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Abstract	This deliverable presents the methodology applied during the end-user validation in the context of Fed4FIRE, as well as the results of the surveys realised with the end-users. It is the Updated version of deliverable D 2.05.
Keywords	End-user, methodology, validation, survey

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Nature of the deliverable:		**R**
Dissemination Level		
PU	Public, fully open, e.g. web	✓
CL	Classified, information as referred to in Commission Decision 2001/844/EC	
CO	Confidential to FED4FIRE+ project and Commission Services	

** R: Document, report (excluding the periodic and final reports)*

DEM: Demonstrator, pilot, prototype, plan designs

DEC: Websites, patents filing, press & media actions, videos, etc.

OTHER: Software, technical diagram, etc.

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EXECUTIVE SUMMARY

This deliverable presents the surveys distributed and completed during the end-user validation of the Fed4FIRE+ project. It summarises the results of the surveys and analyses them with the perspective of the Fed4FIRE+ project. Based on the results of the different inputs, several recommendations can be proposed to the federator to improve the Fed4FIRE+ service.

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ABBREVIATIONS

DPO	Data Protection Officer
EU	European Union
F4F+	Fed4FIRE+
FEC5	5th Fed4FIRE+ Engineering Conference
FIRE	Future Internet Research and Experimentation
GDPR	General Data Protection Regulation
IoT	Internet of Things
IP	Internet protocol
NDN	Named Data Networking
NGI	Next Generation Internet
NGOA	Next Generation Optical Access Network
NUC	Next Unit of Computing
PbD	Privacy by Design
PDP	Personal Data Protection
PII	Personally Identifiable Information
R&D	Research and Development
SDN	Software Defined Network
SDO	Standards Development Organization
SDR	Software Defined Radio
SLA	Service-Level Agreement
SME	Small-to-Medium-Sized Enterprise
TaaS	Testbed as a Service
TRL	Technology Readiness Level

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1. INTRODUCTION

Fed4FIRE+ is the direct successor of the Fed4FIRE project that ran from 2013 to 2016 under the FP7 programme. Fed4FIRE+ started in January 2017 and will finish at the end of September 2021. The project builds, maintains and manages the largest federation of Next Generation Internet (NGI) testbeds offering free access to these experimentation facilities. The project consequently supports the research and innovation communities in Europe in the field of NGI.

1.1 OBJECTIVES

As already stated in D2.05, the aims of the Fed4FIRE+ project are the following:

Its primary objective is to build upon and improve the infrastructure already put in place during the development of Fed4FIRE. This includes exploiting and expanding the existing facilities, upgrading and improving them, and extending their functionality to the wider community and marketplace.

Following dedicated market analysis, the federation is focussed on fixed and wireless infrastructure, services, and applications in relation to cloud computing, big data analysis, media delivery networks, smart cities, 5G, and IoT. New facilities can join at any time conditional on their ability to meet a set of entry requirements that may be updated over time.

The project, ideally, ultimately serves as a streamliner for people and other research entities to use testbeds across the world and allow them to conduct experiments cost free and over a shortened period of time. An expected consequence of this is that Fed4FIRE+ will permit research that will set new standards for scale and influence and significantly increase the speed of scientific progress and reduce costs in the decades to come.

1.2 VALUE PROPOSITION

As explained in the Description of Action and as mentioned in D2.05, the main reasons for experimenters and testbed providers to participate to the Fed4FIRE+ project are the following:

For experimenters:

1. Easy access to a wide variety of testbed facilities
2. Zero-cost access to testbed facilities
3. Option of using multiple testbeds in a single experiment
4. Access to newly-launched testbeds
5. A single portal for all testbeds
6. Additional tools to help manage experiments running on multiple testbeds
7. Receiving support from testbed's owners

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For testbed providers:

1. Access to a large group of experimenters
2. Greater chance of success stories potentially attracting additional funding
3. Greater diversity of potential experimenters from different application domains
4. Possibility of gaining enhanced functionality through services provided by Fed4FIRE+
5. Increase its own visibility
6. Become part of a large community of researchers and testbeds
7. Become a member of the de facto premier European FIRE federation

The concept, as well as the work package and task, have already been described in D2.05. For the completeness of this deliverable we have added here sections 1.3 to 1.6 from D2.05.

1.3 CONCEPT

The original Fed4FIRE project developed the necessary tools and interfaces toconnect a variety of previously unconnected testbeds covering a wide range of sizes, locations, technologies and purposes. By building an infrastructure that would allow access to all of them as if the user were using each testbed directly as well as making the interface simple enough that any experimenter could conduct their experiments without any detailed understanding of the way the service they were using operated, Fed4FIRE created an invaluable tool for 21st-century research and business support. Fed4FIRE+ continues to improve the service and create new and innovative tools that will help support an already successful project.

In addition, Fed4FIRE+ builds upon the following projects:

- OpenLab: experimental plane middleware facilitating the use of the testbeds;
- CREW: a federated test-platform using advanced spectrum-sensing, cognitive radio, and cognitive networking strategies;
- WiSHFUL: software for controlling the radio and network aspects of different devices;
- IoT Lab: crowd-sourcing and crowd-sensing technology for ICT research;
- F-Interop: online testing tools including interoperability, conformance, and performance-testing;
- FORGE: a program looking to bring FIRE technology to eLearning such as Open Educational Resources, MOOCs (Massive Open Online Courses), and eBooks;
- and SUNRISE, MONROE, GEANT, FUTEBOL, and TRIANGLE among others.

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Eventually, Fed4FIRE+ will create an open marketplace for experimenters which will simultaneously allow the project to become self-sufficient and generate data on stakeholders' needs. Open Calls will also be initiated to allow external entities to develop and improve the network.

Importantly, there will be a renewed focus on:

- Personal data protection in line with the European Parliament's General Data Protection Regulation (GDPR),
- The reuse of data generated by the project in participation with the H2020 Pilot on Open Research Data,
- Building trusted relationships across the network modelled on the Federated Trust and User Experience framework,
- Facilitating replicability of experiments' results,
- Building a robust authentication service upon the prototype authentication proxy of Fed4FIRE+ to ease the introduction of new experimenters and testbeds,
- Improving the legibility of descriptions covering every aspect of the federated process allowing, for example, easier discovery of resources and services, the application of optimal infrastructure, and the ability to monitor the usage and availability of billing and SLA checks.

1.4 WORK PACKAGE 2 - FEDERATOR

This Work Package is dedicated to running and administering the Federation. Its primary goals are to ensure that the following tasks are taken care of: operations, management, control, improvements, requirements, and sustainability. This is such that the testbeds are maintained and remain well-connected to the larger system.

To do this, the Work Package will define and implement the mechanisms that will determine how the testbeds and federation at large are monitored, accessed, combined, and improved. This is a continuation of the work already completed in Fed4FIRE and other former FIRE projects.

1.5 TASK 2.8 - END-USER VALIDATION

Task 2.8 is responsible for getting feedback from users of the Fed4FIRE+ service predominantly through open calls. This forms part of the "Experiment Cycle" in which users use the service, provide feedback to the federator, the federator evaluates the feedback, and finally the federator updates the service in line with the feedback received. This happens multiple times with the purpose of ensuring that the federation service is of optimal quality.

The feedback elicited will focus on the testbeds and tools used and, in particular, testbeds users' experiences and their impact on the users' businesses.

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1.6 DELIVERABLE 2.10 - END-USER VALIDATION

This deliverable is the second of three (followed by D2.14 in M60), all focussed on the collection of feedback from users and overall improvement of the Fed4FIRE+ service. The objective of the deliverable is to set out a methodology for conducting the end-user validation and carry out surveys collecting feedback from users which will then feed into the general improvement of the Fed4FIRE+ service.

This deliverable is based on the deliverable D2.05 published previously and was initially based on the first set of questions presented in the deliverable D2.05. After submitting the surveys and analysing the results, a comprehensive roadmap of the Task T2.8 is elaborated and implemented in the different Work Packages, in particular in the WP2 and WP5.

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2. METHODOLOGY

2.1 METHODOLOGY

This deliverable has been based on two surveys. In D2.05 an initial survey was presented. It was improved, extended and completed. First of all, additional groups of end-users have been added (see 2.3 Categories of End-User). Then, the questions have been simplified based on some initial feedbacks from consortium members and included others that are essential to obtain valuable information on potential improvements of the platform. The first survey has been presented and distributed to all participants of the 5th Fed4FIRE+ Engineering Conference (FEC5) on 23rd and 24th of April in Copenhagen and 21 surveys have been collected. The aim of the first version was on the one hand, to collect initial feedback on the usage of the platform, such as main benefits of the platform for the users, main challenges, etc. On the other hand, the idea was to validate the survey and to gather comments on how to improve it to be clear for the respondents and the most valuable for analysis. Then, the survey was again improved taking into account the provided recommendations. The second and final version of the survey was distributed to open call participants by email on May 10th 2019 by Prof. dr. Ir. Peter Van Daele from imec - Ghent University. As there were no further recommendations on survey improvements, on June 21st 276 additional users of the platform (patrons of experimentations, testbed providers and open access users) were invited by Brecht Vermeulen from imec - Ghent University to fill out the survey.

2.2 CATEGORIES OF END-USER

As mentioned in D2.05, the main target groups are academia, research organizations, industry and SMEs. In order to cover all potential target groups, also standards development organizations (SDOs) and non-profit organizations were taken into account. End-users of the platform can also be classified according to the initial purpose of the access to the platform. Here are identified patrons of the different Fed4FIRE+ experimentations, the participants to the Fed4FIRE+ open calls, participants to open calls of other projects, users that have accessed the platform through free access, users that have participated to open calls and have also accessed it through free access, and testbed providers.

The platform is used in different manners by all groups of users. The aim of the survey is to understand the potential changes that could be taken in order to improve the end-user experience on the Fed4FIRE+ platform. It is possible that there is a correlation between the user group and the recommendations made. It is important to take into account the point of view of all end-users as they might provide valuable inputs from different perspectives.

Academics, industry and SMEs have already been described in D2.05. To keep the fluidity when reading the deliverable, we have repeated them here:

2.2.1 Academics

Academics are most likely to be based at universities but may also work from home or in the capacity of a tutor to others. Their working situations are likely to be more idiosyncratic than those working in industry or for a company due to the nature of the work they are conducting. For this reason, it's important that the service is flexible and can fit into as wide range as possible.

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2.2.2 Industry

People working in industry are likely to be highly goal-focussed and will therefore require a service that works quickly and efficiently. To this end, it's important that the service is clear and well-structured and that delays in results are minimal.

2.2.3 SMEs

Similar to people working in industry, SMEs are also highly goal-oriented, however, their resources are likely to be more limited and will theoretically looking for the maximum amount of output for a relatively small amount of input. These people will be looking at minimising false moves and working within not only a financial budget but also a time budget. This requires the service with the largest amount of information possible in the shortest time.

2.2.4 Standards development organizations (SDOs)

SDOs can use the platform to test, validate and adapt the standards they are creating. They are important users as the improvement of standardization depends on their results.

2.2.5 Non-profit organizations

Non-profit organizations, similar to SMEs, might have limited resources to test their developments. Hence, Fed4FIRE+ can be a relevant platform to decrease inequalities and give a chance to organizations with more limited means to validate their products.

2.2.6 Research organizations

Certainly, research organizations see great value in IoT testing platforms, their aim being to investigate on new technologies and create innovations. Fed4FIRE+ can hence be useful to test any potential implementation or development for them.

The classification above of users of the platform is based on the form of organization the users are part of. We can also segregate the end-users according to their reason of access to the platform.

2.2.7 Experimentation patrons

Patrons of Fed4FIRE+ experimentations are Fed4FIRE+ project partners, responsible for guiding and supporting the participants of the experimentations. They might use the platform to review the different possibilities for their experimenters and help them on potential challenges encountered.

2.2.8 Fed4FIRE+ open call participants

It is essential that participants to Fed4FIRE+ open calls share their experience with the platform. They are users that have been funded to carry out a specific project to test their implementations and might hence be the most active users.

2.2.9 Open call participants of other projects

Participants to open calls that are not from Fed4FIRE+ provide also important feedback and might be also active users, as they received funding from their projects to test their developments.

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2.2.10 Free access users

The testers that have entered the platform through free access correspond to the users that have not been involved into any open call and might not have received funding to use the Fed4FIRE+ services.

2.2.11 Open call and free access users

It is possible that users have accessed the platform in different contexts: as open call participants and through free access.

2.2.12 Experimentation facility providers

The providers of experimentation facilities might have used their own or other testbeds to test their integration to the Fed4FIRE+ platform. Getting their feedback is relevant as they provide a different perspective compared to the other users.

2.3 DATA COLLECTION

The data was collected in two iterations. As mentioned above, the first survey (First version: Fed4FIRE+ User Validation Survey) was printed and distributed to the FEC5 participants (for the survey questions see Annexe 1). The data was collected via a printed survey. The final version of the survey (New Fed4FIRE+ User Validation Survey) was distributed online via Lime Survey (for the survey questions see Annexe 2). Imec sent the link to the users of the platform.

2.4 ANALYSIS

The data collected in both surveys has been summarized and analyzed. The idea was to extract valuable information for potential improvements of the platform by using as many questions with predefined answers, such as dropdown lists, 5-point-choice array answers, multiple choice, etc. The number of open questions was intentionally limited, as the comparability is more complicated than for closed questions or questions with predefined choices. Though, some open questions were included to give the respondents the freedom to provide some information we might not have thought about. Where possible graphical representations and statistical analysis have been used to compare results and extract meaningful information on potential improvements and mainly appreciated features.

The recommendations to improve the Fed4FIRE+ services provided at the end of the deliverable are based on the analysis of the survey answers.

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3. END-USER VALIDATION TOOLS

3.1 OBJECTIVES

The aim of the development and distribution of the survey and analysis of its results is to pinpoint any potential challenges faced when using the Fed4FIRE+ services, to determine its main value for the end-users of the platform and to adapt the facilities to new and evolving needs and requiremnets. The main idea is to be able to distinguish potential enhancements of the platform in order to increase its attractiveness for the end-users and to attract more users.

3.2 SURVEY FOR END-USER VALIDATION

All our analysis are based on two surveys. A first survey was suggested to the participants of the FEC5, then a second online version was created and distributed to the end-users.

The survey questions are conditional on the user group. For example, an open call participant will have different questions than a patron of an experimentation or a testbed provider. The first survey was filled out by Fed4FIRE project partners (testbed providers, patrons of experimentations) and open call participants. The second survey included project partners, open call participants and experimenters who used the facilities through the open access-mode.

The questions from both surveys can be found in the Annex of this deliverable.

According to the feedback received in Copenhagen a final version of the survey was created and distributed on May 10th 2019. Changes were made on types of users. A category that includes users that have accessed the platform via open calls and via open access was added. Most of the questions are conditional on the type of user and therefore the conditions for some questions were corrected accordingly.

3.2.1 First version: Fed4FIRE+ User Validation Survey

21 completed surveys from the participants of FEC5 event were collected.

Response summary

Full responses	21
Incomplete responses	0
Total responses	21

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1) Type of organization

Most respondents (ten) come from Academia, five SMEs, as well as research organizations and only one from the industry as shown in Figure 1.

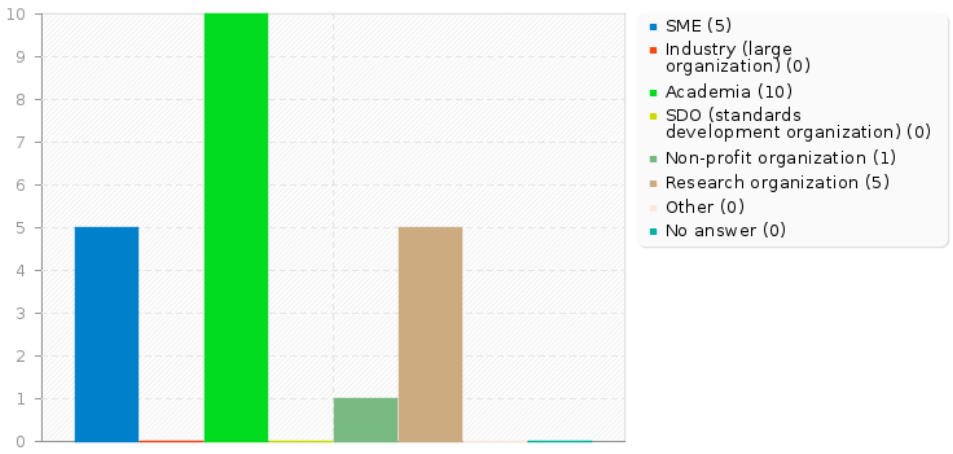

Figure 1 - Types of organizations using Fed4FIRE+

2) Finding out about Fed4FIRE+

More than half of the respondents found out about Fed4FIRE+ as they were involved in other research projects or collaborated with partners that worked with Fed4FIRE+.

3) Type of user

12 from the 21 respondents participated to a Fed4FIRE+ open call, eight are testbed providers and one is both a patron of an experiment and a provider of an experimentation facility.

4) 95% of participants agree that their **objectives** were **reached** by using the Fed4FIRE+ services. Only 1 out of the 21 respondents thinks that his/her objective was partially achieved.

5) Highest **satisfaction rated** for :

- Support from Fed4FIRE+
- Contributions to user's project (not much deviation)
- Expectations regarding service met (not much deviation)

Rated the lowest:

- Ease of access to the service

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	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Fed4FIRE+ website	0	0	4 (19.05%)	13 (61.90%)	4 (19.05%)	4	0.63
Ease of access to the service (end-user friendliness)	0	0	4 (19.05%)	14 (66.67%)	3 (14.29%)	3.95	0.59
Support from Fed4FIRE+	0	1 (4.76%)	1 (4.76%)	5 (23.81%)	14 (66.67%)	4.52	0.81
Expectations regarding service met	0	0	2 (9.52%)	10 (47.62%)	9 (42.86%)	4.33	0.66
Contributions to your project	0	0	2 (9.52%)	8 (38.10%)	11 (52.38)	4.43	0.68
Technical capabilities	0	0	3 (14.29%)	9 (42.86%)	9 (42.86%)	4.29	0.72
Flexibility of system/ possibility to adapt to your needs	0	2 (9.52%)	5 (23.81%)	5 (23.81%)	9 (42.86%)	4	1.05

Figure 2 - Level of satisfaction with Fed4FIRE+ services

17 respondents continued with a more detailed survey, four did not.

Additional questions:

1) Names of testbeds

Here the respondents indicated the testbeds that they have used. Once all the questionaires were received, the answers were discussed with the consortium and it was decided to change the answer field of this questions by replacing the open text field to indicate the used testbed(s) into a list where respondents can tick any used testbed.

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2) Application domain of experiment/project

Mainly the respondents work on networks, 5G and other topics, as shown in the Figure 3. Thanks to the feedback from respondents the application domains were added.

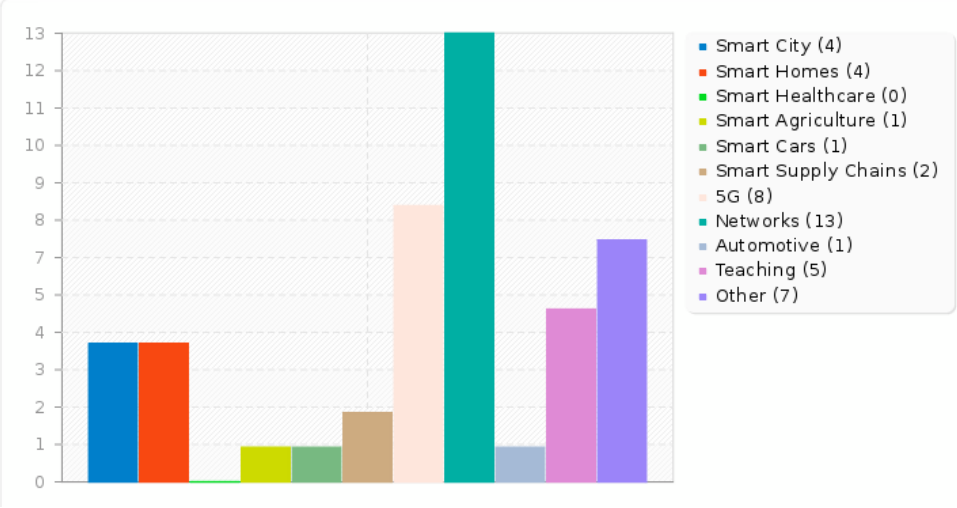

Figure 3 - Application domains

3) Testbeds/tools used

Also, this question was adapted by adding the missing testbeds to the list.

4) Resources used

bots, edge server, cloud server, virtual machines, virtual links, fixed nodes, mobile nodes, gateways, virtual SND slice, etc.

5) Open Calls

14 from 17 participated to Open Calls

5a) Names of Open calls

5b) Satisfaction

70% are very satisfied and the rest are quite satisfied. The results are overall positive. The satisfaction rate for open call participants is relatively high.

5c) Additional comments form Open Callers

The following positive comments were also collected: good experience, responsiveness from testbed providers and reviewers, relevant reporting, praise of documentation and support, possibility to test in real-life environment.

The FEC5 participants recommended to improve expected steps related to workflow and interactions between open call participants and patrons.

The respondents suggested to add calendar with dates, deadlines, details on when to contact who and on what should be provided.

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6) Relevance of Fed4FIRE+ features (see Figure 4)

Most relevant feature:

- Open access to the research facilities

Many features had a high score:

- Large variety of testbeds and resources
- Easy use of the Fed4FIRE+ platform and tools
- Large panel of research domains: IoT, smart cities, wired network, wireless network, SDN/NFV, 5G, cloud computing, etc.

	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Large variety of testbeds and resources	0	0	3 (14.29%)	3 (14.29%)	11 (52.38%)	4.47	0.8
Open access to the research facilities	0	0	2 (9.52%)	4 (19.05%)	11 (52.38%)	4.53	0.72
Easy use of the Fed4FIRE+ platform and tools	0	0	1 (4.76%)	7 (33.33%)	9 (42.86%)	4.47	0.62
Large panel of research domains: IoT, smart cities, wired network, wireless network, SDN/NFV, 5G, cloud computing, etc.	0	0	2 (9.52%)	5 (23.81%)	10 (47.62%)	4.47	0.72
Limited cost to set an experiment	0	1	2 (9.52%)	6 (28.57%)	8 (38.10%)	4.24	0.9

Figure 4 - Relevance of Fed4FIRE+ features

7) Features that need most improvement

Documentation:

- update of documentation
- more detailed descriptions of available resources and features per testbed
- unified, homogenous, well defined resource descriptions that can be machine readable. This will allow AI software to take decisions on infrastructure allocation.
- provide access to the deliverables on the website

Provide examples/communication:

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- some testimonials
- more video testimonials on how to use them
- some success storries/ case studies which can motivate more companies to use F4F+
- communication among European researchers (students, PhD, professors)

Technical improvements:

- ease of interconnecting testbeds
- radio resources (spectrum) reservation
- resource availability
- USRPs with multiple RF choices
- more mobile infrastructure
- some of the testbeds should be increased; in the case of citylab respondent would like to perform more experiments with denser deployment scenarios
- possibility to have the most recent software version
- usability and access: it should be straightforward to set up anything or it should be actively supervised
- providing courses in the FECs
- interoperability: provide standard ways and the minimum set of tools as long as possible

8) Challenges encountered:

- OS in some nodes are not updated
- Extension of GTS testbed
- hard to set up. 5GHz wifi experiments
- jFed stable version was not compatible with NITOS
- transmitting and receiving to different bounds
- transfer of numerical results into visual representation
- tech challenges like NAT
- lack of some resources to either reuse code from others in the project or other technical issues, these outside of the Fed4FIRE+ reach

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9) Demos and tutorials were used by 10 from 17 respondents.

9a) All of that respondents that used the **demos or tutorials** were quite satisfied or very satisfied with them.

9b) Additional comments: One respondent mentioned that the videos were useful.

10) Reason for using platform & main objectives:

- geographically scattered resources
- technical knowledge offered
- support from patron
- to access to a great number of resources provided by the testbeds
- access to resources we do not have high level testbed automation

Main objectives :

- set up of experiment
- to evaluate SCION ever multiple domains
- validate the offline experimentation approach in large scale, in a controlable environment
- to deploy respondents cooperative cognitive network solutions
- to test CDN related mechanisms on large scale heterogenous environment
- to test and validate ML models that can predict performance of a Wi-Fi link, which is a key activity of the company
- to test cybersecurity aspects of our IoT platform

We noticed that actually here we had included two questions into one. For the final survey we splitted them.

11) Factors that mainly contributed to achieving the results / factors that mainly contributed to failling to achieve the results

- financial support
- support from federation
- access to multiple testbeds
- able to reserve the necessary resources to a large scale necessary to necessary validation of the OE Approach for every testbed used (w-iLab-t + NITOS)
- easy integration inside the federation

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- great support
- resource diversity
- automation tools
- factors to achieve the small cell virtualization factor to pare: USRP into 2RF.
- resource diversity and availability
- versatility of the F4F testbeds that enabled to run our experiments in different scenarios, with ease in setup and configuration
- experiment and validate our IoT platforms web services which are secure by desgin.
- documentation and ad-hoc support

What would be needed:

- more efficient support
- more complete infrastructure

Most comments are positive and mainly linked to resources availability and resources diversity.

12) Duration of usage of F4F+

	Nbr. of respondents (% of total)
Up to six months	5 (33.33%)
Up to a year	3 (20%)
Up to two years	2 (13.33%)
More than two years	5 (33.33%)

Figure 5 - Usage duration

Most respondents either use the platform for less than six months or more than two years. Most of the ones using it for a longer period are participants of to the F4F+ project (consortium members).

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13) Recommendation by respondents

Most respondents are likely to recommend the F4F+ platform and to use it in the future (see figure 6).

	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Willingness to use again	0	0	2 (11.76%)	1 (5.88%)	14 (82.35)	4.71	0.69
Would you recommend it to colleagues	0	0	2 (11.76%)	1 (5.88%)	14 (82.35)	4.71	0.69
Would you recommend it to others (industry)	0	0	2 (11.76%)	3 (17.65%)	12 (70.59%)	4.59	0.71
Would you recommend it to others (academia)	0	0	2 (11.76%)	2 (11.76%)	13 (76.47%)	4.65	0.7

Figure 6 - Recommendations

14) Additional comments

- more visibility for scientifiy community necessary
- evolution of Fed4FIRE+ for teaching purposes is desired
- more presentations for open call participants to present their experimentations
- content with the evolution of the testbeds
- suggested improvements:
  - website
  - improve user-friendliness and workflows
  - user-experience during experimentation

15) Who should be invited to use the platform

SMEs, research centers, students, universities, technical professional, people from other disciplines.

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Main findings from the first survey:

Number and kind of respondents

We have been able to collect interesting information from 21 respondents during the FEC5. More than half of the respondents are from academia and the rest mainly research organisations or SMEs. Most respondents might hence have limited budget or infrastructure to carry out tests, the only exception can be research organisations. The majority of the respondents of this survey are open call participants, this is due to the nature of the event when the survey was distributed. Also, the first version of the survey was mainly conceived for participants of experimentations on Fed4FIRE+.

Positive feedback, main advantages and strengths

Nearly all participants agree that their objectives have been reached by using the Fed4FIRE+ services. Besides, the level of satisfaction of open call participants with the Fed4FIRE+ service is relatively high; all participants are either very satisfied or quite satisfied. We have not included similar questions for the other respondents, but it has been added in the second survey. The main strengths of the plaform are the access to resources and facilities, the large panel of testbeds and resources diversity, the ease of use of platform and tools and the variety of domains that can be supported. Other strengths of the services have been the financial support (for open call participants), the technical support from federation and the possibility to reserve resources on a large scale. Also, the ease when integrating inside the federation as well as when setting up and configuring different scenarios have been greatly appreciated by the users. The automation tools and documentation have similarly contributed to the success of the respondents' respective projects.

Weaknesses and recommendations

The users of the Fed4FIRE+ services have stated that they would desire some improvements of the platform, such as more updated and unified documentation, more details on available resources and features and easier acess to documentation on the website. With regards to access to information the users recommend to share success stories, provide more testimonials on usage of the platform, a wider dissemination to European researchers and more visibility for the scientific community in general. To improve specific resource reservation, to make more resources available, to facilitate the interconnection of testbeds, to provide a more mobile infrastructure, to simplify and standardize the plaform setup for usage and to extend testbeds for denser deployment scenarios are technical recommendations stated by the respondents of the first survey. Also, the need to improve website, the end-user friendliness and user experience during experimentation have been expressed. When reusing code from other projects some users have encountered difficulties on the platform; as well as the visual representation of numerical results and other technical challenges.

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3.2.2 New Fed4FIRE+ User Validation Survey

Response summary

Full responses	32
Incomplete responses	25
Total responses	57

1) Type of organization

Most respondents are SMEs and Academia. The rest are from the Industry (large organisations) and from research organisationx, though together they only account for around 18% of all respondents.

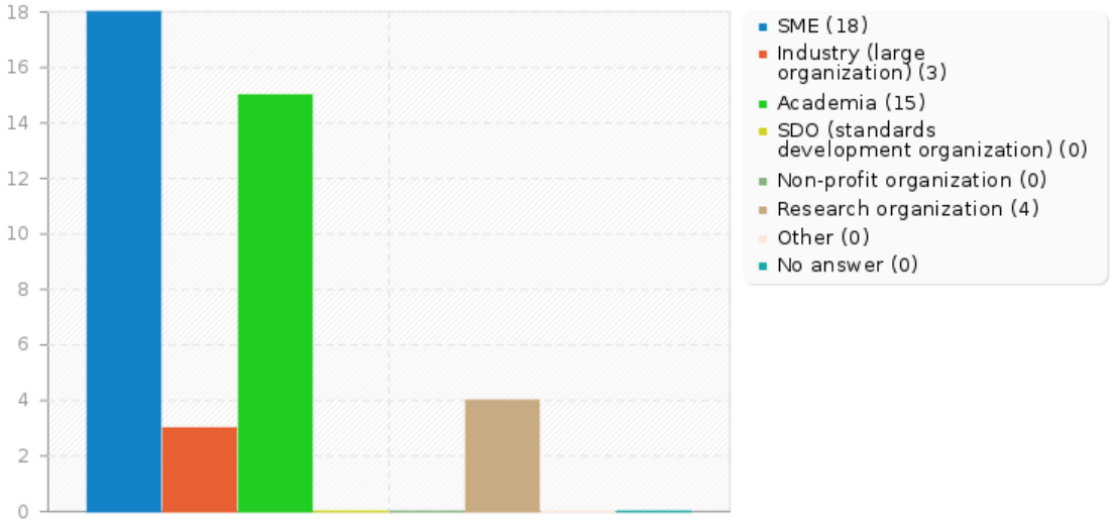

Figure 7 - Types of organizations using Fed4FIRE+ - Second Survey

2) Finding out about Fed4FIRE+

More than half of the users of the Fed4FIRE+ services found out about it as they used it in other research projects or some colleague/friend did so and informed them. So it is interesting to notice that the best means of communication about the existence of the platform is by word of mouth. Only 20% of all respondents learnt about Fed4FIRE+ through the website and 7.5% through social media. This means that the online communication method should be rethought. Promotion via research papers and during scientific events are not significant and should be improved.

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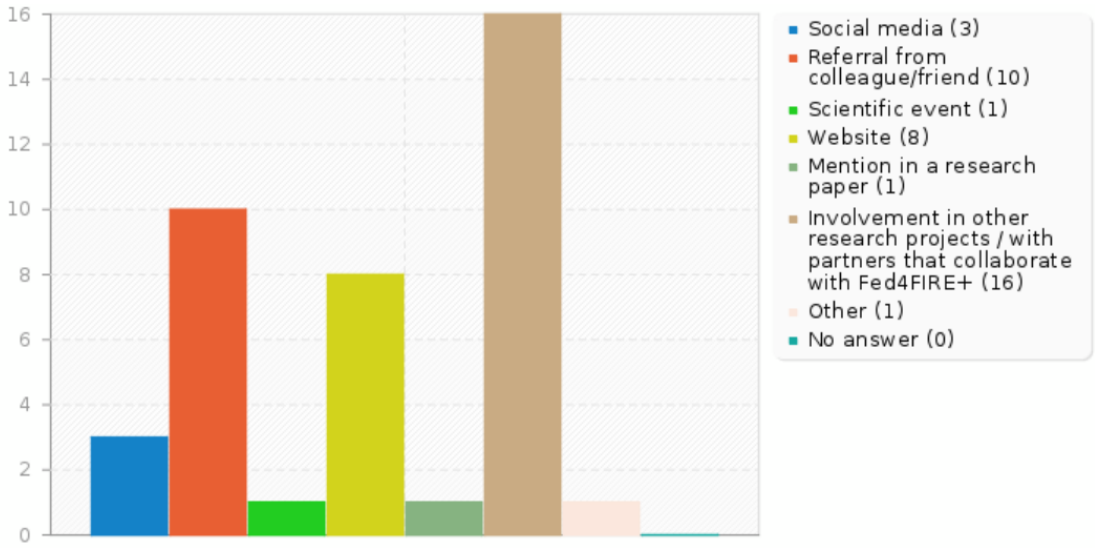

Figure 8 - Communication about Fed4FIRE+

3) Type of user

Similar than for the first survey, the majority of respondents are participants to Open Calls. Including Open Call participants from other projects, as well as the group of users that are Open Callers and free access users, 90% of respondents are Open Call attendants. No patron of an experimentation has filled out the survey, only one person through free access and three testbed providers.

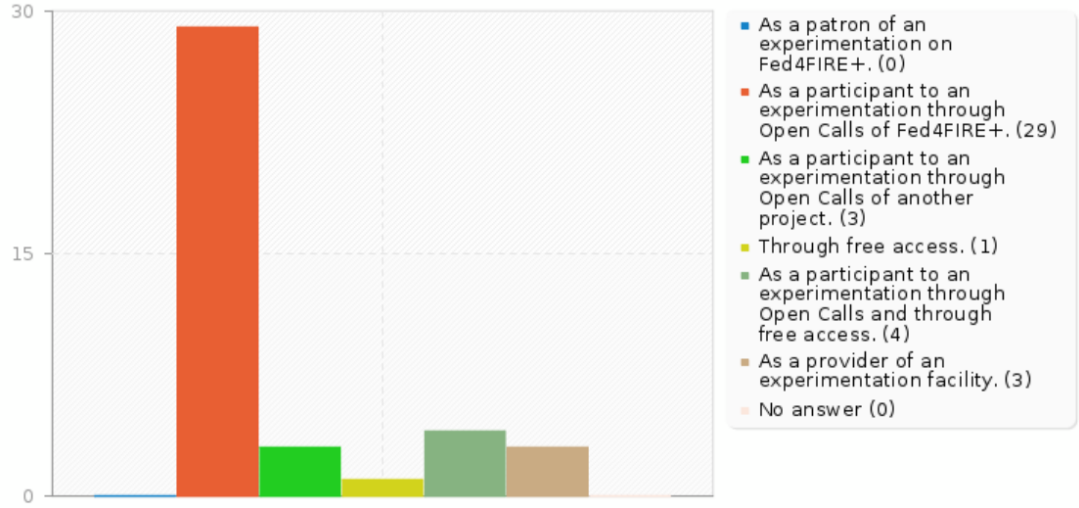

Figure 9 - Type of user of the platform

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4) To the question if the **main objectives where reached** 80% answered with yes.

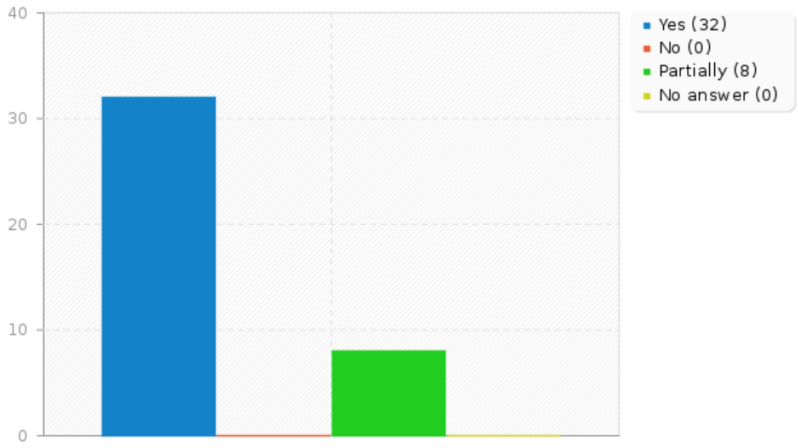

Figure 10 - Achievement of objectives

5) Level of satisfaction with the Fed4FIRE+ service

Highest ranking:

- Support from Fed4FIRE+ (as for the first survey)
- Fed4FIRE+ website

Followed by:

- Technical capabilites
- Contributions to user's projects (as for the first survey)

Lowest ranking:

- Flexibility of the system/ possibility to adapt to user's needs (but high standard deviation)

	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Fed4FIRE+ website	0	0	4 (10.81%)	17 (45.95%)	16 (43.24%)	4.32	0.67
Ease of access to the service (end-user friendliness)	0	0	7 (18.92%)	23 (66.67%)	7 (62.16%)	4	0.62
Support from Fed4FIRE+	0	0	4 (10.81%)	11 (29.73%)	22 (59.46%)	4.49	0.69
Expectations regarding service met	0	0	8 (21.62%)	19 (51.35%)	10 (27.03%)	4.05	0.7
Contributions to your project	0	0	7 (18.92%)	17 (45.95%)	13 (35.14)	4.16	0.73
Technical capabilities	0	0	5 (13.89%)	20 (55.56%)	11 (30.56%)	4.17	0.65
Flexibility of system/ possibility to adapt to your needs	0	0	15 (41.67%)	14 (38.89%)	7 (19.44%)	3.78	0.76

Figure 11 - Rate of satisfaction with the service

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For experimentation facility provider highest rating:

- Fed4FIRE+ website
- Expectations regarding service met
- Technical capabilities

Lowest rating

- Contributions to testbed provider's project (has no real project like Open Callers, just provide testbed)
- Flexibility of sytem / possibility to adapt to testbed provider's needs

	1	2	3	4	5	Arithmetic Mean
Fed4FIRE+ website	0	0	0	0	3	5
Ease of access to the service (end-user friendliness)	0	0	0	1	2	4.67
Support from Fed4FIRE+	0	0	0	1	2	4.67
Expectations regarding service met	0	0	0	0	3	5
Contributions to your project	0	0	0	2	1	4.33
Technical capabilities	0	0	0	0	3	5
Flexibility of system/ possibility to adapt to your needs	0	0	1	0	2	4.33

Figure 12 - Rate of satisfaction with the service for testbed providers

6) Nearly 83% of all respondents are aware that the **use of the Fed4FIRE+ resources are free of charge.**

7) Only one respondent has used the platform through free access. This person is not aware that he/she has the **possibility to participate to funded Open Calls!**

About half of all participants decided to continue with the second more detailed survey.

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Additional questions:

1) **Names and descriptions of experiments**

Passenger Information at Scale: End-to-end scalability test of on-board passenger information software with two new developments situated at the level of the on-board controller and at the server application in the data center of the operator.

MMT-IoT Sniffing: Test of the security functions and the scalability of the MMT-IoT solution

Unikernel-based CDNs for 5G Networks(UNIC): Implementation of an Unikernel-based CDN and enablement of a large-scale, multi-domain experimentation, involving: (i) end-to-end network slicing; (ii) dynamic resource discovery and allocation; and (iii) experimentation with modular media service orchestration mechanisms, e.g., on content caching and service elasticity.

CoPro5G: a cooperative proactive resource management for 5G small cell networks

CLONE – CLOudlet information centric Networking Experiments: Verification and measurement of KPIs related to content delivery supported by open source Named Data Networking (NDN) Future Internet architecture cache “cloudlets” combined with Tara Hill National Park’s proprietary software Android application.

MEC4FAIRFEST: Explores a network-assisted approach for adaptive HTTP streaming and Mobile Edge Computing. Mobile Edge Computing emerging standard gives new opportunities to improve DASH performance, by moving IT and cloud computing capabilities down to the edge of the mobile network.

CDN-X-ALL:

- Multi-access Edge Computing CDN solution
- Direct contributions to Fed4FIRE+ by developing, implementing and upgrading the testbed federation with an OpenAirInterface based 3GPP MBMS stack
- The solution allows to shield from network issues and performance degradation by dynamic changing the CDN where the content is retrieved in case of a multi-CDN video distribution.

"FIVE" (Experimenting in Fed4Fire+ with VEhicle Communication System): FIVE brought to Fed4FIRE+ a new in-house Cellular-V2X software radio modem prototype, for developing and experimentally evaluating state-of-the-art connected vehicle technologies and applications.

Evaluating Next Generation optical Access enerGy Efficiency using Fed4FIRE (ENGAGE-F4F) Project: Evaluation of the impact of next generation optical access networks (NGOAs) by integrating access and metro networks using software defined network (SDN)

Collecting live sensor data to prepare a PoC

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CReAT. Experimentation towards seamless vertical and horizontal handovers between different wireless technologies. Minimize impact of handovers for any application, proactively switch technologies/operator.

MMT-IoT. Security analysis on IoT networks using the novel MMT-IoT network extractor. Performing scalability test and determination of the limits of security analysis on IoT networks

MEC4FAIRFEST: Exploitation of MEC capabilities in order to improve the QoE of the end user. Collection of L2 metrics of radio link and exploitation of them in order to adjust the quality of the video stream provided to the users.

CDN-X-ALL: Exploitation of MEC capabilities in order to improve the QoE of the end user. Collection of L3 metrics of wired link and exploitation of them in order to select and/or switch CDN from which retrieve the video stream that will be provided to the users.

MAGIC (F4P03-L06): Multi-platform innovative solutions to tackle important challenges of Wi-Fi technology by using only user-space information

Openstack testbed without bare metal machines; used testbed with bare metal machines (without any virtualization involved)

2) Application domains of projects

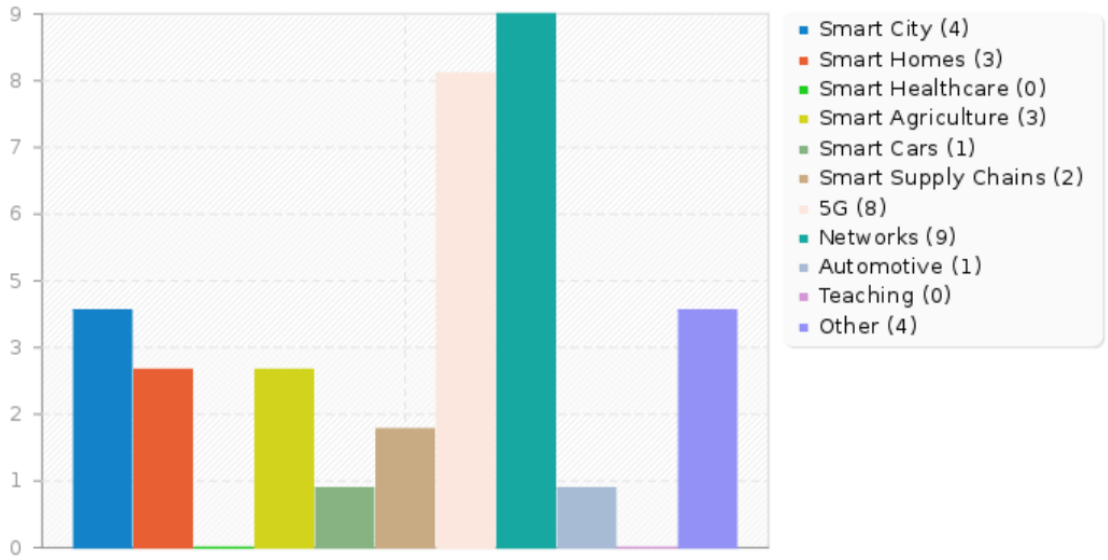

Figure 13 - Application domains

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3) **Testbeds used**

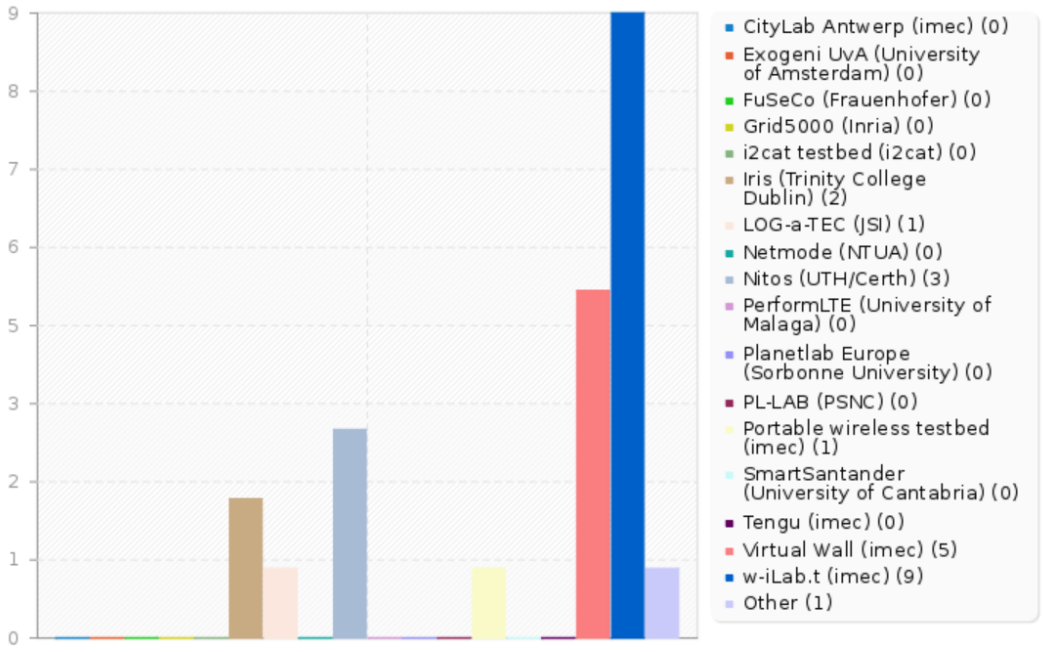

Figure 14 - Usage of different testbeds

4) **Resources of testbeds used**

- A node configured as a server;
  Ansible node for deployment;
  Nodes running kubernetes for automatic deployment of a large number of clients (in our case, trains).

- Intel NUC (Next Unit of Computing) machines, Zolertia Re-mote IoT sensors.

- Heterogeneous physical machines hosting Unikernels, i.e., to address heterogeneity.

- USRP devices

- X310s, Virtual machines, N210s.

- USRP/Openairinterface-enabled nodes as eNodeB
  Openairinterface-enabled nodes as EPC
  LTE nodes as End User Equipment
  Generic nodes as Media Server

- w-iLab.t (iMinds): 2xmobile nodes (robots), 2xDSS, 2xNUC, 2xUSRP B200 mini, 1xfixed node (APU)
  Portable wireless testbed (imec): 2 x NUC-USRP B200 mini combos (NUCs #10, #11, USRPs Ser. 30F10DB, 31D4A17), 1 x NUC (#9)
  Nitos (UTH/Certh): 2 x USRP B210 equipped Icarus nodes (typically #55,#56)

- VMs, XEN VMs, Physical Nodes, USRPs.

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- x1 temperature and x1 humidity sensors (Zolertia Re-Mote) and x2 RM090 to go through A to Z to prepare our PoC.
- virtual machines
- LTE-enabled robots
- NUC nodes from w.iLab and the Zolertia devices attached to them
- Wireless indoor LTE testbed, including wireless and wired node. The nodes are equipped with open source implementation of Radio stack (OpenAirInterface) and commercial LTE dongles.
- Wi-Fi devices (ZOTACs, DSSs, APUs, and NUCs) of this testbed as well as some servers.

5) Satisfaction with Open Call Experience

Over 90% of the respondents (Open Call participants) were either quite satisfied or very satisfied with their Open Call experience.

6) Willingness to have different types of open calls

- The fact is that Stage-1 and Stage-2 are not that practical while the Stage-2 is not accepted. In this sense, you just explore the possibilities without executing the actual experiment.
- Interested in more projects like ORCA
- It would be great to see calls in different areas of IoT. First of all in smart agriculture sector.

7) Relevance of Fed4FIRE+ features

Most highly rated features:

- Low cost of experiment
- Large variety of testbeds and resources
- Open access to the research facilities

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	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Large variety of testbeds and resources	0	0	1 (9.09%)	4 (36.36%)	6 (54.55%)	4.45	0.69
Open access to the research facilities	0	0	0	6 (54.55%)	5 (45.45.%)	4.45	0.52
Easy use of the Fed4FIRE+ platform and tools	0	0	1 (9.09%)	5 (45.45.%)	5 (45.45%)	4.36	0.67
Large panel of research domains: IoT, smart cities, wired network, wireless network, SDN/NFV, 5G, cloud computing, etc.	0	0	2 (18.18%)	6 (54.55%)	3 (27.27%)	4.09	0.7
Low cost to set an experiment	0	0	2 (18.18%)	1 (9.09%)	8 (72.73%)	4.55	0.82

Figure 15 - Level of relevance for the different features

8) Necessary improvements

- a clear explanation of what can be expected, what is the value, advantages over Amazon tests, etc.(especially usefull for new users of the plaform)
- Documentation of the platforms, and up-to-date tutorials to correctly set-up "hello world" deployments.
  Easiness of finding the documentation.
- resource availability
- increase amount of USRPs with advanced features such as multiple RF for MIMO and carrier aggregation
- The funding was extremely important. However, the access to software defined radio (SDR) equipment is very useful for research into 5G.
- The testbed documentation should be more detailed. It could be useful to have more information for simplifying the deployment of the experiments.
- Smartsantander accessible through jFed
- 2 years ago LTE experimentation required a lot of manual commands, which often failed. Documentation was not always available. Would be nice to have tooling to support this / SDKs to integrate in applications

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- The organization of the documentation. There is a lack of more explained tutorials rather than showing which are the commands to run to make it work.
- As a possible future improvement, it would be nice to have at least one KVM for each device type and, if possible, an application showing the spectrum usage within the testbed in real-time.

9) Challenges

- Practical "how to's", but these were all quickly solved thanks to great support from the testbed owner.
- Sparsity of the documentation to interact with the platform.
  Technical limitations to deploy proprietary (not open source) on the Log-a-Tec platform.
- Yes, the fact that we didn't have USRPs with multiple RF to deploy for small cell networks with carrier aggregation.
- SDR is very challenging for a computer scientist. We encountered many challenges learning about it. More tutorials would be useful
- The deployment can be sometimes complicated. Moreover, some nodes sometimes fail during the experimentation.
- As mentioned previously, configuration improvement. However, I got a lot of support from the Fed4FIRE team.
- The main challenge was to experiment with DSS nodes due to (i) bad initial configuration of those devices (when using a LEDE image), and (ii) driver problems in the wired connection.

10) Marketing material

- I did not see recent communication, but given our previous background knowledge on FIRE/Fed4FIRE for us this was very clear.
- It's clear enough, but it would be advisable to include a sheet with "technical limitations" for each platform.
- Yes. It would be good to be transparent on which features are currently supported in which test-bed (e.g., link stitching options).
- The marketing material are satisfying.
- Yes, we found out about it. I think different tutorials would be useful for different testbeds.
- It is rather clear. Enhance advertisement of the Output of Open Call Experiments as Use-Cases.
- Yes, the marketing material is clear enough (stated 5 times).

11) Tutorials and demos on the website

All of the 11 respondents said they used the tutorials/demos.

11a) Level of satisfaction with demos/tutorials: 8 out of 11 were quite satisfied and one very satisfied.

11b) Other comments on demos/tutorials

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- It was good to be able to get the right pointers from the testbed owner.
- More advanced tutorials would be very helpful. For example, using srsLTE software UE, EPC, and base station.
- There were some things which were not up-to-date, however, were fixed quite fast after interactions with Fed4FIRE team.

12) Reasons for using Fed4FIRE+

Most respondents ranked first as motivation for using the Fed4FIRE+ services the funding for experiments and the facility to test their product on a large scale. Also, very important seems the possibility to test on a quasi-realistic environment , as most respondents ranked it on second place. The least motivation for using Fed4FIRE plus are the possibility to test over multiple (federated) testbeds, as well as the support from the testbed provider.

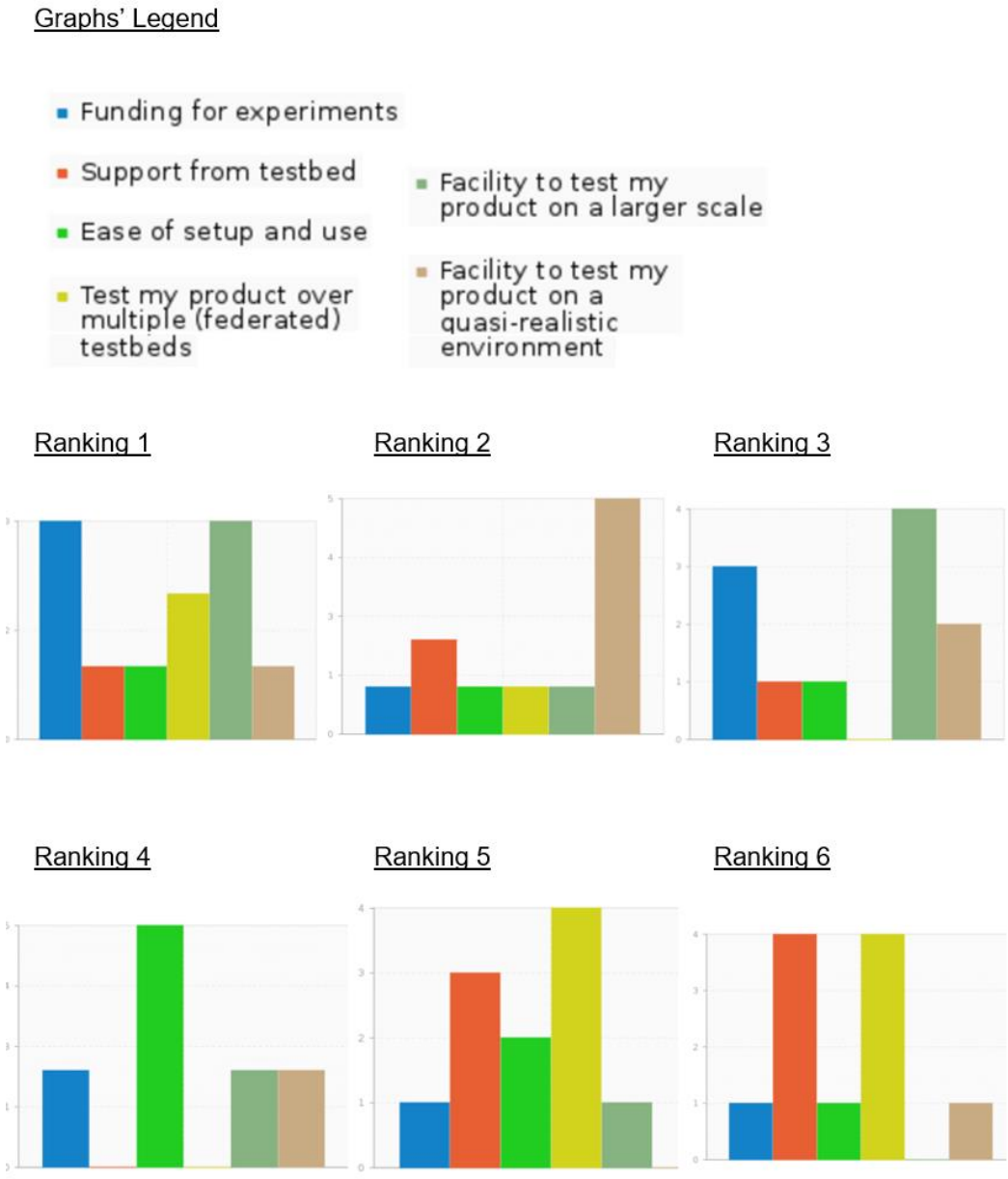

Figure 16 - Ranking of motivations for usage

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13) Main objectives

- Test new product at scale in an efficient/reproducible manner.
- To test the feasibility of implementing a proof-of-concept software on a real IoT device and give insights about the scalability of this innovative product.
- Although the first experimental results extracted from our relevant platform were promising, we had difficulties to conduct experimentation resembling real CDN deployments. FED4FIRE was the ideal platform to conduct large-scale experiments over heterogeneous resources.
- To deploy cognitive radio networking solutions to large-scale testbed.
- The main objective of the experiments is to compare these future Internet scenarios against existing point-to-point communication based on Internet protocol (IP) communication.
- Experimentation of different solutions for enhancing media delivery in a real testbed, instead of testing through simulation. Then, using the results for improving future solution for media delivery and publish the results of the experimentation such to contribute to the state of the art in media research field.
- We came to Fed4Fire+ for 4 main reasons:
  1) To assess the performance of our modem in real-world conditions, by moving from emulation- and lab-based evaluation to over-the-air field testing
  2) To enhance our prototype with new features from higher layers, such a networking and facility software implementations
  3) To exploit the available resources to compose an SDR ON-BOARD UNIT.
  4) To demonstrate the applicability of our prototype to safety-oriented ITS scenarios, for example collision avoidance applications
- Testing my services
- Test different handover technologies
- To perform security analysis on IoT network and evaluate the scalability of our new product MMT-IoT
- Our objectives were to analyze the operation, behavior, and breaking point of our algorithms specifically designed to (i) determine the best channel assignment for a set of APs, (ii) locate and track Wi-Fi users, (iii) dynamically adjust the AP transmission power in such a way that the expected QoS is guaranteed, (iv) and to configure and manage a set of decentralized APs from a remote location. For that, we performed scalability and robustness tests, which were very useful to bring to light the weaknesses of our methods and to define the improvement guidelines that will lead our product development for the next releases

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14) Factors contributing to achievement or failure of results

- clear problem/goal from our side
  good support/pointers from Fed4FIRE+
  the facilities
- Mainly the free access to a completely open testbed and the support of the partners. An initial proposition of the ideas and a discussion with the partners allows us to adapt our experiments to the FED4FIRE platform requirements.
- The availability of heterogeneous / large-scale resources to provide a realistic CDN environment.
- The fact that the patron team, i.e. IMEC and UGhent, have a strong experience in SDR platforms.
- The help and knowledge from the Iris testbed provider was fundamental. They provided a lot of support and assistance to achieve results.
- The support of the patron's testbed and the possibility to fund the experiment.
- * Availability of large variety of resources
  * Easy access to resources
  * Support from testbed operators
- grant and easy access to testbeds
- Success, possibility to mange testbed nodes as root allowing to install anything to evaluate
- Failing, instability of LTE nodes
- The easiness to remotely deploy on the w.iLab platform.
- (1) The provision of KVMs eased a lot the integration of our technology.
  (2) The information provided by the mobility testbed of wilab.t was fundamental to get insights about the behavior of our algorithms.

15) Next steps on results of experiment

- Was good to provide us with some trust on the scalability of the product; we learned good techniques to do the experiment; we should likely run similar tests again now the product became more mature.
- Start testing on a bigger scale in order to detect failure points. This will allows us to know the limitations of our solution.
- To evolve further our platform towards an experimentation environment for 5G media verticals.
- To submit to Stage-2 opening.
- We have extended the Android NDN application to run natively using the OFDM radio access technology without the support of physical layer or data link error

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detection mechanisms due to dropped connections, failures, and collisions. However, further development is required to support challenges in this environment.

- Using the results for improving future solution for media delivery and publish the results of the experimentation such to contribute to the state of the art in media research field.

- * Add new features to our products
  * Investigate commercialization opportunities.

- apply to stage 2

- Further analysis of different handover techniques

- We are aiming to perform a Phase 2 to further extend the scalability tests and enhance the performance of our tool.

- Based on the results of the experiment we conducted within Fed4FIRE+, we are improving our algorithms.

16) Advancement of business thanks to experiment

- trust in our solution, tooling, functional improvements

- It allowed us to move from a solution implemented on an emulator towards having a software working on real IoT devices that was validated in quasi-real scenarios.

- Allowed us to test our platform and ideas in a realistic environment.

- We can expose a strong experience in wireless networking for large-scale.

- With the funding, we have been able to employ two new key staff that supporting the development of the product in real tourist environments. Furthermore, its given us excellent experience and knowledge about how to use 5G networks. So this is fundamental for our future growth.

- It lets to improve the knowledge on media delivery and improve the media delivery solution.

- * Increased visibility
  * Provided demos and showcases for potential customers
  * Increased technical know-how through interaction with high quality equipment and knowledgeable experts (testbed operators)

- approaching new customers

- Gained us knowledge on the handover topics, insights in pro/cons of different techniques

- It allowed us to increase the TRL of our tool and leave the Proof of concept phase.

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- Thanks to this project, we have been able to speed up the testing and the time-to-market of our innovative algorithms. Furthermore, we have drawn important conclusions that have allowed us to define improvement guidelines for our algorithms. These improvement guidelines will help us to keep improving and growing in the right direction, and furthermore, they will also help us to be a reference in the market in a near future.

17) Recommenations about testin facilities

- USRP with 2 AD devices, i.e. 2 RF for MIMO and CA.
- NFV MANO compliant testbeds.
- IoT networks (LoRa, NB-IoT) and devices (microcontrollers, radio, etc.)
  ITS-G5 infrastructure (e.g. RSU, OBUs)
- Would be nice to have actual moving LTE nodes connected to commercial operators (e.g., vans/trains/cargo transport/...)

18) Additional comments

- Satisfaction with collaboration

- Very good experience with the Fed4FIRE+ team
  Great input and feedback at the conferences.
  Funding very useful for the company
  The access to the knowledge and expertise from the Iris testbed very helpful

- Thanks to Open Call were able to assess and improve the performance of a newly developed company prototype in real-world conditions and demonstrate its usage involving real end-users, thus moving from emulation- and lab-based evaluation to field testing, and eventually accelerate our product development

19) Usage periodes

Over 60% of respondents used the platform for les than 6 months.

	Nbr. of respondents (% of total)
Up to six months	7 (63.64%)
Up to a year	3 (27.27%)
Up to two years	0
More than two years	1 (9.09%)

Figure 17 - Time of use

20) 10 of the 11 respondents would have been able to use the testing facilities even **without funding for their experiments**

Testbed provider (1): answered with NO

Other comments: Examples and tutorials are necessary, need for confidentiality, certification and usage billing employing the same business model of cloud infrastructures

Without Fed4FIRE+: Without funding the investment of man power to employ testbeds not coming from a standardization body, a community initiative or an open source project,

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where the reliability, replicability and standards compliance or certification to grant universal conclusions, will not be feasible. Going further the transmission of commercial strategies and roadmaps without confidentiality and privacy framework of the open access schema will turn this action unworkable.

21) Use again and recommendation

All respondents are likely to use Fed4FIRE+ and recommend it to others. It is the most probably that they will recommend it to their colleagues.

	1	2	3	4	5	Arithmetic Mean	Stand. Dev.
Would you use it again?	0	0	1 (9.09%)	4 (36.36%)	6 (54.55%)	4.45	0.69
Would you recommend it to colleagues?	0	0	0	4 (36.36%)	7 (63.63%)	4.64	0.5
Would you recommend it to others (industry)?	1 (9.09%)	0	0	4 (36.36%)	6 (54.55%)	4.27	1.19
Would you recommend it to others (academia)?	0	0	1 (9.09%)	3 (27.27%)	7 (63.63%)	4.55	0.69

Figure 18 - Reuse and recommendations

22) Other comments:

Funding is obviously a very good reason to ensure resource availability, which is always a challenge. Whether or not to use it again/keep using a facility is (1) a matter of getting it planned and (2) a matter of creating the necessary trust that resources/time invested is not "lost" in the case that test environments would suddenly become unavailable.

23) Places to advertise Fed4FIRE+ services

Only one response: At small universities and associated innovation hubs. For example, at Waterford IT.

Testbed provider: Currently, in open calls, only a single party can submit an experiment. It would be good if multiple parties at a time can submit a proposal to do experiments together.

24) Please to be invited to use the platform

Only one response: SMEs working in Wireless Networks and collaborating with vendors and operators.

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25) Possible website improvements

- To include real-time information about resource-allocation / -availability, number of open-callers, number of open-access users, etc.
- More details about the testbed. Maybe some basic videos how to set up and get started.
- More details on Open Call / Experiment Achievements
- Testbed provider: Website could be improved by adding more videos on performing different experiments.

Testbed Provider:

- **Would like more users or experiments via Fed4FIRE+? Answer:** yes, for the moment only used the virtual wall. In future, interest in using the wireless testbeds
- **What other support would you like to see from Fed4FIRE+ in addition to that it already provides? Answer:** support for students to do class laboratory exercises. Our institute will greatly benefit from it. Example of such exercises could be routing experiments, ARP spoofing etc.
- **Add. Comments:** greatful about availability of platform and possibility to do experiments; had possibility to publish some papers on topic

Main findings from the second survey:

Classification of respondents

In total 57 users of the platform answered the survey, of which 32 are full and 25 only partial responses. 19 respondents answered also the second part of the survey. They are mainly from academia and SMEs. 90% of respondents have accessed the platform as Open Call participants; very few as open callers from other projects, through open calls and free access; only one through free access, three as testbed provider and no one as a patron of an experimentation. The types of application domain of their projects are mainly on 5G and networks. The testbeds that were used by the majority of the respondents are w-iLab.t and Virtual Wall, both from Imec.

Satisfaction level

80% of respondents consider that their objectives where reached when using the platform. When considering the answers from all types of users we can say that the Fed4FIRE+ services that rated the highest are the support from Fed4FIRE+ (as for the first survey) and the Fed4FIRE+ website. The flexibility of the system/possibility to adapt to user's needs ranked the lowest. With regards to the features of the platform the ones that have the highest ranking are the low cost of experiments, the large variety of testbeds and resources, and the open access to the research facilities.

When going through the survey and summarizing all comments and remarks from the respondents we have found out that one of the main advantages is the support from the Fed4FIRE+ team for users of the platform. Also, the availability and variety of resources on

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the platform, as well as the funding are seen as major assets of FedFIRE+. Similarly, the main motivations for using Fed4FIRE+ have been the possibility to get funding for experiments, to test developments on a large scale and to test on a quasi-realistic environment.

The Open Call experience has been overall very positive. Over 90% of the respondents were either quite satisfied or very satisfied with it.

Necessary improvements and challenges

We can understand very clearly from the survey that the main recommendation by users of the platform is to improve the documentation. Different respondents have indicated that there is a considerable need to access more detailed information about deployments of experimentations, interacting with the platform, technical limitations and available features, as well as about the value of the platform compared to others.

With regards to technical improvements many times the resource availability was mentioned as a challenge. For example, the provision of KVMs and the increase of the amount of USRPs with advanced features were recommendations mentioned. Technical features that the users wish to add to the platform are (i) the accessibility of SmartSantander through jFed, (ii) the support of LTE experimentation and (iii) the availability of SDKs to integrate to applications. The instability of specific nodes (LTE, SSD) during experimentations were experienced by some users. Others mentioned that they had difficulties in deploying their experimentations.

Communication

Most respondents found out about Fed4FIRE+ thanks to the fact that they used it on other projects or thanks to the referral from a colleague or friend. Also, many found out about it thanks to the project website. Users seem to be well informed about the free availability of the platform. Nearly 83% of all respondents are aware that the use of the Fed4FIRE+ resources are free of charge. The marketing material seems to be clear, though there is a need, as already mentioned above, for more documentation on how to use the platform, deploy solutions and available features. An interesting recommendation was to enhance the advertisement of the outputs of open call experiments as use cases. This would be a simple, clear and evocative manner of sharing experimenter's experience and communicate Fed4FIRE+ features to future potential users. Users are quite satisfied with demos/tutorials; all respondents used them. Some respondents mentioned that they would have wanted more advanced tutorials and others mentioned that the information provided by the testbed owners was very relevant.

With regards to the website, users recommended to include real-time information about resource-allocation and availability, the number of open-callers and the number of open-access users. Users would like to see more details about the testbeds, for example adding videos about the setup of an experimentation. Similarly, more details on Open Call achievements could be shared according to the survey results.

Fed4FIRE+ value

The platform users have been able to test their solutions or services in an efficient and reproducible way, testing in real-world conditions (instead of simulations), on a large-scale and over heterogenous resources. They have carried out feasibility, scalability, performance, security and robustness tests. Many users mentioned that they would like to continue testing their solutions, for example to test on a larger scale. Some mentioned the possibility of applying

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for other open calls. Thanks to Fed4FIRE+ the users have been able to obtain more information, among others, on the scalability, limitations and performance of their developments, with the final aim to improve them, potentially add more features and demonstrate the applicability of their prototype. It was mentioned that they might share their experience in order to contribute to state of art in research in their area and to investigate about commercial opportunities on the market. Some respondents, plan to continue testing (some on a bigger scale) in order to improve their solution, to detect failure points and to get to know their limitations.

For most users the acquisition of knowledge on their solution has been very valuable. They have been able to improve them and to gain more trust, which is essential to develop their businesses. An increased technology readiness level (TRL) and even the ability to leave the proof of concept phase were mentioned. A shorter testing phase, an accelerated product development and faster time-to market have also been achieved. Some users were able to provide demos and showcases for potential customers, to increase technical knowhow, to approach new customers and hence to increase business opportunities.

Relevance of funding

In general, the funding has been very useful for the beneficiaries. As seen above, one of the main motivations for using Fed4FIRE+ was the funding for experiments. One Open Call participant mentioned that they were even able to employ additional staff members for product development thanks to the funding. Though 10 out of 11 respondents to this specific question mentioned that they would have been able to use the testing facilities even without funding. The testbed provider that answered the question mentioned that the provision of testbeds that are not deployed by a standardization body, a community initiative or an open source project and where reliability, replicability and standards compliance are guaranteed without funding is very complicated. Therefore, funding for testing facility providers is essential.

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4. RECOMMENDATIONS

From the survey we have learn that the users of the platform are relatively satisfied with their experience on the Fed4FIRE+ platform. Nevertheless, there are some recommendations that we should take into account to improve the provided services, among others.

First of all, the documentation should be made clearer and more easily accessible. It should include (more) details about available features, explanations on how to perform deployments of experimentations and on how to interact with the platform. It has been recommended to also include information on the limitations of the Fed4FIRE+ platform and advantages compared to others. All this could be shared in demos and tutorials and on the website. It should be easily accessible and inform about open call achievements, use cases, resource allocation and availability and number of users, among others. Even though, the support provided by testbed owners has been very useful and important for many users of the platform, documentation is still necessary. Support should likewise be fostered and encouraged.

Recommendations on technical improvements were mainly linked to the facilitation of deployment of experimentations and enhancing the nodes to reduce the probability of some of them to fail. With regards to the recommendation on resource availability it might be useful to conduct a more detailed and technical survey on which specific needs users of the plaform have, as they are very specific to each end-user of the Fed4FIRE+ services.

Enhancements on communication are also necessary. Most users heard about Fed4FIRE+ thanks to their or some friend's or colleague's involvement into the project or open calls and who informed them. The website communication can as well be optimized. Only very few respondents found out about the platform as a result of its mention in research papers, at scientific events or through social media. These can be very important communication channels and should not be neglected. Overall, more dissemination to different channels is needed, as many people from the IoT community are not aware of it. Providing more use cases to better showcase the value proposition and advertise the usage of the platform seems to be a viable solution, among others.

Most respondents will use the platform for a maximum of 12 months. The Fed4FIRE+ team might want to support the users to continue using the platform for a longer period of time. Therefore, it would be relevant to find out what the reason for the short testing periods are and how to encourage the users to test on a regular basis until the testing results of their developments stabilize.

Finally, it is important to continue providing funding to testbed providers as well as open call participants for the plaform to be extended and used. Some would not be able to do so without funding.

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5. CONCLUSIONS AND NEXT STEPS

The Fed4FIRE+ services have been very relevant and useful for many end-users on different domains. Each of them might utilize the diverse platforms in a specific manner. Overall, we can say that the platform and the provided services have been much appreciated by the end-users and helped them get valuable information on their developments, essential to improve them and get closer to potential business opportunities. Most respondents of the surveys are SMEs and academia, which might not have the necessary resources to create their own testbeds. Federating these different testbeds can be very useful to test innovations on a large environment with many different available resources. It is complicated for any organisation to create such an environment on their own, and even more for the ones with less resources.

The different surveys filled by the Fed4FIRE+ stakeholders helped us to better understand the intentions of the end-users and to obtain some interesting propositions of improvements. The project core partners should take into account all the remarks and comments described in this document. The recommendations should be prioritized and then implemented across the different Work Packages to meet the end-users' expectations. There could maybe be another survey put inplace more specific for testbed provider and patrons of experiments to obtain more information from their points of view.

In view of the limited responses one receives on the survey when the experimenter or user is contacted after completion of the experiment, Fed4FIRE+ will adapt the application for obtaining an access account to include an explicit agreement statement that the user will be required to complete the survey after completion of the experiment. In this way, the project hopes to significantly increase the number of responses and to improve the collection of feedback from the end-users.

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ANNEXES

1. Survey 1:

   First version: Fed4FIRE+ User Validation Survey

End-User Validation Survey

This survey aims to collect feedback from Fed4FIRE+ users in order to improve the service.
It will only take about 2 minutes. Thank you in advance!

1) What kind of organization do you work for? (Please select one option)
   - ○ SME
   - ○ Industry (large organization)
   - ○ Academia
   - ○ SDO (standards development organization)
   - ○ Non-profit organization
   - ○ Research organization
   - ○ Other:

2) How did you find out about the Fed4FIRE+? (Please select one option)
   - ○ Social media
   - ○ Referral from a colleague/friend
   - ○ Scientific event
   - ○ Website
   - ○ Mention in a research paper
   - ○ Involvement in other research projects / with partners that collaborate with Fed4FIRE+
   - ○ Other:

3) In which context did you use the Fed4FIRE+ platform? (Please select one option)
   - ○ As a patron of an experimentation on Fed4FIRE+
   - ○ As a participant to an experimentation through Open Calls on Fed4FIRE+
   - ○ As a participant to an experimentation through Open Access on Fed4FIRE+
   - ○ As a provider of an experimentation facility
   - ○ Other:

4) Were your main objectives reached by using the Fed4FIRE+ service? (Please select one option)
   - ○ Yes
   - ○ No
   - ○ Partially

5) How would you rate your satisfaction with the service? (1= not satisfied at all, 5= very satisfied)

	1	2	3	4	5
Fed4FIRE+ website	○	○	○	○	○
Ease of access to the service (end-user friendliness)	○	○	○	○	○
Support from Fed4FIRE+	○	○	○	○	○
Expectations regarding service met	○	○	○	○	○
Contributions to your project	○	○	○	○	○
Technical capabilities	○	○	○	○	○
Flexibility of system/ possibility to adapt to your needs	○	○	○	○	○

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End-User Validation Survey (part 2)

This survey aims to collect feedback from Fed4FIRE+ users in order to improve the service.
It will only take about 5 minutes. Thank you in advance!

Organization & Usage

1) Please indicate the name(s) of your testbed(s) / your experiment(s) and describe it (them).

For example, who are the expected end-users? What problems does it attempt to solve?

2) What is the application domain of your project/experiment? (Please select one or several options)

- Smart City
- Smart Home
- Smart Healthcare
- Smart Agriculture
- Smart Cars
- Smart Supply Chains
- 5G
- Networks
- Automotive
- Teaching
- Other:

3) Which testbed(s)/tool(s) did you use? (Please select one or several options)

- Bristol openflow
- Bristol VTAM
- ESAT MM Testbed
- ExoGENI NICTA
- FUSECO
- i2CAT openflow (SDNRM)
- i2CAT VTAM (CRM)
- Iris TCD
- LOG-a-TEC
- NETMODE
- NITOS Broker
- Perform LTE
- PL-LAB
- Planetlab Europe
- SmartSantander
- Virtual Wall 1
- Virtual Wall 2

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- Virtual Wall 2 (openflow)
- w-iLab.t 1
- w-iLab.t 2
- Other:

4) Which type of resources of the testbed(s)/tool(s) did you use?

For example: type of node, virtual machine, sensor, etc.

Open Calls

5) Did you participate to any of the Open Calls?

- Yes
- No

5) a) Please indicate to which Open Call you have participated.

5) b) How satisfied were you with the Open Call experience? (1 = Not satisfied at all, 5 = Very satisfied)

	1	2	3	4	5
Satisfaction with Open Call experience	○	○	○	○	○

5) c) Please provide any additional comments with regards to your Open Call experience.

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Fed4FIRE+ Experience

6) How would you rate the relevance of the Fed4FIRE+ features for you? (1= not relevant at all, 5= very important)

	1	2	3	4	5
Large variety of testbeds and resources	○	○	○	○	○
Open access to the research facilities	○	○	○	○	○
Easy use of the Fed4FIRE+ platform and tools	○	○	○	○	○
Large panel of research domains: IoT, smart cities, wired network, wireless network, SDN/NFV, 5G, cloud computing, etc.	○	○	○	○	○
Limited cost to set an experiment	○	○	○	○	○

7) In your opinion, what are the features of Fed4FIRE+ that need the most improvement?

8) Are there any challenges you have encountered?

9) Did you use the tutorials or demos on the website?

- ○ Yes
- ○ No

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FED4FIRE
FEDERATION FOR FIRE PLUS

9) a) How satisfied were you with the tutorial or demo presented on the website? (1 = Not satisfied at all, 5 = Very satisfied)

	1	2	3	4	5
Satisfaction with tutorial/demo	○	○	○	○	○

9) b) Do you have any additional comments on tutorials or demos?

10) Why did you use the Fed4FIRE+ platform? What were your main objectives?

11) Which are the factors that mainly contributed to achieving the results / that mainly contributed to failing to achieve the results?

Usage & Recommendations

12) For how long did you use the Fed4FIRE+ service?

In days, weeks, months or years.

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FED4FIRE
FEDERATION FOR FIRE PLUS

13) How likely are you to use the service again and recommend it? (1 = Not at all likely, 5 = Very likely)

	1	2	3	4	5
Willingness to use again	○	○	○	○	○
Would you recommend it to colleagues	○	○	○	○	○
Would you recommend it to others (industry)	○	○	○	○	○
Would you recommend it to others (academia)	○	○	○	○	○

14) Please provide here any additional recommendations or comments.

15) Help us spread the word about Fed4FIRE+! Who should we invite to use the platform?

Thank you for your time!

We hope you will continue enjoying the Fed4FIRE+ services.

2. Survey 2:

   New Fed4FIRE+ User Validation Survey

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1) What kind of organization do you work for?

Answer options:

- SME
- Industry (large organization)
- Academia
- SDO (standards development organization)
- Non-profit organization
- Research organization
- Other:

2) How did you find out about the Fed4FIRE+?

Answer options:

- Social Media
- Referral from colleague/ friend
- Scientific event
- Website
- Mention in a research paper
- Involvment in other research projects/ with partners that collaborate with Fed4FIRE+
- Other:

3) In which context did you use the Fed4FIRE+ platform?

Answer options:

- As a patron of an experimentation on Fed4FIRE+.
- As a participant to an experimentation through Open Calls of Fed4FIRE+.
- As a participant to an experimentation through Open Calls of another project.
- Through free access.
- As a participant to an experimentation through Open Calls and through free access.

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- As a provider of an experimentation facility.

4) Were your main objectives reached by using the Fed4FIRE+ service?

Answer options:

- Yes
- No
- Partially

5) How would you rate your satisfaction with the service? (1= not satisfied at all, 5= very satisfied)

Answer options:

	1	2	3	4	5
Fed4FIRE+ website	○	○	○	○	○
Ease of access to the service (end-user friendliness)	○	○	○	○	○
Support from Fed4FIRE+	○	○	○	○	○
Expectations regarding service met	○	○	○	○	○
Contributions to your project	○	○	○	○	○
Technical capabilities	○	○	○	○	○
Flexibility of system/ possibility to adapt to your needs	○	○	○	○	○

6) Are you aware that the Fed4FIRE+ resources are free of charge to use?

Answer options:

- Yes
- No

Would you be willing to participate to a more detailed survey? It will only take about 5 to 10 more minutes.

Answer options:

- Yes
- No

All following questions are conditional on the answer to questions 3) and the last one.

1) Please indicate the name(s) of your experiments/ the experiment(s) you where a patron of and describe it (them).

Text field for answers.

Comment: For example, who are the expected end-users? What problems does it attempt to solve?

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2) What is the application domain of your project/experiment /of the proyect/experiment you were a patron of?

Answer options:

- Smart City
- Smart Homes
- Smart Healthcare
- Smart Agriculture
- Smart Cars
- Smart Supply Chains
- 5G
- Networks
- Automotive
- Teaching
- Other:

3) Which testbed(s)/tool(s) did you/ your experimenters use?

Answer options:

- Bristol openflow
- Bristol VTAM
- ESAT VTAM
- ESAT MM Testbed
- ExoGENI NICTA
- FUSECO
- i2CAT openflow (SDNRM)
- i2CAT VTAM (CRM)
- Iris TCD
- LOG-a-TEC
- NETMODE
- NITOS Broker
- Perform LTE
- PL-LAB
- Planetlab Europe
- SmartSantander
- Virtual Wall 1
- Virtual Wall 2

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- Virtual Wall 2 (openflow)
- w-iLab.t 1
- w-iLab.t 2
- Other:

4) Which type of resources of the testbed(s)/tool(s) did you/ your experimenters use?

Text field for answers.

Comment: For example: type of node, virtual machine, sensor, etc.

5) How satisfied are you with your Open Call/ experiment experience?/ How satisfied are your experimenters with their experience on Fed4FIRE+? (1 = Not satisfied at all, 5 = very satisfied)

Answer options:

	1	2	3	4	5
Satisfaction with Open Call experience	○	○	○	○	○

6) Do you think your experimenters would like/ would you like any different types of open call? / Would you like any different types of open call?

Text field for answers.

7) How would you rate the relevance of the Fed4FIRE+ features for you/ your experimenters? (1= not relevant at all , 5= very important)

Answer options:

	1	2	3	4	5
Large variety of testbeds and resources	○	○	○	○	○
Open access to the research facilities	○	○	○	○	○
Easy use of the Fed4FIRE+ platform and tools	○	○	○	○	○
Large panel of research domains: IoT, smart cities, wired network, wireless network, SDN/NFV, 5G, cloud computing, etc.	○	○	○	○	○
Low cost to set an experiment	○	○	○	○	○

8) In your opinion, what are the features of Fed4FIRE+ that need the most improvement?

Text field for answers.

9) Are there any challenges you/ your experimenters have encountered?

Text field for answers.

Only for open call participants:

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10) Is the marketing material of Fed4FIRE+ clear enough? If not, please suggest improvements

Text field for answers.

11) Did you use the tutorials or demos on the website?

Answer options:

- Yes
- No

11 a) How satisfied were you with the tutorial or demo presented on the website? (1 = Not satisfied at all, 5 = Very satisfied)

	1	2	3	4	5
Satisfaction with tutorial/demo	○	○	○	○	○

11 b) Do you have any additional comments on tutorials or demos?

Text field for answers.

For all respondents:

12) Why do/did you/ your experimenters use Fed4FIRE+? Please rank the following possible reasons

Answer options:

Your choices	Your ranking
Funding for experiments	
Support from testbed	
Ease of setup and use	
Test their product over multiple (federated) testbeds	
Facility to test their product on a larger scale	
Facility to test their product on a quasi-realistic environment	

13) What were your / your experimenters' main objectives?

Text field for answers.

Only for open call participants:

14) Which are the factors that mainly contributed to achieving the results / that mainly contributed to failling to achieve the results?

Text field for answers.

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15) What are the next steps based on the results of the experiment?

Text field for answers.

16) How has the experiment advanced your business?

Text field for answers.

For all respondents:

17) What new types of testing facilities should Fed4FIRE+ offer in addition to the current ones? (e.g. different types of testbeds)

Text field for answers.

18) Please provide any additional comments with regards to your/ your and your experimenters' experience on the platform.

Text field for answers.

Only for open call participants:

19) For how long did you use the Fed4FIRE+ service?

Text field for answers.

Comment: In days, weeks, months or years.

20) Would you use the testing facilities even if you were not funded to run the experiment?

Answer options:

- Yes
- No

21) How likely are you to use the service again and recommend it? (1 = Not at all likely, 5 = Very likely)

Answer options:

	1	2	3	4	5
Would you use it again?	○	○	○	○	○
Would you recommend it to colleagues?	○	○	○	○	○
Would you recommend it to others (industry)?	○	○	○	○	○
Would you recommend it to others (academia)?	○	○	○	○	○

22) Please provide here any additional recommendations or comments.

Text field for answers.

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For all respondents:

23) Can you suggest any places where Fed4FIRE+ could advertise its services (e.g. open calls and resources)? If so, please provide details.

Text field for answers.

24) Help us spread the word about Fed4FIRE+! Who should we invite to use the platform?

Text field for answers.

Comment: This can include email addresses, websites, etc.

25) How can we improve the Fed4FIRE+ website?

Text field for answers.

Questions only for testbed providers:

1) Please indicate the name(s) of your testbed(s) and describe it (them).

Text field for answers.

Comment: For example, who are the expected end-users? What problems does it attempt to solve?

2) What proportion of your testbed's utilisation comes through Fed4FIRE+? (i.e. percentage of your whole resource capacity)

Answer options:

- less than 10%
- 10%-20%
- 20%-30%
- 30%-40%
- 40%-50%
- 50%-60%
- 60%-70%
- 70%-80%
- 80%-90%
- more than 90%
- Other:

3) Would you like more users or experiments via Fed4FIRE+? If so, which percentage increase would you like?

Text field for answers.

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4) Would your testbed be able to continue without the funding of Fed4FIRE+?
   - Yes
   - No

5) What other support would you like to see from Fed4FIRE+ in addition to that it already provides?

Text field for answers.

6) Please provide here any additional recommendations or comments.

Text field for answers.

7) Can you suggest any places where Fed4FIRE+ could advertise its services (e.g. open calls and resources)? If so, please provide details.

Text field for answers.

8) Help us spread the word about Fed4FIRE+! Who should we invite to use the platform?

Text field for answers.

Comment: This can include email addresses, websites, etc.

9) How can we improve the Fed4FIRE+ website?

Text field for answers.

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