Amplifying Future Internet Research and Experimentation for a Sustainable Future

AMPLIFIRE

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Executive Summary

This deliverable develops a roadmap for Future Internet Research and Experimentation (FIRE) within the Horizon 2020 program. The objective of the roadmap is to identify how FIRE can move forward via a series of key developments and milestones to achieve the advancements in testbed facilities and services that will create state of the art ecosystem for future experimental research. The activities of the road-mapping process are embedded within the overall FIRE Radar process. The report focus is in particular on the presentation of the roadmap and the community dialogue activities that led to it. The roadmap itself is built upon established methods for producing technology roadmaps that aid towards achieving targeted objectives, and covers milestones in the timeframe of 2014 – 2020. As FIRE is complex and there are high levels of uncertainty in the domain, the roadmap considers multiple paths.

Table of Contents

1. Introduction

1.1 Scope

FIRE (Future Internet Research and Experimentation) is built around a set of experimental facilities supporting research and development of novel Future Internet technologies. A key activity within AmpliFIRE is to develop what is titled the **FIRE Radar**. This is a simple and systematic process of observing, analysing and understanding developments within and around the FIRE programme. Importantly, this process emphasizes the use of community dialogue and engagement of FIRE's stakeholders, in order to provide a basis for addressing divergent views, creating shared understanding, and enabling planning and decision making. The FIRE Radar process as implemnented by AmpliFIRE is structured in three stages:

1. **Mission and vision**. Mission relates to the understanding of FIRE's particular value add, i.e. "Why FIRE?" Vision is about the longer term perspective and achievements, "Where should FIRE go?" These elements are addressed in Deliverable D1.1 [6].
2. **Objectives and strategy**. Objectives identify the results to be achieved, i.e. the "what should FIRE be?" Strategy concerns the approach to achieve the identified objectives, the "How". These elements are reported in Deliverable D1.2 [1] [2].
3. **Roadmap and action plan**. The Roadmap is about the sequence of steps to be taken to implement the strategy and realize the objectives. This document reports on the results achieved in developing the FIRE Roadmap thus far.

Subsequently, this deliverable develops a roadmap for Future Internet Research and Experimentation (FIRE) within the Horizon 2020 program. As such the work reported is part of Task T1.3 "Shepherding the FIRE Innovation Ecosystem Towards 2020". This task addresses the evolution and direction that FIRE must take beyond 2015 as Horizon 2020 possibiloities unfold, and aims at constructing a realistic and tested plan to support experimental research for the period of 2015 towards 2020. The current report provides the first version of the FIRE Roadmap. A final version is scheduled for early 2015.

The objective of the FIRE roadmap is to identify how FIRE can move forward via a series of key developments and milestones to achieve the advancements in testbed facilities and services that will create state of the art ecosystem for future experimental research. It is clear that the activities of the road-mapping process are embedded within the overall FIRE Radar process (and the shared activities that coincide); however, we do not reproduce all such information here and focus in particular on the presentation of the roadmap (and the key community dialogue activities that led to it).

The FIRE roadmap covers milestones in the **timeframe of 2014 – 2020.** As FIRE is complex and there are high levels of uncertainty in the domain, the roadmap considers multiple paths**.**

1.2 The FIRE Radar methodology

The three stages of the FIRE Radar process can be understood as a cyclic "learning" process or "co-creation" dialogue within a community setting, where information is gathered, developments are understood, ideas are raised and discussed regarding future options and actions, and proposals made leading to an agreed plan. From this learning or co-creation perspective we can identify four processes within the learning cycle:

- **Intelligence gathering and reflection**. Gathering weak or strong signals about trends, but also interests and opinions, and reflecting about the certainties and uncertainties, and

trying to make sense out of it. Information comes from different sources and reflection can take part in community settings through workshops or through social media. Mainly AmpliFIRE's task T1.1 "FIRE Vision and Scenarios 2020" has been the place for this activity, reported in D1.1 [3].

- **Ideas development and prototyping**. This is a more constructive activity based on brainstorms, in workshops or through social media discussions. This is about thinking about proposals for future development of the FIRE program and specific project types. The concept of "prototype" is applicable to such a process as it brings about the notion of co-creation of ideas and views.
- **Testing and validation of ideas**. This activity comprises community discussions about the proposed ideas, understanding the trade-offs, leading to rejection or further development, and addressing the divergent opinions and trade-offs. For example a technical workshop on FIRE's evolution, and a technical workshop on the 2016-2017 EC Work Programme inputs[1].
- **Consensus, deciding, planning and doing.** This step results in agreements and decisions. For example deciding about the FIRE vision, or setting up an agreed action plan for FIRE's development for the future, agreed within the community, and supporting the EC unit E4 with developing and structuring ideas about the upcoming Workplan 2016-2017.

This leads to the overall "FIRE Radar Process Map" depicted in **Error! Reference source not found.** where the FIRE Radar process map is presented in terms of leading questions [3]. As usual in such cycles this is not a linear process but iterative and cyclic, leading to spirals of increased understanding, focus and agreement. We are using this as a framework to understand and implement the FIRE Radar process.

	Intelligence gathering and reflection	**Idea development and prototyping**	**Testing and validation of ideas**	**Consensus formation, deciding, "doing"**
Mission and Vision	- What is changing? - What are the relevant key trends and developments? - How uncertain are they? - What are key issues?	- What are the opportunities for FIRE?	- What is the FIRE vision? - What is FIRE's unique value? - For which stakeholder segments?	- Are we agreeing on the FIRE vision and mission?
Objectives and strategy	- What are the actors involved and their interests?	- What are FIRE's objectives for the future? - How to achieve the objectives?	- What is the direction for FIRE's evolution?	- Are we agreeing on FIRE's future objectives?
Roadmap and action plan	- What is the practical setting and possible constraints for implementing the FIRE roadmap?	- What are the implementation recommendations? - What are the milestones? - What are the solutions?	- What are the specific objectives? - What are the milestones?	- Do we agree about the actions, milestones, solutions?

Table 1. The FIRE Radar process map

[1] (1) "Evolution of FIRE: Facilities, Services and Collaboration Strategies for Sustainability", pre-FIA workshop at FIA Athens, March 2014. (2) "FIRE Technical Workshop", at the FIRE Board Meeting, Munich, September 18, 2014.

Error! Reference source not found. then highlights the tools we are using to carry out the FIRE Radar procedure [3]; these tools are a combination of research tools (e.g. document search and database building), planning tools (e.g. scenario planning), and community engagement tools (e.g. expert workshop and interviews).

	Intelligence gathering and reflection	Idea development and prototyping	Testing and validation of ideas	Consensus formation, deciding, "doing"
Mission and vision	- Document search - Database building - Expert elicitation - Expert workshops	- Scenario idea generation - Scenario elaboration - Sensitivity analysis	- Scenario validation workshops - Expert interviews	- Scenario validation community dialogue
Objectives and strategy	- Landscape mapping - Expert elicitation	- Expert group discussion	- Expert group discussion	- Community dialogue (FIRE Board, Forum)
Roadmap and action plan	- Document search	- Roadmap development workshop - Expert inputs gathering	- Roadmap validation workshop - Electronic polls - Expert inputs gathering	- Roadmap validation workshop

Table 2. Tools used to carry out the FIRE Radar

The FIRE Roadmap itself is built upon established methods for producing technology roadmaps that aid towards achieving targeted objectives:

> *"A technology roadmap identifies alternate technology "roads" for meeting certain performance objectives. A single path may be selected and a plan developed. If there is high uncertainty or risk, then multiple paths may be selected and pursued concurrently. The roadmap identifies precise objectives and helps focus resources on the critical technologies that are needed to meet those objectives."* [4]

The goal of this D1.3 document is not to detail the overall FIRE Radar process. It is to present the current methodology employed and activitie implemented to develop the Roadmap (until August 2014), and to provide a preliminary version of this Roadmap that can be used as an input for further community dialogue. In the subsequent section we specifically introduce the FIRE Roadmap methodology.

1.3 The FIRE Roadmap methodology

Importantly, this document focuses solely on the FIRE roadmap and action plan within the overall FIRE Radar process. In this section we introduce the specific methodology for the creation of the roadmap. The final roadmap will be delivered in March 2015 and therefore the content and methodology will be refined over time (to react to both community feedback and changes in the FIRE research landscape, e.g. proposals funded in H2020 ICT11).

The roadmap for the future of the FIRE ecosystem can be considered akin to technology roadmap planning (FIRE proposes new experimentation technologies to meet changing experimenter demands) where investment decisions directly inform new technology:

> *"Technology road-mapping is a needs-driven technology planning process to help identify, select, and develop technology alternatives to satisfy a set of product needs. It brings together a team of experts to develop a framework for organizing and presenting the critical technology-planning information to make the appropriate technology investment decisions and to leverage those investments."* [4]

Given its scope within the FIRE Radar, The FIRE Roadmap activity (and this deliverable in particular) will follow common processes for developing a technology and innovation roadmap [4] [5]: i) *"Identify the product that will be the focus of the roadmap"* [4], and identify the novelties that deviate from the current regime [5]; ii) *"Recommend the alternatives that should be pursued"*; and iii) *Write and validate the roadmap*. These relate closely to the Radar activities [3] in **Error! Reference source not found.** and **Error! Reference source not found.**. It is also important to consider that the FIRE Roadmap addresses the further evolution of the FIRE Ecosystem within the Future Internet landscape, and not only technology and research planning from business perspective. Societal, policy and ecosystem concerns will be important to address.

We now explain fully the current method for the Roadmap (as illustrated in Figure 1); the first three processes are carried out iteratively as the roadmap is refined over time (e.g. collecting new inputs as research and experiment trends emerge).

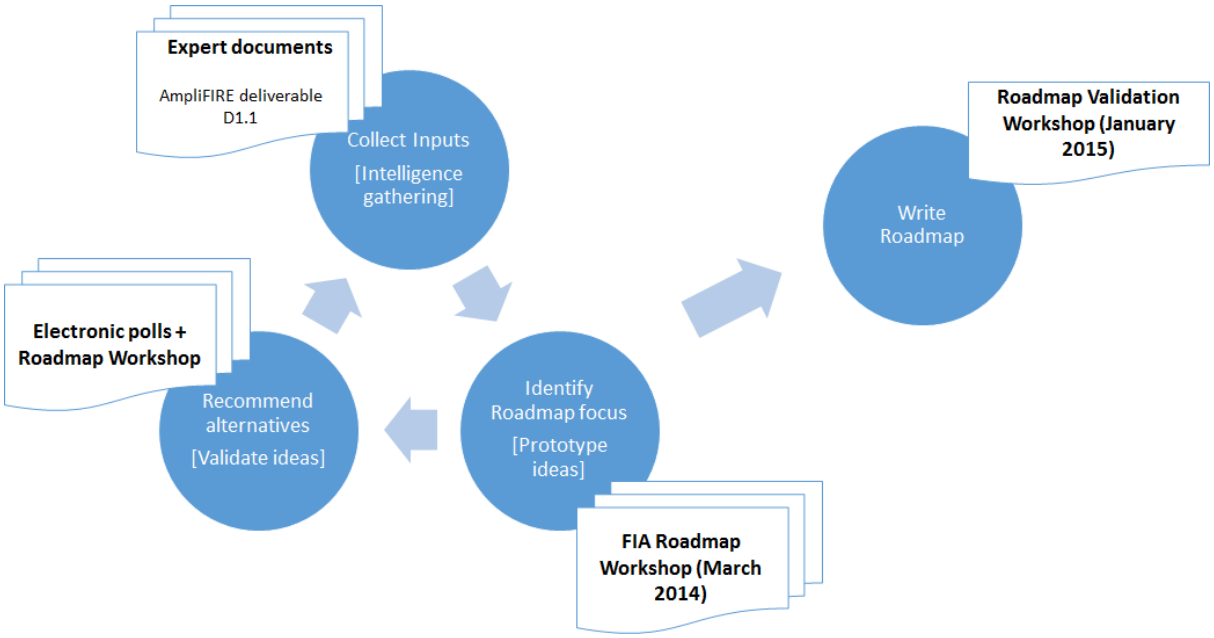

Figure 1 The FIRE Roadmap Methodology

1. **Collecting initial inputs (Intelligence gathering and reflection):** here we collect inputs from the FIRE Radar to identify the overriding strategy and objectives. The activities and inputs from the FIRE Radar provide significant input to this task—the scenario planning exercise [6]; the FIRE landing places and strategy recommendations [1]; the change in experimental demands [7]; the changes in service offering [9].
2. **Identifying the focus of the focus of the roadmap (Idea development and prototyping):** interact with the community to shape the objectives and identify what novelties will move FIRE forward, what solutions can be implemented, and what are the realistic milestones. What are the key *novel* elements of the FIRE ecosystem to plan for? How will these impact on the wider FIRE ecosystem plan? In this context we considered:
    - New types of services, e.g., Testbed-as-a-Service (TaaS), Knowledge as a Service (KaaS).
    - New experimentation tools, e.g., provenance tools, experiment reporting tools, resource management tools.
    - New experimental resources, i.e., new types of testbeds.

- New users (experimenters, industrial users, international collaborations).

For this purpose, an initial FIRE roadmap workshop was carried out in March 2014 at FIA Athens (the report of the workshop is included in Appendix A). Part of the discussion collected input regarding the focus of the Roadmap, and also ideas concerning realising a future FIRE vision.

3. **Recommending alternatives (Testing and validation of ideas):** in order to realise change, the roadmap requires acceptance from the community of stakeholders. Therefore an initial testing of the prior ideas is required; this activity is centred on electronic polls that pose various options for the Roadmap structure and also the Roadmap solutions. Each poll is a small set of questions on a particular topic (e.g. SME involvement, Technology trends, etc.) and the answers form strength of opinion about particular alternatives to follow. Presently, two polls have been carried out (the results are provided in Appendix B), and four more are planned. We will utilise a Roadmap Validation workshop (e.g. a session at the FIRE Forum scheduled on the 15th October 2014) to present this document to the community, including results from the polls, and receive feedback. Such interaction is largely in the form of expert input gathering.
4. **Writing the Roadmap (Consensus formation, deciding, "doing"):** A final roadmap workshop will be held in early 2015 where agreement of the roadmap and solutions will be discussed with the purpose of achieving consensus with the wider FIRE community. This will lead to the final presentation of this document in March 2015.

2. The Over-all FIRE Roadmap

The preliminary FIRE Roadmap structure is presented in Figure 2. This provides a high-level overview of the roadmap. The roadmap is split into three phases: i) 2014-16, ii) 2016-2018, iii) 2018-2020 that identify the milestones and decision points of the roadmap. These phases are then broken down into a common template:

- The ***objective*** layer highlights what FIRE aims to achieve before the end of the phase through a set of *solutions*. Each objective is taken from the overall FIRE strategy part of the Radar (these are described in section 4 of Deliverable D1.2 [2]).
- The ***technology trends*** layer observe important research and experiment directions that will directly influence FIRE moving forward. FIRE as a programme must remain useful to the research and technology communities; these are generally collected from Deliverable D1.1 [3] and recent material regarding state of the art research in Future Internet technologies.
- The ***Future Internet landscape*** layer observes broader trends that FIRE could and in many cases must align with to achieve objectives e.g. providing experimental support to Smart Cities and 5G researchers. These are identifiable by large research programmes both in Europe and globally.
- The ***solution layers*** outlines specific actions FIRE can take to meet the objectives. FIRE is a complex system of experimental facilities; therefore in order to consider solutions we can break it down into sub-layers where novelties can emerge and solutions can be realised to meet the higher objectives. We have identified three core layers (these were discussed with the FIRE community at the FIRE Roadmap workshop, Pre FIA, Athens 2014—see Appendix B):
    - The *FIRE resources layer* considers the role of the testbeds made available through FIRE i.e. whose development is funded in part by the FIRE programme. These represent an important element in achieving objectives through making the right experimental facilities available, sustaining these facilities, and ensuring their provision meets user demands. The work carried out in [7] regarding gap analysis is an important consideration of the kinds of resources that must be provisioned.
    - The *FIRE service and access layer* considers the services provided to the user to allow them to perform experiments; these can be experimental services to perform and monitor experiments (set up experiment, report on results, etc.), services to utilise facilities directly (SLA management, security, resource management), and central services managing the FIRE offering (e.g. a FIRE portal). Also the mechanisms employed to allow users to access and make use of the testbed are considered e.g. fully open access, open calls, policy based access, etc.
    - The *FIRE Experimenter layer* considers the consumer, i.e. the overall FIRE user base who utililse the available FIRE testbed resources. Solutions in this layer will implement changes in the user base, e.g. changing from a traditional academic community in Europe, to a more global community, and/or more industry and SME users.

Phase	2014-2016	2016-2018	2018-2020
Objectives	Increased Relevance & Impact for European and global research	Open and continued Integration of cutting edge facilities	Boost SMEs and industrial toward Future Internet R&D Lab
Technology Trends	- Networking/Software pillars - Heterogeneity and Scale - Cross domain federation	- 5G & Converged networks - Big Data - IoT Cyber Physical Systems	
Future Internet Landscape	- FI-PPP - USA (GENI) - Japan and Brazil - Initial H2020 research projects (E1, E2)	- 5G-PPP - USA, Korea - H2020 research projects (E1, E2)	- Preparing for next EC work programme (H2030)
Solutions	**FIRE Resources**		
	- Balanced FIRE pillars: networking and services - Converged federation of cross domain resources	- Call for 5G relevant testbeds - Call for IoT and big data relevant testbeds - Converged federation aligned with 5G	- Loosely coupled foundation of publically funded and privately operating resources targeted at FI R&D
	FIRE Service and Access		
	- Require Open Access - Increase ease of use, and repeatability and reproducibility of experiments	- Fund support action to support cross FIRE experiments - Prioritise Experimentation as a Service - Create a FIRE broker for first point of contact	- New Finance Model: Ensure sustainability of successful resources with public funding - Create FIRE legal entity - Advocate secure and trustworthy service delivery. Support transfer from public resource to pay per use.
	FIRE Experimenters		
	- Align technically with FI-PPP and GENI to increase users of FIRE facilities - Promote domain specific community APIs - Align EC research programmes	- Align FIRE resources with 5G-PPP requirements to bring users to FIRE facilities	- Require SME focused open calls - Professional FIRE marketing operation

Figure 2: The Initial FIRE Roadmap

It is important to identify that FIRE exists within an EC programme, and the Future Internet Landscape is largely driven by EC policy and strategy; and hence, solutions must be aware of this ecosystem. This also means that while knowledge about 2014-2018 exists; 2018-2020 is largely unknown[2].

The remainder of the document is split into three sections documenting the elements of each of the three phases (2014-2016, 2016-2018, 2018-2020). Where possible we highlight community information regarding the content (e.g. where electronic poll results highlight the importance of a particular solution), however, the fully validated roadmap is left for the final deliverable (we present a summary of the validation plan in this report's conclusions).

[2] The 2nd version of the FIRE Roadmap will explore this phase in greater detail, with detailed analysis of futures documents.

3. FIRE Roadmap Phase I (2014 to 2016)

3.1 Objectives

By 2016 FIRE will increase its relevance and impact primarily for European wide technology research, but will also increase its global relevance.

Deliverable D1.2 [2] describes two strategic directions towards ensuring FIRE becomes an R&D laboratory for Future Internet technologies. The first of these directions concentrates on increasing the relevance and impact of FIRE itself, i.e. ensuring that Future Internet researchers see FIRE as the preeminent worldwide experimentation facility. Activities along this pathway include: reducing the barrier to experimentation, ensuring open access for tackling important problems, and continuously integrating cutting edge facilities. This strategic direction is incremental to the current FIRE approach (we are already seeing FIRE implement activities to achieve these goals), hence when considering the implementation of solutions in this phase it is essential to maintain this momentum.

Deliverable D2.1 [8] also makes specific recommendations for ensuring that the current and foreseen expectations of experimenters are met (hence increasing the user base). The roadmap solutions takes the following of these recommendations into account within this first phase:

- Federation of multiple facilities: a single collection of resources that can be accessed by FIRE users.
- Open calls for innovative ideas: with a federation in place, a centrally managed open call can fund innovative experiments and technologies.
- Common European experimentation platform: interconnect FIRE testbeds, with ESFRI, ICT Labs, FI-PPP, CIP ICT-PSP, GEANT and regional networks to create a European platform. Form a collaboration with living labs.

To meet the overall aim of increasing relevance and impact, there are a set of key objectives that should be realised, many of these can be measured with Key Performance Indicators (KPIs) that are selected from the FIRE KPI working group report [8] as means to assess impact.

1) Increase the number of experiments operating across all FIRE facilities. A 10% increase was targeted by 2014; 10% yearly growth to 2016 would represent a significant increase in impact.
2) Growth in the percentage of SME and industrial users. The FIRE community did not see pressing need to significantly increase this user base (see Appendix B, Poll 1, Q2) although it is clear there is a wish to grow.
3) Growth in the percentage of users from outside EC funded projects and international users.

3.2 Technology trends

With the FIRE Work Programme established (2014-2015) there remains little opportunity in the timescale for FIRE to deliver new technologies. New facility projects have already been chosen for a January 2015 start, and the 2015 call will create new facilities beginning January 2016. The only instrument available is hence the prioritisation of new projects in the 2015 call to meet emerging technology trends.

Present day research trends emphasize software and services technologies, particularly in the fields of: IoT and Big Data (cf. Gartner's Top 10 strategic technology trends for 2014[3]).

3.2.1 Trends in the FIRE Portfolio

If we examine the current FIRE technology (i.e. the testbed portfolio); we can see the extent to which FIRE is moving towards meeting these emerging trends. Figure 3 shows the technology areas, e.g. IoT, Content networking, and Data management. The central areas are resources (Fed4FIRE, Bonfire, OpenLab, etc.), the areas outside are the experiment projects; and hence EAR-IT is an experiment project atop IoT testbed resources.

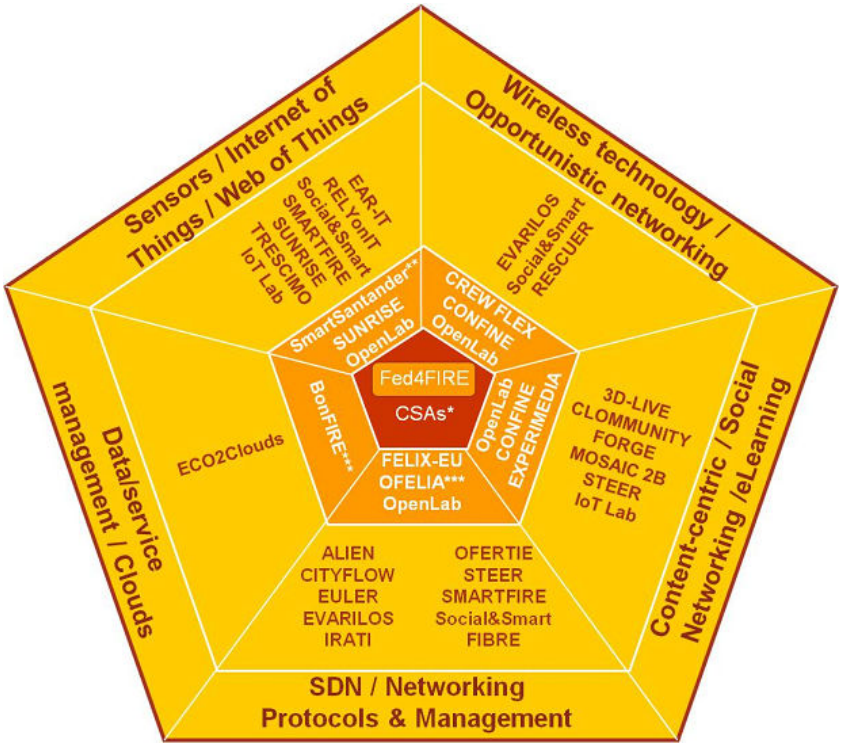

Figure 3 Current FIRE Technologies (see: FIRE Portal)

FIRE remains strong in the majority of networking areas (wireless, content-based, fixed, etc.). However, while SDN has proved a driver of experimentation (with numerous projects surrounding OpenFlow)—the picture remains unclear as to its future within FIRE, i.e. SDN as a topic for research in itself, or will SDN simply become a technology resource integrated within other experimental facilities e.g. Data Centre management, or communication flows within federated testbeds.

If we analyse trends against the current situation we can quickly identify that FIRE has limited support (if any) for experiments involving large-scale data. The only facility directly relevant is Bonfire[4] which concentrates more on computational resources than data resources (and indeed will likely only be available as part of Fed4FIRE in this phase). Further there are no experimental services to better manage large data sources (open data sets). All current

[3] http://futurethinking.ee.co.uk/how-mobility-cloud-and-big-data-will-dominate-the-business-it-agenda-in-2014/

[4] http://www.bonfire-project.eu/

research trends indicate data at scale (e.g. IoT, Smart Cities and 5G) and FIRE must consider its service provision in this regard if it wishes to grow its user base beyond traditional networking and systems infrastructure and embrace interdisciplinary research.

FIRE has included facilities with support for IoT like technologies. From SmartSantander with city based objects, to Sunrise's underwater networks, and Experimedia's immersive environments. However, these have so far been niche facilities with a specific target (i.e. community of experiments) not directed towards general purpose IoT experimentation (i.e a range of sensors and locations across application domains). Hence, there is growing need for more general purpose IoT facilities and improved integration with other FIRE facilities to support complex heterogeneous systems research—only SmartSantander is currently integrated into Fed4FIRE.

We are also seeing trends to improve the efficiency of Future Internet resources through virtualisation technologies; here there aims to be more services available, at less cost and with fewer resource consumption. Services also seek to be easier to launch, distribute and manage remotely. Such technology developments will feed directly into Green ICT initiatives globally to reduce the digital footprint.

3.2.2 Summary

The Future Internet is underpinned by two main pillars: (1) Networking and (2) Clouds/Services. FIRE is strong in networking, but has limited resource coverage in the pillar of Services. Hence, if FIRE want to continue supporting Future Internet research it must strengthen the Services pillar. At present, Figure 3 clearly indicates an imbalance with the Networking pillar resources being more diverse and comprehensive in comparison to Service pillar resources.

3.3 Future Internet landscape

Deliverable D1.2 highlights FIRE's position in the current Future Internet Landscape [1] [2](see Figure 4).
We do not provide a detailed analysis here (see the prior deliverable), but the key initiatives from this set to increase impact are: international linkages, FI-PPP (market-oriented users), and 5G-PPP. With the 5G-PPP just beginning within this roadmap phase frame and the FI-PPP coming to a conclusion; then collaboration solutions should prioritise the alignment of FI-PPP with FIRE, i.e. *"To create an overall end to end Future Internet innovation ecosystem, which goes from the early experimentation phase (FIRE), to the large scale industry and commercial oriented service phase (FI-PPP)"* [1]. Progress on this has begun:

- Development of IoT applications using FI-WARE software on the SmartSantander testbed; there was a dedicated developer event on this topic in Santander in October 2013[5].
- Exploration of the above Innovation pathway within the XIFI project [ref]; here a QoS experiment from the OFERTIE project is transferred to use FI-WARE software on the XIFI infrastructure [9].
- The deployment of FI-WARE generic enablers during the third phase of the FI-PPP will also be possible on a typical FIRE testbed (iMinds), whose resources are available to both FI-PPP (via the XIFI cloud stack) and FIRE users (e.g. via the Fed4FIRE APIs). In this context, iMinds is also investigating how to optimize the use of phyiscal resources by

[5] http://www.fi-ware.org/2013/09/19/santander-smart-city-event/

XIFI, by dynamically installing the XIFI software on a changing number of servers, based on the actual demand; For this, tools that were co-developed as part of FIRE are used.

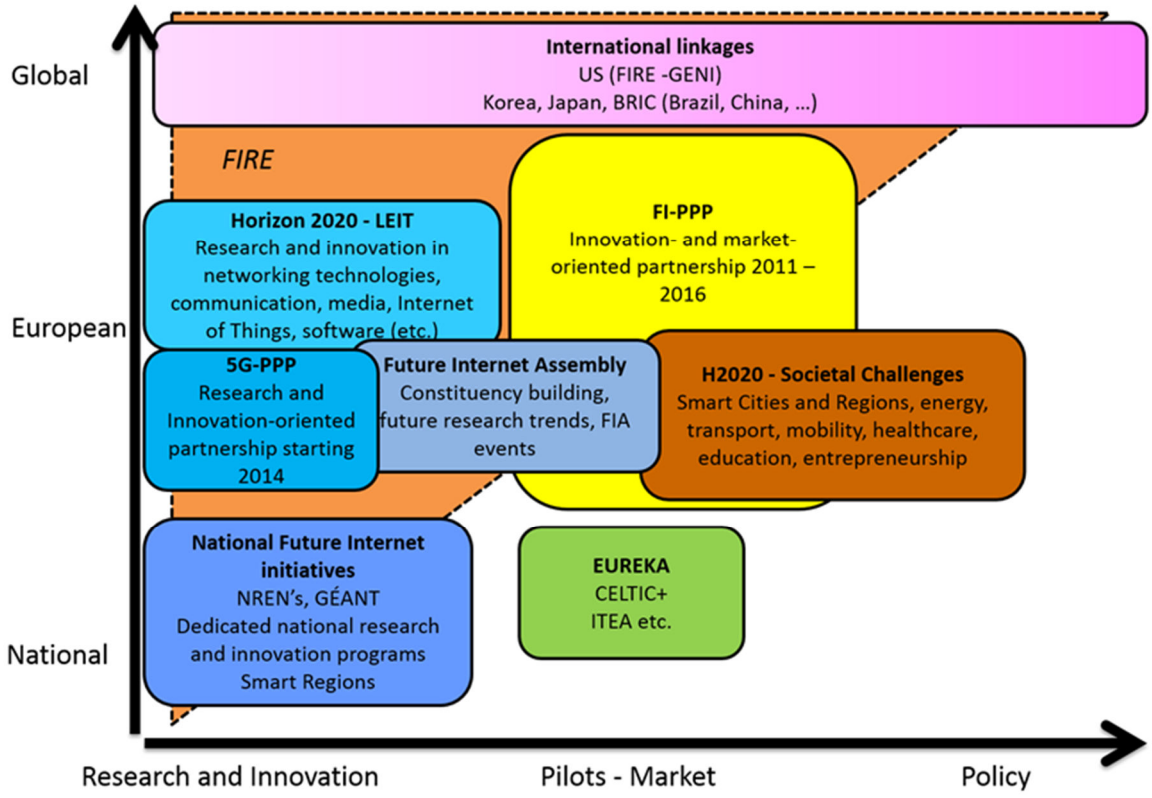

Figure 4 Positioning of FIRE in the Future Internet Landscape

Furthermore, the Horizon 2020 LEIT work programme is looking towards collaborations between Japan and Brazil in the 2014-2015 work programme (EUJ-4 and EUB-3 calls for proposals on experimental platforms). GENI is the US equivalent to FIRE (and hence is a key collaborator to increase global usage)—they are technically closely aligned. Although the long term future of GENI is uncertain it is a priority to maintain momentum between the two communities to establish common standards and access policies. This initiative is led by Fed4FIRE; and this should continue through the 2016 phase. We will also see the first research projects of H2020 who may have need to leverage FIRE-like experimental resources; and hence there is a growing need to establish strategic alignments between EC units to ensure that experimental facilities are not repeatedly implemented (where ones already exist).

3.4 FIRE Resource Solutions

Here we investigate potential solutions within this first phase that concern the FIRE resources i.e. the set of testbeds that are available for experimentation. Note, project funding remains a key instrument in shaping the FIRE resource portfolio and hence, many of the solutions are built upon this instrument. However, as previously stated, with the programme call text for this period finalised, prioritisation is the instrument available.

1) Fund facilities that will increase impact and relevance by balancing FI pillars

In order to achieve increased impact, and reduce the gap in the FIRE offering towards the pillars of Future Internet technologies (as identified in the above technology trend analysis) it is highly recommend that testbeds in the domain of software services are prioritised. This is also suggested based upon the future phases of the roadmap (see Technology trends 2016-

2018); in phase II, 5G and converged networks will see increasing prominence in research and hence such technologies will lay the building blocks for a balanced offering.

- Prioritise facilities that balance the Future Internet resource offering, i.e. software and services resources that match the current experimenter demands.

2) A Converged Federation

The benefits of federation have shown to meet future Internet researcher needs e.g. the value offering of Fed4FIRE [10]: efficiency of tools, single access points, lowering the barrier to experimentation by only needing to learn a single toolset, supporting cross domain experiments. The popularity of Fed4FIRE open calls [3] has indicated there is demand for this value. Hence, in order to continue to attract users from the wider community the federation path should be continued, but with importance placed on targeted integration.

- Integration of new and existing projects (networking, computation and data resources cf. SDN technologies) integrated into a FIRE federation. Collaboration budget within individual projects for technology development to carry out the integration. New projects to leverage existing tools, or develop adaptors.

3.5 FIRE Services and Access Solutions

The following are solutions that can be applied to achieve the objective of increasing the number of experimenters (with novelties within the services dimension).

3) Require open access

FIRE is often seen as a closed shop, with access to facilities restricted to consortium members or by winning an experiment through an open call mechanism. This means that the number of experiments is pre-determined by the project's budget. To increase the number of experimenters, and indeed attract them to FIRE in the first place – the facilities themselves must be available for use. Open access does not necessarily mean open to all and does not mean open for free; the project can limit the experiments based upon submitted proposals to use facilities. A solution to implement this objective would be:

- Require that a facility project funded within the FIRE+ programme has open access for a minimum period of time. For a new facility after 2 years; for an ongoing facility after 1 year (until the end of the project).

4) Increase ease of use, and repeatability and reproducibility of experiments

FIRE+ in the 2014/2015 programme called for projects promoting Experimentation as a Service (EaaS); no doubt this will help users lower the barrier to experimentation. However, this does not go far enough—there remains a danger that history will repeat itself within FIRE, where individual projects created tools and there was then a need for convergence (i.e. a set of EaaS tools). Instead work should be co-ordinated across FIRE to manage FIRE specific tools:

- Fund activities for developing FIRE tools with preference to services supporting reproducibility. This can either be as a funded project in the work programme or through centrally managed open calls.

- Implement a separate FIRE portal which all FIRE projects (operating in open access mode) must be usable from. Fed4FIRE is developing a portal—one solution is to choose this as the central point, and support the integration of new projects into the portal.

3.6 FIRE Experimenters Solutions

5) Increase broader Future Internet user base

Make FIRE accessible to the larger Future Internet community; within the Future Internet landscape: FI-PPP and GENI are prominent initiatives in this time period (as discussed in the landscape above). One instrument to implement this activity is to offer APIs that match community practices, i.e. OMF and SFA only go so far in that large communities will not learn these technologies. Bonfire and Experimedia are examples of FIRE resources with community APIs (with Bonfire also integrated into the Fed4FIRE federation) and highlight what is possible.

- Promote common experimentation standards across initiatives e.g. for cloud resources promote cloud APIs, for IoT resources promote IoT APIs.
- Implement interoperability solutions between FIRE and GENI resources. Fund integration activities; this is provided through Fed4FIRE's budget at the moment and funding should be considered when this is no longer available.
- Implement interoperability solutions between FIRE and FI-PPP resources; consider a small action to investigate the issue in greater depth (rather than the ad-hoc approach currently employed).

6) Alignment of EC Units

Strengthen the strategic alignment between FIRE and other EC programmes of research; the pool of research projects offer another growing user base, and may also significantly reduce repetition of capacity building. There have been identified several opportunities for collaboration between FIRE facilities and other initiatives such as Internet of Things, Smart Cities, FI-PPP and recently 5G PPP. FIRE should continue to promote such collaboration opportunities and continue discussions with other initiatives and related Units, based on clear value propositions that are attractive for all stakeholders. This could be the basis for joint research and innovation actions to be defined in next Calls.

4. Roadmap Phase II (2016 to 2018)

4.1 Objectives

By 2018 FIRE will become a sustained and open federation that allows experimentation on highly integrated Future Internet technologies; supporting networking and cloud pillars of the Net Futures community.

This objective is again on the pathway to FIRE becoming the R&D laboratory for Future Internet technologies as proposed in the D1.2 strategy deliverable [1]. To achieve this aim, there are a set of key objectives that should be realised:

1) Increase in open and sustained facilities integrated into a centrally accessible federation of resources. That is, the percentage of resources funded by FIRE: i) accessible via a FIRE federation, and ii) usable in combination with other federated resources. The aim is to achieve 100% coverage.
2) Increase in the number of users openly accessing the FIRE facilities.
3) FIRE resources sustained beyond the lifetime of their project (where they remain useful and important to experimentation).

Deliverable D2.1 [7] indicates the recommendation to better support experimenters by putting a centrally sustained federation in place:

- *"Sustainability Model should consider how to create, deliver and capture financial, economic, social, and technological value. Results oriented or pay-per-use models should be considered with clear distinction between facilities (to be) offered and experimenters usage, with the major contribution going to the experiments and innovative ideas towards market including the incubation. An independent stakeholder alliance with public private funding mechanism to manage the European common platform should be considered."*
- *Common European platform for experimentation—highly integrated with ICT research projects, FI-PPP and 5G PPP.*

4.2 Technology Trends

FIRE's future is directly influenced by research and experimentation trends; and hence the roadmap must take into account the technology trends when proposing solutions (particularly those regarding the types of resources FIRE will make available and the experimentation services required). We explore the original radar document and highlight research that will be relevant in 2016-2018. Within this phase, it is clear that there will be a growing need for research in the following three areas (See D1.1 [3], and 1st FIRE Board technology workshop):

1) 5G technologies. This is the next phase of mobile telecommunication technologies to deal with the rapid increase in number of mobile users and the exponential increase in data communications. There are many areas for research in this domain, particularly concentrating on the efficient use of resources e.g. spectrum sharing. New radio architectures, new hardware, new air interfaces are at the core of the research—and offer interesting future resources for FIRE testbeds to consider. There will also be increased research into a coverged architecture where networks coverge to deliver better and secure end-to-end services: virtualisation, QoS, QoE, SLA management are all important topics for experimentation

within holistic 5G architectures. Research is also seeing the convergence of domains for 5G, e.g. the integrated placement of cloud resources in the 5G architecture (e.g. at a base station) to optimise delivery and efficiency. FIRE is particularly strong in networking with state of the art wireless and LTE technologies, and hence must continue to consider testbeds that complement the existing base and create the relevant resources for the 5G community

2) Heterogeneous complex systems. The Internet of Things is another technology trend growing in increasing promise (and promising significant research over the next 5 years); this is a global network of interconnected "*things*" or *objects*. The key feature of this environment is heterogeneity. Objects can be one of a number of different hardware devices, including: RFID tags, actuators, wireless sensors, mobile devices, vehicles, UAVs, workstations, etc. With this heterogeneity, devices will utilise different Operating Systems, different networking technologies (Bluetooth, Zigbee, 802.11b, GSM, 3G, 4G, IR, etc.), different software platforms, and communicate data using different protocols and data formats. Therefore, many of the research challenges in IoT are centred upon the taming of such heterogeneity: in terms of interoperability, security, privacy, management of scale, etc. Cyber Physical Systems are another area rich in research potential—again this will be characterised by heterogeneity with the added complexity of human users embedded in the interactions (requiring multi-modal interfaces, and new media technologies).

3) Large-scale data research. The fastest growing application area for next generation computing is *Big Data*, whereby vast quantities of data is processed, mined and analysed. For example, Twitter produces 12 Tbytes of data every day that can be searched and analysed for social, marketing and political trends. Billions of energy meter readings can be analysed to predict and conserve consumption. The Sloan Digital Sky Survey of astronomy data produces 200Gb of data every day. More and more open datasets are being made available on the web to support novel application usage[6][7][8]: e.g. census data. Hence, there is a growing suite of facilities to build and demonstrate the potential of Big Data.

Big Data will bring together experimental research in data mining, predictive analysis tools, machine learning, natural language processing, and many other computational data based research with the capabilities of distributed and cloud computing. Therefore significant innovation is required to make these facilities available such that they can be leveraged by the end users and scientists performing big data applications:

- *Integration of real time data streams* with cloud processing facilities and cloud software computation and storage stacks.
- Making data, modellers, analytic, visualisations, results, and indeed any big data services available to support *future and repeated scientific experimentation*. For example, EVOPilot[9] is a UK pilot project funded by the Natural Environment Research Council to create a universal observatory of scientific data and cloud based tools for performing environmental monitoring.

Summary

If FIRE is to increase its relevance within Future Internet research it should consider the need for larger scale facilities that cannot easily/cheaply be put together on a per experimenter

[6] http://data.gov.uk/data
[7] https://explore.data.gov/
[8] http://aws.amazon.com/publicdatasets/
[9] http://www.evo-uk.org/

basis. The growing needs of user focused research, technology convergence and interdisciplinary research can potentially meet a much wider user base than nice systems and networking experimenters. While clearly FIRE should continue to be seen as a flagship for networking research, the following are recommendations based upon technology trends

- FIRE to fund testbeds directly relevant to 5G experimentation; and/or fund the continuation of networking testbeds
- FIRE to continue towards a converged federation supported by common central tools, particularly with the goal of supporting 5G and IoT research.
- FIRE to consider more comprehensive IoT facilities that allow realistic experimentation with real-world impact.
- FIRE to address support for Big Data requirements through additional or improved FIRE testbeds that can add to the heterogeneity and scale of experiments.

4.3 Future Internet Landscape

In the 2016-2018 timeframe the key initiative for FIRE to collaborate with is the 5G-PPP, and solutions within this phase should consider such collaboration opportunities. In the early stages, FIRE has significant value in that is has already available 5G relevant testbeds—reducing the need to fund new experimental facilities (where they are already available in Europe). FIRE may also be better aligned to the 5G-PPP in comparison to the FI-PPP. The FI-PPP is an operationally oriented ecosystem—with applications/sectors tightly couple to the vertically integrated solutions e.g. the FITMAN project using FI-WARE software deployed on FI-Lab nodes. The 5G-PPP promises to be more research oriented with scope for FIRE resources to be directly leveraged, and for FIRE projects to build upon 5G-PPP results. This follows the more traditional open innovation path of networking technology research.

4.4 FIRE Resources Solutions

1) Fund cutting edge technology facilities

If FIRE is to become a Future Internet R&D lab in 2020 (globally—not just within Europe) then it must continue to add new resources that match current experimenter demands, and correspondingly let existing resources that no longer fill a need in the Lab fall away. Fall away does not necessarily mean disappear; it may be that the technology can move forward from an experimental testbed to a service delivery platform or a supportive technology further along the innovation pathway (c.f. FI-PPP). Based on the state of the art analysis and trend identification there is a need to consider 5G testbeds, large-scale data oriented testbeds, and testbeds relevant to large-scale IoT and CPS.

Add to call for proposals in the 2016/2017 work programme- new FIRE testbeds in the following areas:

1) 5G relevant testbeds to support experimentation with new 5G air interfaces and hardware. Additionally testbeds to support experimentation with resource optimisation e.g. wireless communication optimisation and spectrum sharing.
2) A large-scale IoT federation supporting highly heterogeneous Things that are openly accessible and geographically dispersed.
3) Testbeds to support big data experimentation, particularly for new data processing technologies, and the provision of novel resources such as large open data sets.

2) A converged set of resources aligned with 5G architectures

The scenarios presented in D1.1 [3] present one scenario with the convergence of research facilities into a single federation; FIRE has progressed in this direction through the Fed4FIRE project—this has significant potential to continue to support cutting edge research e.g. end-to-end research in holistic 5G architectures. Therefore, a similar initiative should be considered during this phase.

4.5 FIRE Service and Access Solutions

3) Support action to implement cross facility experimentation

In the prior objectives it is clear that FIRE needs to better sustain relevant resources, and better support cross domain experimentation via a common European platform. Fed4FIRE is a first step in this direction; however, during this phase Fed4FIRE will no longer be a funded project, and hence particular consideration must be taken into account as to how such activities can be carried on.

If a central cross facility experimentation facility is to continue, the following solutions can be considered:

- Sustain federation activity: fund a support action to continue the operation of Fed4FIRE, i.e. the management of the federation operation (e.g. tool maintenance and portal services), the support of new experiments and experimenters (open call management), and day-to-day upkeep.
- Require integration of new facilities under the Fed4FIRE umbrella. Project budget to reflect man power required for integration.
- Central open calls for cross FIRE experiments. Increase the funding for cross FIRE experiments (i.e. those that utilise multiple testbeds).
- Proportion of a facility budget for open calls to be made available for the central collaborative experiments. The above CSA can manage the awarding of cross project funding.
- Fund relevant new testbeds. Allocate proportion of open call budget for collaboaration and integration of new facilities.

Hence we recommend a support action to continue the operation and management of a central FIRE federation, and also manage a central budget for cross domain experimentation. This should be funded after the conclusion of Fed4FIRE, i.e. in 2016

4) Implement a FIRE broker

A broker service can dramatically decrease the effort for performing experimentation and attracting new users to FIRE. A new experimenter contacts the broker service to discuss what is and isn't possible and where moving forward is possible, the broker provides advice as to how FIRE resources can be leveraged to perform the experiment. While not necessarily important for the traditional FIRE community, SMEs and users will similar knowledge about FIRE will be better supported, as identified as recommendation from [11] "*One of the key challenges for especially collaboration with industry and SMEs is that there must be a set of*

communication tools and mechanisms that can adapt the "language" and the "message" to audiences often consisting of quite diverse groups (industry vs research).".

- Implement a small action (potentially as part of a wider FIRE support action) to provide broker services across the FIRE portfolio.

Results from the 2nd FIRE poll (Appendix B) indicate that the FIRE community agree with putting this solution in place. Here, 67% agree of strongly agree to the benefits provided by such a service.

4.6 FIRE Experimenters Solutions

5) Align with 5G research community and 5G industry

In this phase, the 5G-PPP will represent a large community of technology developers and researchers from across both industry and academia. With little information available about the expected composition of the 5G-PPP little can be said beyond prioritising the investigation of the relationship once the activities are in place. Further, FIRE projects may be able to participate directly through the use of their resources in 5G-PPP projects; therefore, it is important that FIRE market its potential throughout this time period.

- Implement a FIRE task force (at the FIRE board level) to investigate and manage the alignment activities. Interested projects (from both FIRE and the 5G-PPP naturally to be included in the execution of this task force.
- Market FIRE testbeds to 5G experimenters, and indeed to the 5G-PPP as a whole to be included in 5G-PPP proposals.

5. Roadmap Phase III (2018 to 2020)

5.1 Objectives

By 2020 FIRE will become the R&D Future Internet laboratory that is attractive to both academic researchers, SME technology developers, and industrial R&D companies with emphasis on key European initiatives such as 5G, Big Data and Cyber Physical Systems domains.

D1.2 strategic directions highlight the core objectives to meet this overall aim (particularly in the second strategic direction of attracting industrial participation) [1] [2]. Furthermore, D3.1 [11]also highlighted the importance of aligning the FIRE offer to support industrial collaboration:

- Increased engagement of SME and industry stakeholders.
- Professional support services.
- Trustworthy and secure access to resources. Industrial users require that their use of facilities is secure and their data and results are private from all. Furthermore, they must be able to trust that resources will be available long-term.

D2.1 highlights important recommendations for achieving the above objectives particularly with attracting new types of users to FIRE [7]:

- Develop a marketing model to attract external users. *"Currently the user community is not aware of publicly available experimental facilities due to lack of visibility of such facilities. So it is important to develop the 'marketing model' of the facilities towards the user community (particularly to SMEs) to be intensified through appropriate channels: Liaison with regional/national business promotion organisations (e.g. chamber of commerce), Booths in the commercial events, media promotion in the commercial sector magazines, etc"* [7]

5.2 Technology trends

Predicting technology trends beyond a 5 year horizon has a low probability of succeeding, although we can predict that research in the key Future Internet areas: Data, Things, Services and People will continue at a broad level without picturing the concrete underlying technologies. Likely, research into 5G and Big Data will be converging—and the growing emergence of fully immersive technologies into the mainstream may become a reality to better support cross disciplinary research.

5.3 Future Internet Landscape

The H2020 programme will be coming to an end—in this phase it is then likely that attention will turn towards what comes next. Hence, there will likely be consideration of the role of the Future Internet activities—will they remain important to the wider research into next generation technologies. Depending upon wider R&D trends, and budget landscape it may morph into a new direction with/without increased prominence.

5.4 FIRE Service and Access Solutions

1) New Finance Model: Ensure sustainability of resources

FIRE supports sustainable facilities with continued minimum funding (small % of funding for experiments carried out). Hence, there is some guarantee of sustainability of industry important facilities beyond a project lifetime.

On a usage basis; facility projects have access to central funds—supporting a lightweight, demand driven model. For example, project X needs to have access to a testbed; they ask the testbed for a quotation; the testbed makes an offer for this and can indicate to project X that the testbed access they require can partly be funded through a "central mechanism". The central mechanism should be very lightweight in this.

This will create a new finance model that encourages projects to be successful (rather than simply support their own experiments); with increased demand they have access to further funding.

- Ensure project budgets make room for operating in sustainable mode e.g. 1 year after project finishes.
- Public funding available for sustaining successful testbeds (central mechanism) e.g. through matched national funding or industrial/private partnerships.
- All continuation proposals to be fully costed with a sustainability plan and business model.
- Define KPI thresholds for impact and relevance; offer first point of cut off for projects.

2) Create a FIRE legal entity

To realize the vision and resolve the challenges, a Network of Future Internet initiatives (NFI) should be established as a legal entity. This would enable pay-per-use services including resource use and consultancy services; industrial and private users can have contracts in place with FIRE itself. The electronic poll 2 (see Appendix B) question about creating a central legal entity indicated that 60% of respondents agreed or strongly agreed this would be useful.

- FIRE action to create and operate a legal entity; either through public funding or a partnership with an organisation willing to take on the role/costs.

There are challenges to establishing a legal entity; and some respondants to the poll questioned the necessity given that agreements can be put in place without an over-arching entity. This solution will be further explored and analysed as the roadmap progresses.

3) Secure and Trustworthy Resources

To attract industry it is necessary to create secure and trustworthy facilities e.g. a trusted cloud facility, or a commercially relevant 5G infrastructure. Therefore, to implement such capabilities it is required that relevant projects move forward and mature their services. Future projects willing to be industry facing must then follow similar methods.

- Percentage of project budget available for secure service development and collaboration with industrial partners to meet requirements.
- Projects to have industrial partner with existing requirements from testbed.

5.5 FIRE Experimenters Solutions

4) Lower the barrier to SME involvement through responsive open calls.

Experimedia successfully demonstrated the benefits such a mechanism provides given the short planning involved in the operation of an SME. This process was similarly followed by Fed4FIRE after the initial open call[10] showed that the "general" open call mechanism which is open to academia and SME/industry at the same time makes it very difficult for SMEs to compete with academia and research institutes, as academia and research institutes are (i) more used to writing proposals and (ii) typically have a different way of interpreting innovation; For SMEs, innovation may be less groundbreaking than for academic researchers.

- All projects required to tailor their open calls to SMEs in a responsive mode.
- Central open calls implemented by FIRE support action to operate SME directed calls.

5) FIRE marketing services

FIRE must ensure that the FIRE offering is widely known and that a community of practitioners and developers is developing and expanding. As a first step towards this solution; the FIRE community is developing a FIRE value proposition that can be offered to different communities e.g. FI-PPP, 5G-PPP, and others.

[10] http://www.fed4fire.eu/fileadmin/documents/newsletters/2013-11-Fed4FIRE-News.pdf

6. Key Roadmap Milestones

The roadmap solutions lead to a set of key milestones indicated in Table 3; these highlight FIRE's achievements by specific dates towards 2020.

Table 3 FIRE Roadmap Milestones

	2014 – 2016	2016 - 2018	2018-2020
FIRE Resources Solutions	Testbeds will be established in the domain of software services (2016) Gradual implementation of converged federation (2016)	Cutting-edge FIRE testbeds are established in key areas such as 5G, IoT, Big Data (2016-2017) A converged set of resources is aligned with 5G architectures (2017-2018)	
FIRE Services and Access Solutions	Open Access is implemented as a requirement (2015-2016) Projects are funded that develop services supporting reproducibility (M16) EaaS solutions will get harmonized and interoperable (2016-2017) All FIRE Open Access projects get integrated into one single portal for offering coherent package of services (2015-2016)	Mechanisms are set in place that support cross-facility experimentation through a central cross-facility experimentation facility (2016) A FIRE Broker initiative is implemented providing broker services across the FIRE portfolio (2017)	Implementation of a new financing model to ensure sustainability of resources (2019) FIRE legal entity enables pay-per-use services (2018-2019) FIRE facilities implement secure and trustworthy resources capabilities (2019)
FIRE Experimenters Solutions	Alignment of EC units leads to cross-domain access to facilities and services (2016 – 2017) FIRE is made accessible to wider communities by offering community APIs (2015 – 2016)	Alignment of FIRE and 5G in terms of facilities, services and experimentation actions (2016-2017)	SMEs are key target group of FIRE, with Open Calls specifically dedicated to SMEs (2018) Professionalisation of FIRE services marketing
FIRE Framing conditions solutions	Professionalisation of FIRE's internal organization (2015) Collaboration agreements in place between FIRE and large initiatives such as 5G PPP (2015)	FIRE is established as legal entity to ensure sustainability and professionalization A Network of Future Internet Initiatives is established (2016-2017) Cross-initiative collaboration in the Future Internet domain is implemented to enable seamless interconnection	FIRE, within NFII, is operating as legal entity to ensure sustainability and professionalisation

7. Conclusions and Outlook

This document presents a preliminary version of the FIRE Roadmap towards 2020; this will be iteratively refined over the coming months. Further electronic polls, workshops and community dialogue will feedback into the final shape of the roadmap:

- Electronic polls on monthly bases will continue during the remainder of 2014.
- The Roadmap will be actively disseminated, and the community will be invited to collaborate, using the FIRE Portal and LinkedIn.
- A Technical Workshop, discussing technological trends and potential elements of the next Work Programme 2016-2017 is scheduled for 18th September 2014.
- A FIRE Forum meeting will be held on 15th October, in which the FIRE Roadmap will be further discussed and validated.
- Next workshops planned for January 2015 and April 2015 will also highlight the Roadmap.

To conclude this document we recommend three key solutions to consider and implement in 2016-2017 work programme as a first milestone on this roadmap:

1) Support action to sustain a FIRE federation

With Fed4FIRE continuing towards conclusion, there must be consideration towards the future of this cross-domain facility. We recommend that a support action is proposed to operate FIRE experiments on the federation (based upon the information gathered from the sustainability year of the Fed4FIRE project. Such a support action would manage day-to-day operation; manage a pot of money for experiments and new federation resources accessible via open calls; and support open-access users.

2) Balance the Future Internet pillars towards converged federation

Consider prioritised services based resources such as IoT facilities and Big Data resources; greater emphasis on persistent storage of experimental results and knowledge as a service captured from previous experiments.

3) Increased alignment with relevant initiatives

Put instruments in place to investigate and deliver strategic, technical and operational alignment with initiatives such as the FI-PPP and 5G-PPP.

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[9] XIFI, "XIFI Showcases Design V1," Deliverable D6.1, 2014.

[10] Fed4FIRE, "Second sustainability plan," Deliverable D2.6, 2014 .

[11] AmpliFIRE, "FIRE COLLABORATION MODELS," Deliverable D3.1, 2014.

Appendix A: FIRE Workshop on the FIRE Roadmap (FIA 2014, March 2014, Athens)

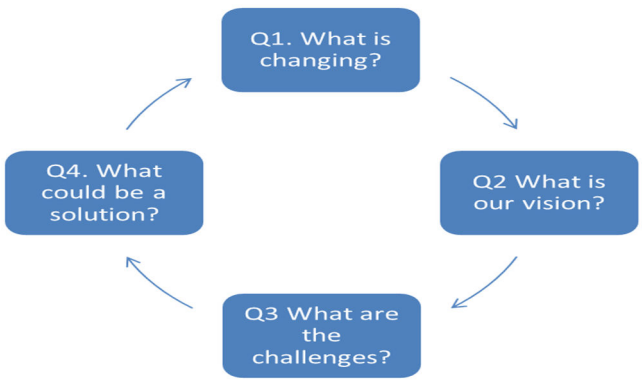
Chair persion: Martin Potts, Martel

Session 1: Introducing the FIRE roadmap, Paul Grace, IT-Innovation

The first session of the workshop consisted of a short 30 minutes presentation introducing the FIRE roadmap activity, and also the scope of the work within the FIRE Radar. The four FIRE scenarios were presented as potential targets on the path to future FIRE with the goal of provoking the audience to think about what they thought future FIRE should look like, and how they think we should get there. Subsequently, the initial structure of the roadmap was presented in terms of layers where the roadmap should focus on i.e. services, users, etc. After a short discussion there was general consensus regarding these layers with provisions that FIRE services should better focus on the reporting and evaluation monitoring aspect of the experimentation service.

Following this, Paul Grace presented to methodology for the second part of the workshop which was an interactive session collecting input and feedback from the audience. For several different "layers" (users, technology, services, trust, external factors, etc.) of the roadmap we asked the audience to fill in post-it notes to answer the following questions:

1) **What is changing**? Identifying the key trends and uncertainties in FIRE's environment which are driving alternative futures of FIRE, and constructing future scenarios related to uncertainty factor outcomes. This is mostly done in T1.1.
2) **What is the vision**? Vision is not carved in stone but part of the exploratory process of FIRE vision dialogues, and in the process debating FIRE's mission and objectives. These are seen as adaptive to short and longer term future developments. Part of the vision development process is to identify options for the future through scenarios that stretch imagination and represent alternative development paths for FIRE. This is done in D1.1 and also in T1.2.
3) **What are the challenges**? Challenges and gaps to be addressed for realizing the FIRE vision. This is part of T2.1.
4) **What are the solutions**? These are meant as the provisional next steps in FIRE's development, they may include partial (elements of) strategies, novel elements in the FIRE program, and form the basis for setting out a roadmap towards the future.



The FIRE Radar community dialogue

The workshop participants were answering the four questions about the FIRE roadmap as illustrated in the figure below. Over-all, this follows an effective structure for engaging with stakeholders regarding future planning: i) identify a set of layers that can be considered individually, ii) ask what is changing in this layer, where do you see it in the future, what are the challenges to get there, and what solutions can be followed.

Layers	What is changing	What is the vision 2020	What are the challenges	Directions for solutions
Experimental facility: user demands				
Facility infrastructure: technologies, tools, federation				
FIRE Experimentation Services				
Users of the experimental facility				
Trust, security, ease of use				

Structure for stakeholder engagement on the FIRE Roadmap

First the audience openly discussed the presented layers (or aspects) of FIRE that are considered important for the road map milestones. The workshop participants then filled out post-it notes for each of the questions for a particular layer i.e. first they posted "what is changing", then "what is the vision", in the final session the "challenges and solutions" were merged into a single post-it input.

A significant response was collected during the workshop: in the one hour interactive session we collected over 100 post-its.

Follow-up after the workshop

These results have been analysed for input into the FIRE roadmap wiki where the full results of the workshop have been made public to the FIRE community. The results have been used to initiate the electronic polls (Appendix B) and will be input to the next road map workshop (September 2014) and FIRE Foirum (15 October 2014).

The results from all of the post-its (over 100) are presented on the FIRE Wiki - http://wiki.ict-fire.eu/index.php/FIA_2014_-_1st_FIRE_Roadmap_Workshop.

Appendix B: Electronic Poll Results

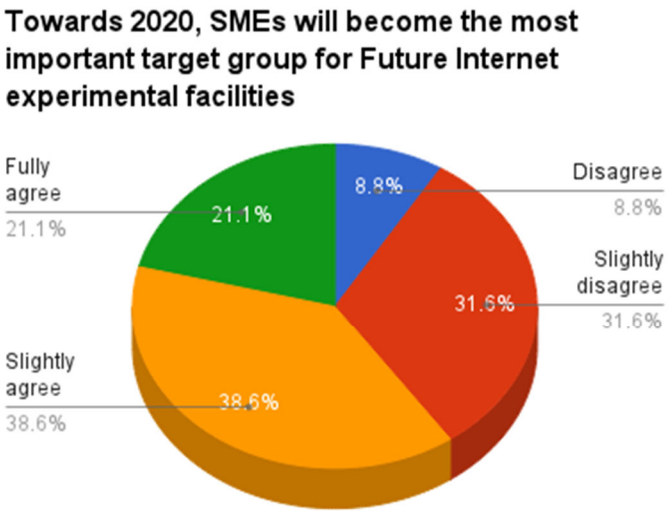
FIRE Poll 1

The first FIRE poll concentrated on the importance of industry and SMEs within FIRE (now and in the future). The objective was to assess the extent to which: i) FIRE is currently changing in terms of increase or decrease of industry based usage; ii) the vision of the community in what they saw the role of industry in Future FIRE; and iii) what solutions the community believe are important to change the current situation.

The poll itself was composed of four statements about a future roadmap for the FIRE Ecosystem, where the importance of industry and SMEs are considered. We advertised the poll to the broader FIRE community using the FIRE News mailing list, the FIRE LinkedIn group, and Twitter.

Question 1

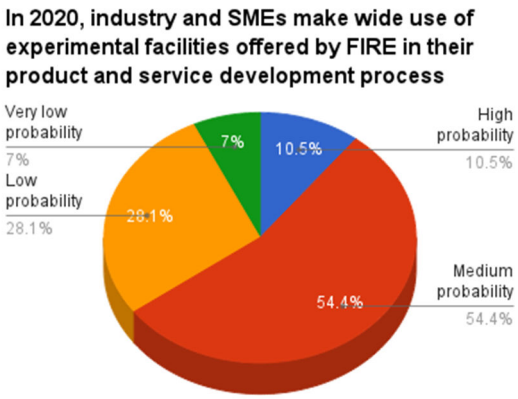
Towards 2020, SMEs will become the most important target group for Future Internet experimental facilities. To what extent do you agree with this statement?



The results do not indicate a strong trend. Hence, it is clear that the community do not strongly agree that SMEs will be the most important stakeholders; instead it is likely that SME importance will grow alongside the traditional experimenters (academic and industry R&D).

Question 2

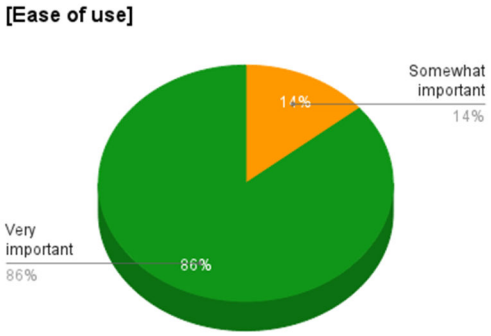
In 2020, industry and SMEs make wide use of experimental facilities offered by FIRE in their product and service development process. What do you think the probability of this occurring is?

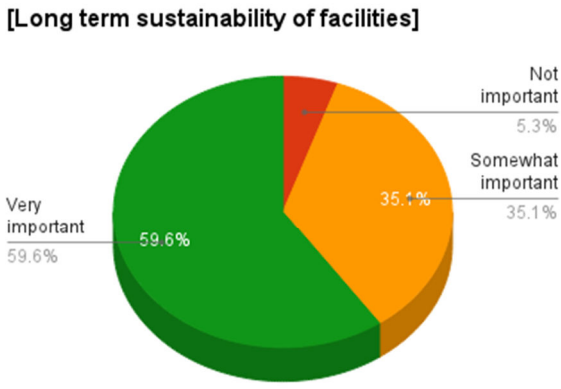


The results again indicate that the community does not see a wide ranging change in FIRE usage by SMEs, while it may be likely that SMEs begin to use FIRE more. The question remains, does FIRE provide the value to SMEs to instrument larger change.

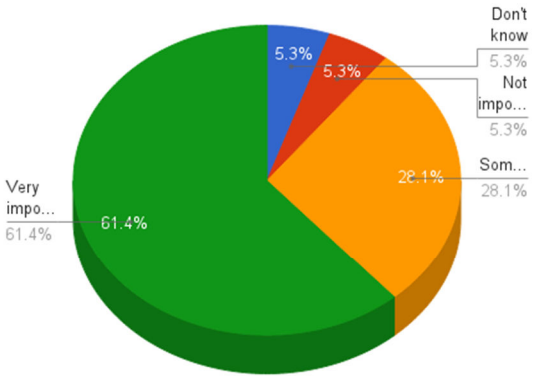
Question 3

A wide adoption and utilization of Future Internet experimental facilities by industry and SMEs requires a number of important characteristics of FIRE facilities.Weight the importance of the following factors in influencing industrial adoption of FIRE.

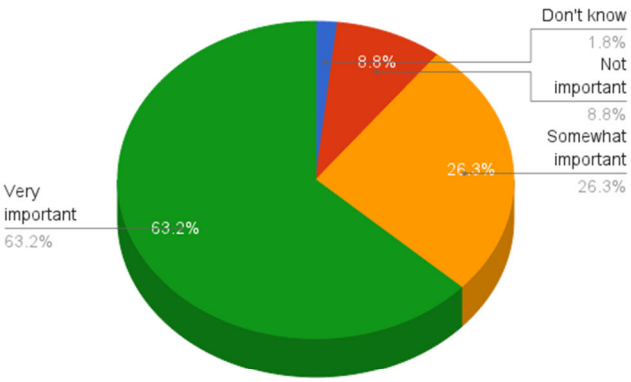




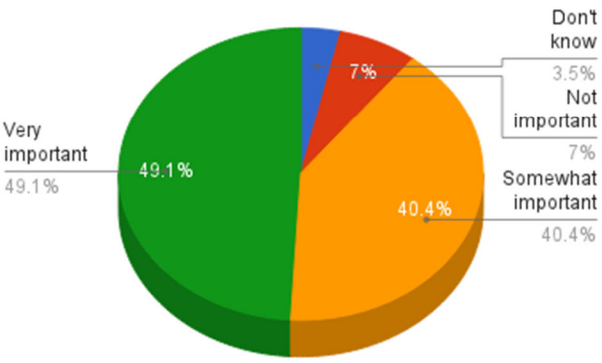
[Repeatability and reproducibility of experiments]



[Trustworthiness and security of facilities]



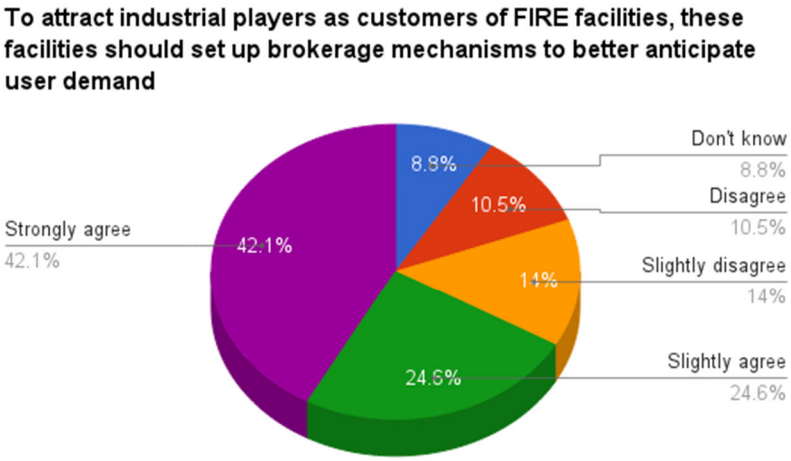
[Quality of Service guarantees]



The results clearly indicate and confirm the importance of maturity in FIRE facilities and that if industry adoption is be achieved then then trustworthiness, ease-of-use, QoS and reproducibility within FIRE must be improved. Sustainability is also central, without long-term guarantees the risk of using FIRE is amplified.

Question 4

To attract industrial players as customers of FIRE facilities, these facilities should set up brokerage mechanisms to better anticipate user demand. To what extent do you agree with this statement?



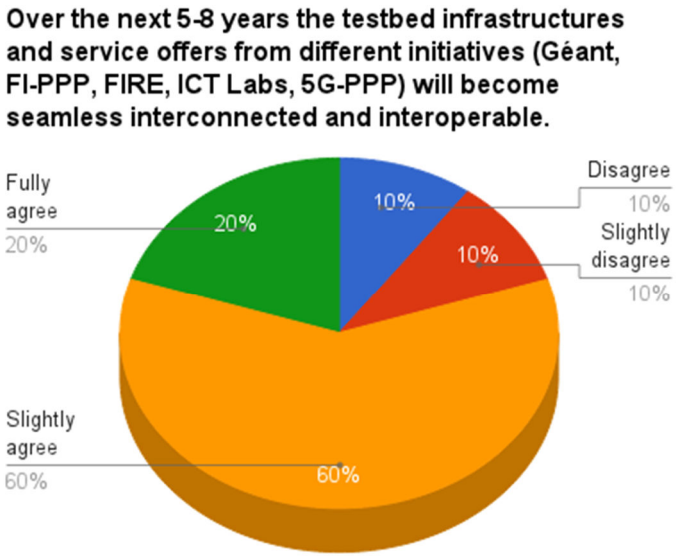
Where industry participation is wanted, the benefits of a broker are positive for many in the community; however, it is not a clear cut trend to suggest the implementation of a dedicated broker service.

FIRE Poll 2

The following are four statements about a future roadmap for the FIRE Ecosystem, where we consider the future service offering provided by FIRE. Please provide your opinions about these statements.

Question 1

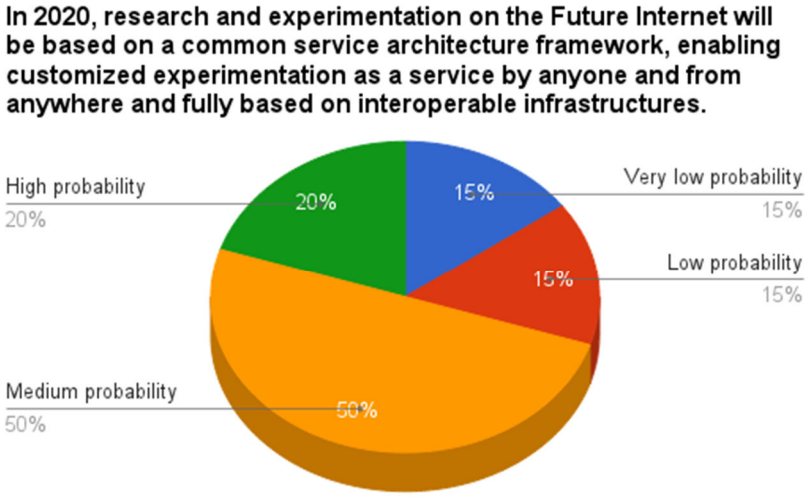
Over the next 5-8 years the testbed infrastructures and service offers from different initiatives (Géant, FI-PPP, FIRE, ICT Labs, 5G-PPP) will become seamless interconnected and interoperable. To what extent do you agree with this statement?



The results demonstrate a moderate agreement with the statement. Probably there are still technical, organisational and policy bottlenecks that hinder the realisation of "seamless interconnection"of infrastructures and service offers.

Question 2

In 2020, research and experimentation on the Future Internet will be based on a common service architecture framework, enabling customized experimentation as a service by anyone and from anywhere and fully based on interoperable infrastructures. What do you think the probability of this occurring is:

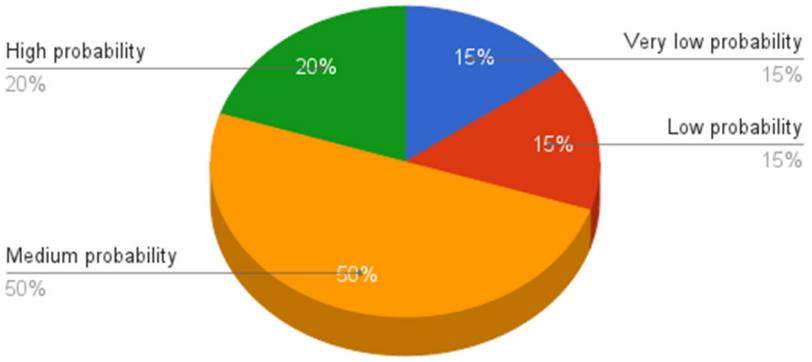


There seems to be a fairly positive view about the statement; with medium to high probability of 70% of respondents.

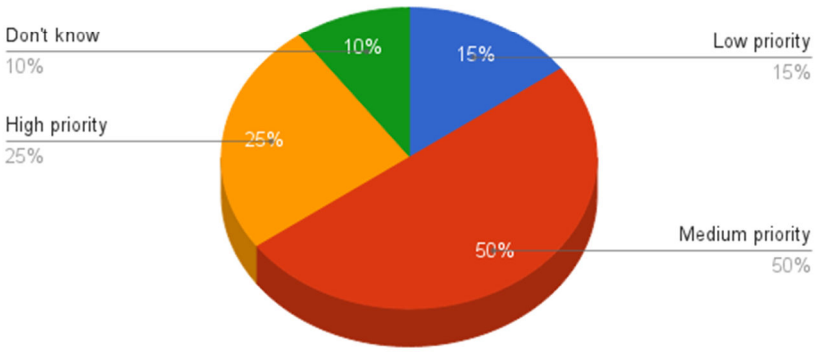
Question 3

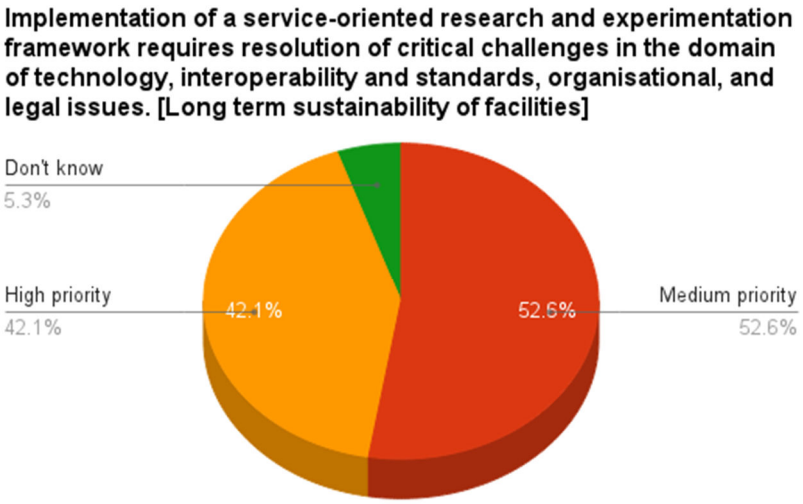
Implementation of a service-oriented research and experimentation framework requires resolution of critical challenges in the domain of technology, interoperability and standards, organisational, and legal issues. Weight the importance of the following factors in influencing the implementation of the service offering:

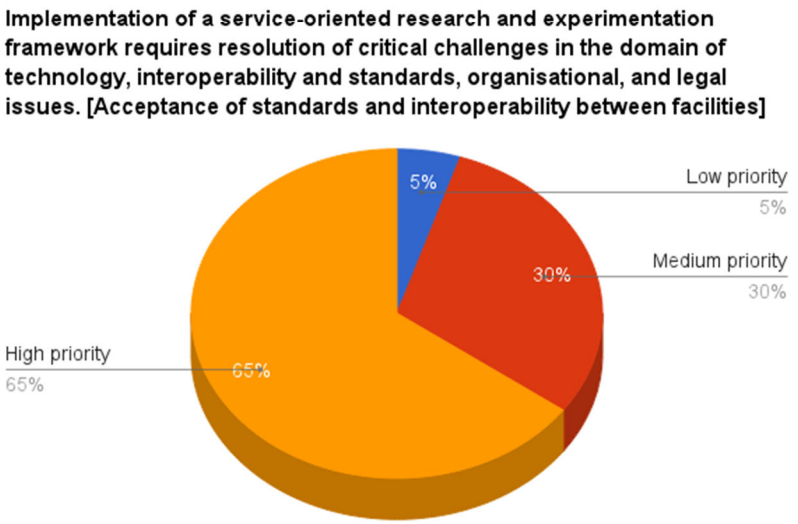
In 2020, research and experimentation on the Future Internet will be based on a common service architecture framework, enabling customized experimentation as a service by anyone and from anywhere and fully based on interoperable infrastructures.



Implementation of a service-oriented research and experimentation framework requires resolution of critical challenges in the domain of technology, interoperability and standards, organisational, and legal issues. [Organisational and legal]



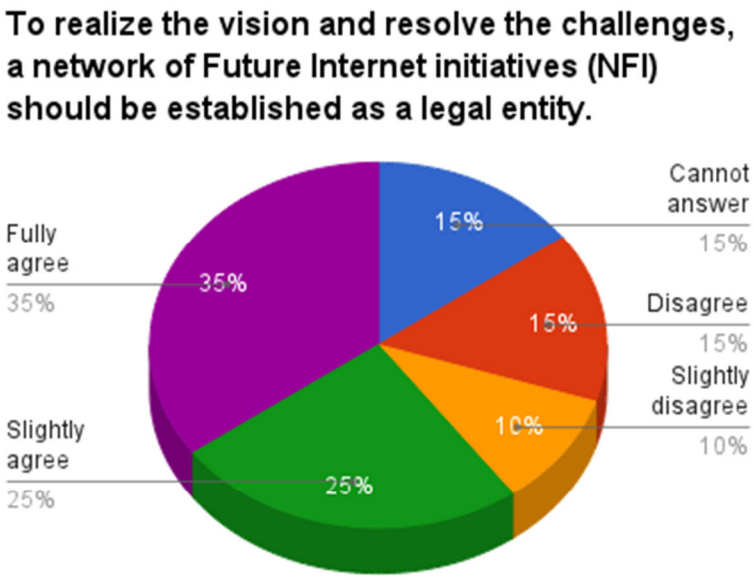




This questions goes one step beying Question 3 which invites for probability estimates. The question tries to identify conditions and bottlenecks. From the response it can be concluded that technology, interoperability and standards, organisational, and legal issues are all important, with medium to high priority.

Question 4

To realize the vision and resolve the challenges, a network of Future Internet initiatives (NFI) should be established as a legal entity. To what extent do you agree with this statement?



The response to this question induicates considerable agreement with the need to establish a legal entity. However there is also a considerable group that is not sure or disagrees. This is an issue that should be further debated in the community.