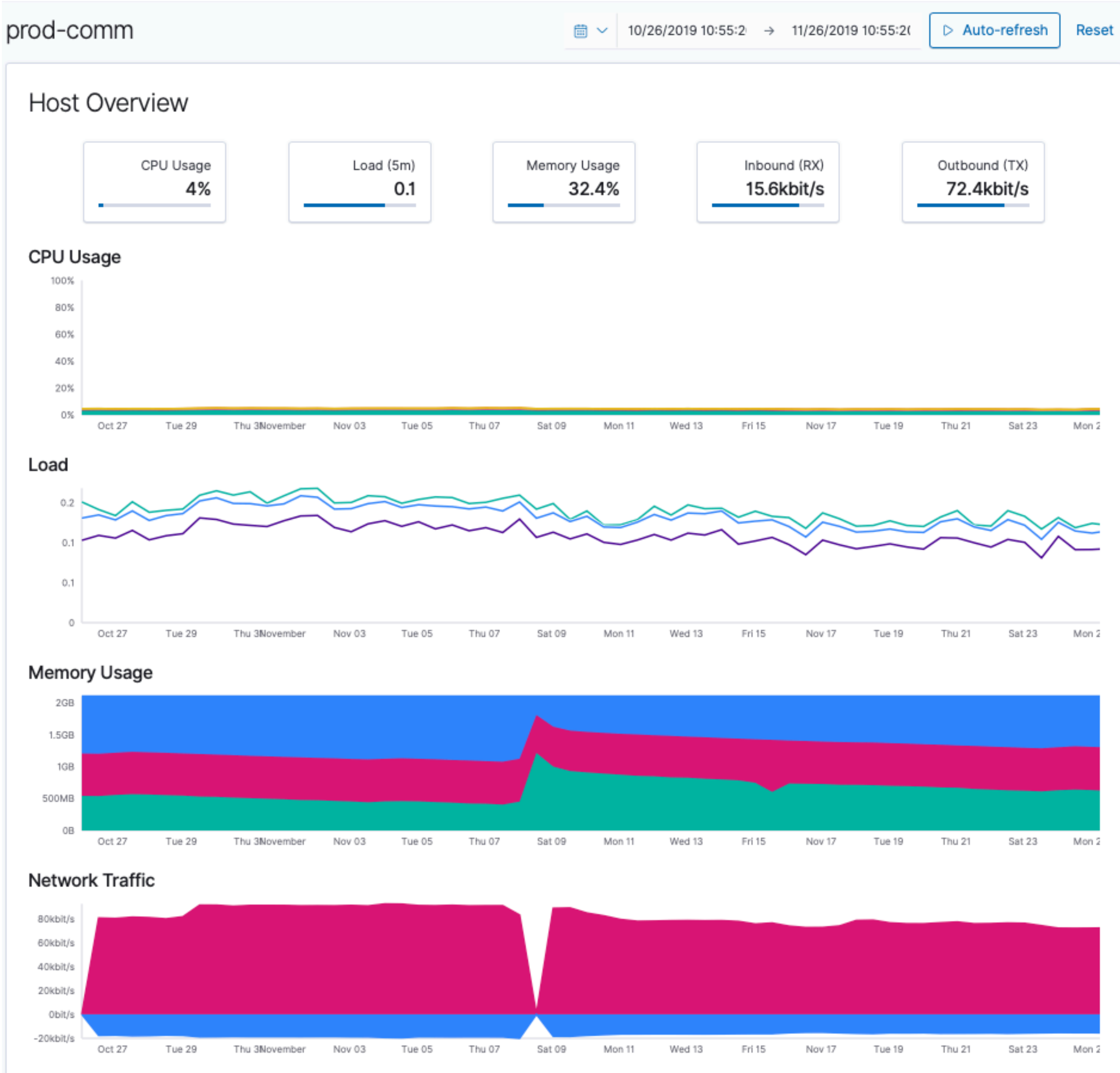

Figure 24: VICINITY Communication Server statistics

The VICINITY Neighbourhood Manager is running a load below 0.2 which is a low load. The memory usage is usually raised by the technology garbage collecting, however stabilized afterwards. The average network traffic bumped up during the last release of the VICINITY, due to introduction of the message counters on the VICINITY Gateway API.

Figure 25: VICINITY Neighbourhood Manager sustainable load

5.3.2. VICINITY Core platform bugs evolution

The VICINITY Core platform bugs evolution statics evaluate the software quality in time (Figure 26). In the graph, the iterations of the VICINITY software development are clearly visible. The core development phase ran until late November 2017, barely raised any bugs. However, after November 2017 the first integration and deployments started, which resulted in identification and collection of the bugs and their fixes. In the February 2019 the Pilot site evaluation phase started with new features to be included and issues from testing. Towards the end of 2019 the number of bugs decreased and stabilized, indicating a good degree of platform maturity, ready to support higher levels of TRL.

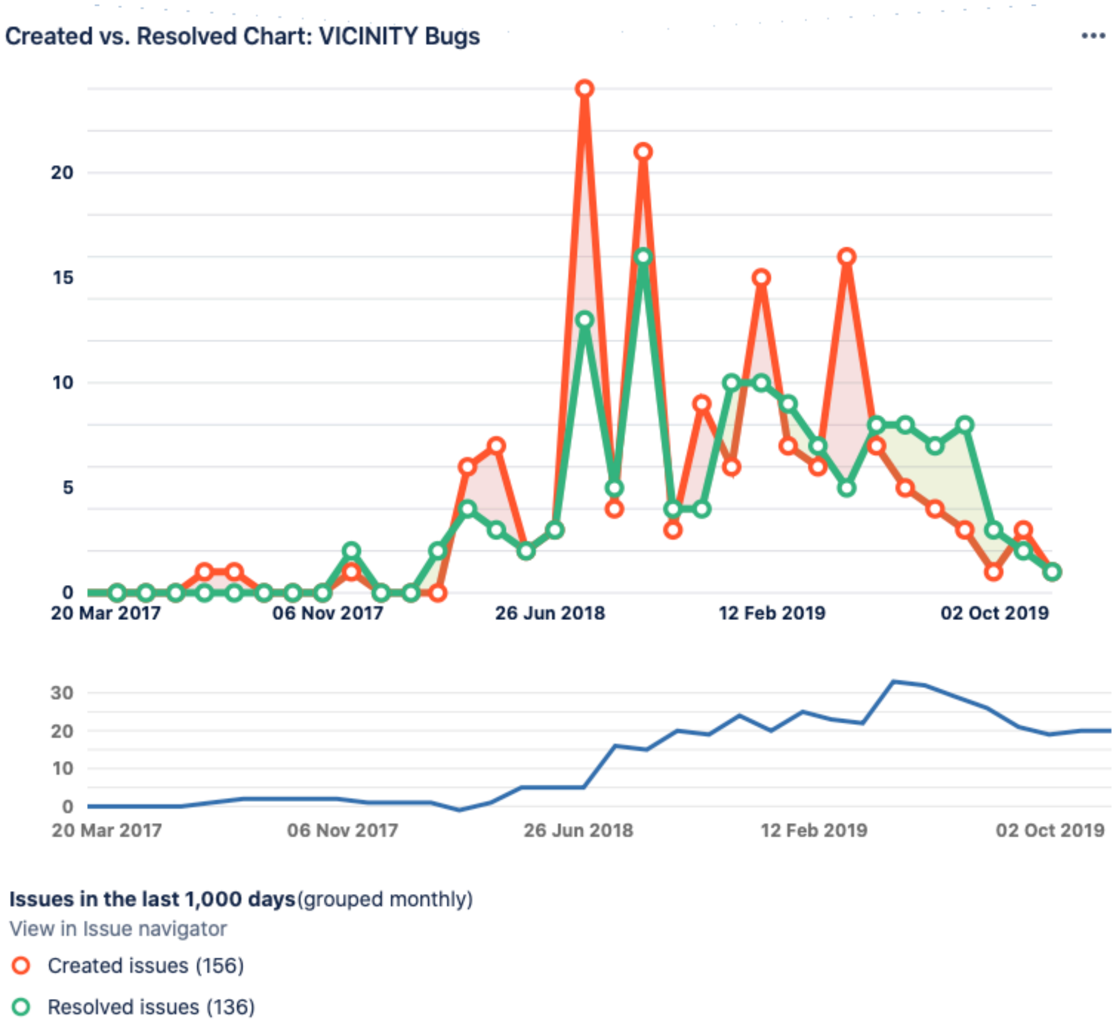

Figure 26: VICINITY Bugs evolution over time

5.3.3. Current infrastructure operation

Currently the VICINITY platform is running in the HETZNER cloud infrastructure. The production environment includes 7 virtual machines with 6 x (1 CPU, 2GB RAM, 20 SSD) and 1 x (2 CPU, 2 GB, 50 SSD). Without any additional infrastructure management services on the top, except backup and snapshotting. In the case of an exceptionally high load, demand VICINITY Neighbourhood Manager and VICINITY Communication Server can be load balanced.

There are options to improve infrastructure availability and reduce the personal costs for maintenance. The following options were investigated:

- Load balancing services;
- Remote storage replica sets.

The load balancing service would only make sense when the whole infrastructure will be moved in to load balancing service provider. However, moving infrastructure to cloud services such as Amazon, Google or Microsoft results in 7-10 times higher basic infrastructure costs. Note, that this step will be necessary when the VICINITY will be on the track of global impact.

Another topic addressed in considering high-availability was to out-source the storage replica set. This would make sense in cases where encryption of the stored information must be maintained. The VICINITY platform uses MonogoDB as storage technology which has a good community license without encryption at the rest features. Storage as a Service provided for MongoDB will not degrade the performance, moreover it improves management and maintenance. The downside is the price, which will be 10 times more without data transfer fees.

5.3.4. Components Technology Readiness Level

The development of the VICINITY Interoperability platform components aimed to reach TRL 7 level, i.e. prototype demonstrated in operational environment. VICINITY Interoperability platform was demonstrated in 4 pilot sites where in real life scenarios [D8.2, D8.3, D8.4, D8.5]. However, there are still improvements necessary to make the solution complete and proven. Apart from the operational improvements in infrastructure scalability, operational processes, VICINITY needs:

- to be approved in large scale use case 50,000 + IoT deployments, to evaluate its large-scale potential;
- to improve diversity of the operational environments in direction of Industry 4.0, to evaluate its mission criticality and Machine learning and Artificial intelligence to evaluate P2P data throughput.

6. Assessment of the Evaluation Tools used

Quantitative and qualitative evaluation tools were used. The qualitative feedback from interviews with stakeholders and questionnaires completed by developers was most helpful in performing the evaluation. The ambition of using quantitative measurements of the effectiveness of the use case with and without the use of VICINITY was discussed but it was concluded that the establishment of a true control test was too difficult. The automatic monitoring of the real-time performance of the VICINITY-supported use cases was implemented and did prove useful in identifying occasions where there was a malfunction (typically the loss of a communication link) when the drop in data samples was immediately obvious.

The most useful feedback was from the open-call developers who had not been involved in the development of the VICINITY framework and had to use the software, tools and documentation that they were supplied with to implement their working demonstration and trial systems. Their successful use of the VICINITY toolkits provided significant validation of the products from this project.

Whilst a more rigorous scientific evaluation of pilots site experiments could have been developed, by using a “control test”, this would have incurred extra cost and required a longer timescale. It is considered that the feedback from stakeholders has been clear and consistent and more than adequate to justify the evaluation reported below.

Two new metrics were developed to judge the level of maturity of the VICINITY framework and the individual pilots, in addition to the use of TRL. These metrics identify functionality at a range of levels, right up to TRL 9.

The metric of “VICINITY Framework compliance” considers how efficiently the pilot system implements the VICINITY Framework. The framework includes the use of adapters, which will be required to accommodate sensors that have not been designed to connect directly to VICINITY. In practice no sensors were available that had the VICINITY interface built in, so adaptors were necessary. This is what was expected in the project but indicates that a higher level of maturity will only be achieved when VICINITY has been adopted by sensor manufacturers.

The second new metric was “Level of Integration with User Systems”: this was applied to the use cases and assessed the extent to which the new Use Cases and Value-Added Services were integrated into the existing operational systems. Once again it was not expected that the demonstration use cases would be fully integrated into the Operations and Maintenance software that the hosts were using, but the systems have been evaluated against a scale that includes these higher levels of maturity and integration.

It is considered to be important to use a performance scale that evaluates the performance level against that of a fully commercialised system rather than to define a target performance for this stage of the development, which we could claim had been met. The approach adopted was considered to be correct although it caused some concer,n as inevitably the Pilots systems did not achieve the maximum available score. The levels of maturity that were achieved are reviewed in the Conclusions section.

7. Conclusions

The functionality and usage of the Pilot Test sites, open call trials and the VICINITY Framework have been assessed and reported in this document. The conclusion section will briefly summarise the approach taken to the evaluation followed by a summary of the evaluation outcomes.

7.1. Background

Each of the four pilots and the eight open-call projects specified, designed, developed, integrated and installed their pilot use cases into the real-world test sites. The different pilots were conducted with different budgets and different numbers of consortium participants (one pilot with three consortium members and three pilots with one consortium member in each). The pilots had different starting positions and different levels of engagement from stakeholders. There would be no value in comparing the achievements of each of these projects on a competitive basis against the achievement of each pilot vs other use cases. These use cases were structured to be complementary and enable operation in different domains. However, there is great value in looking for common findings, and indeed any outlying findings that are outside the typical findings.

The pilots were engaged with the VICINITY framework from the outset and directly contributed to the various stages of the development and helped to identify snags and areas for improvement. Whereas the open-call projects joined the VICINITY once the Framework was more mature and documentation had been reviewed and improved by feedback from the Pilot site developers.

The evaluation of the delivery of the promised USP: suitability: usability and state of maturity has been completed primarily by discussion with the system developers and other stakeholders. Performance metrics were collected automatically by BVR on aspects such as the usage of VICINITY information that has been made available on GitHub and the loading and performance of the framework core platform. UniKL developed a Dashboard that aggregated information from the individual pilot projects which included information on the number of sensors that were attached and the quantity of messages that were passed, performance of the system and many other parameters that give comprehensive overview of the breadth and depth of each solution designed within the project and facilitated by the VICINITY platform.

7.2. Evaluation of VICINITY

The overall evaluation of the VICINITY trials has confirmed that the project has taken the VICINITY concept from TRL 2 (Technology concept formulated) to TRL 7 (system prototype demonstrated in operational environment). This is sufficient to give confidence that the approach works and adds value, and that TRL 8 and 9 can be achieved, subject to the completion of the additional development work required. The concept has been proved to work and to facilitate new service integration. The next steps will need to include the VICINITY interface being built into sensors. They will then be VICINITY ready, rather than rely upon the use of adaptors with the inevitable additional cost – the development of integrated sensors was outside the scope of the current project. Another important step will be to move to the provision of a commercially supported service, so that early adopters can be assured that there will solidly support for the services that they intend to launch.

The documentation on the VICINITY framework has been updated during the project and made available on GitHub. The documentation is considered to be fit for purpose, and GitHub is an effective way to make the information available. The addition of an introductory document to provide a step-by-step introduction to adopting and implementing VICINITY, was suggested by some first Open Call participants and a notable improvement was reported by the second Open Call participants. Their comments in turn led to the creation of an explanatory video.

The four pilots overcame a wide range of difficulties such as radio propagation limitations, and sensors performance limitations as well as identifying and resolving a small number of technical issues with the early implementation of VICINITY Framework. Feedback was applied to improve the design and documentation. At the end of each of the pilot trials the opportunity to build an operational system based on the trial is being discussed, based on the value that was perceived during the operation of the trials.

The two rounds of open call projects, four projects in each round, provided an important independent evaluation by the developers of the trial systems as people that had not been involved in the development of the VICINITY framework and architecture. All of these projects successfully implemented their service using VICINITY. Each project concluded that there would be commercial benefits for them in adopting VICINITY because of the ease of integration and the market proposition that they were using an open architecture which allows integration with existing sensors and competitive procurement of new sensors. The organisations that developed these trials are keen for VICINITY to move to a commercially supported service so that they can migrate their businesses to rely upon VICINITY.

In summary, the VICINITY project achieved its objectives, and the concept is now ready to be taken forward from TRL 7 TO TRL 9 and offered as a commercially supported service.

8. References

[1] http://www.vicinity-h2020.eu

[2] ICT 30 – 2015: Internet of Things and Platforms for Connected Smart Objects - http://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/topics/914-ict-30-2015.html

[3] https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2016_2017/annexes/h2020-wp1617-annex-g-trl_en.pdf

[4] If This, Then That, also known as IFTTT, a free web-based service to create chains of simple conditional statements, called applets. https://ifttt.com/