

# **Future Internet Research and Experimentation**

**Discussion at the conference "The Future of the Internet"**

**31 March – 2 April 2008, Bled – Slovenia**

***DRAFT* Report of the break-out session on**

**"Future Internet Research and Experimentation"**

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# 1 Session outline

## Plenary Presentation of the Issues Paper (see Annex A)

Anastasius Gavras (Eurescom GmbH, Panlab/PII, FIREWorks)

1 April 2008, 10:30 – 12:30 (15 minutes)

## Break-out session:

2 April 2008, 9:00 – 12:30

The session started with about one hour of short position statements from different perspectives followed by a group discussion on the topics of the issues paper.

These topics were organised in four blocks as follows:

Collect requirements	Supporting the research cycle	Design principles	Sustainability, governance, industry
<p>Scope and expected value of concrete and visionary research</p> <p>What must be supported by a large-scale experimental facility?</p> <p>How to allow for testing of technologies on the network as well as on the service layer?</p> <p>A complex system cutting across many layers</p> <p>Vertical vs. horizontal integration</p> <p>How can end-users be effectively involved?</p> <p>How to incorporate user-driven innovation?</p> <p>How to assess the usability and socio-economic impact?</p>	<p>How can the experimental facility effectively support the research cycle?</p> <p>How to meet future requirements for experimentation by ongoing research?</p> <p>How to plan for future inclusion, integration, and use of maturing testbed prototypes?</p>	<p>Configuration, roadmap and offering of relevant projects</p> <p>Availability of testbed services in 2-3 years</p> <p>Design principles and characteristics of the FIRE facility</p> <p>federation, virtualisation, auto-configuration, modularisation, security, adherence to open standards, use of open source...</p>	<p>How will fundamental federation principles be applied?</p> <p>openness in provisioning and use, excellence of the offering, governance and management of the federation</p> <p>Joint industry commitment and academic involvement</p> <p>How to promote close collaboration?</p> <p>How does this collaboration contribute to the sustainability of the facility?</p>

## Objective and target audience:

Taking the opportunity of participation to the Bled Conference of all Future Internet related projects of Challenge 1, the major focus of the session was to discuss the relationship of the FIRE initiative with the research community. In detail, the goal was to discuss the configuration and offering of the FIRE facility versus the requirements and expectations of the research community, as well as to discuss the concept of experimentally-driven research towards the Future Internet.

## 1.1 Draft Agenda

Session organiser: Max Lemke (EC-INFISO-F4)

Co-chairs: Serge Fdida (serge.fdida@lip6.fr), Anastasius Gavras (gavras@eurescom.eu)

Rapporteur: Georgios Tselentis (EC-INFISO-F4) in collaboration with the PANLAB project

### Opening

Mario Campolargo, EC-INFISO, Director "Emerging Technologies and Infrastructures"

### Offering of relevant testbed infrastructure projects

Onelab / Onelab2: Serge Fdida, UPMC

Panlab / PII: Anastasius Gavras, Eurescom

Federica: Mauro Campanella, GARR

UNITE: Georgios Kormentzas, University of Aegean

### The testbed offering and the testing needs of the ETPs

The eMobility White Paper on Experimental Research: Rahim Tafazolli, University of Surrey

NESSI: Serge Druais (including the NEXOF project), Thales

### The needs of the research community

ANA: Martin May, ETH Zürich

4Ward, Henrik Abramovicz, Ericsson

Trilogy, PSIRP: Dirk Trossen, BT

SENSEI: Mirko Presser, University of Surrey

Resume-Net: Bernhard Plattner, ETH Zuerich

SOA4ALL, BEINGRID: Santi Ristol, ATOS

ASPIRE: Alben Mihovska, Aalborg University

HDTV-Optics: Sergi Figuerola, i2Cat

Security: P. Soria-Rodriguez, Atos Research & Innovation

## 1.2 Opening

### 1.2.1 M. Campolargo: Expectations - offering in 2-3 years

Mario Campolargo welcomed the participants and expressed his expectation for cross-fertilisation among the relevant areas towards the future internet. The complexity of the future internet requires a new holistic approach and large-scale testing.

## 1.3 Offering of relevant testbed infrastructure projects

### 1.3.1 Serge Fdida, Onelab / Onelab2

Serge Fdida presented the basic design which originates in the PlanetLab. The PlanetLab design is extended and deepened, maintaining the federation principle. The extensions include wireless testbeds (WiFi, UMTS) and the use of emulation. Deepening means improvements in the network monitoring area, e.g. by the introduction of a distributed topology tracing system.

PlanetLab Europe is now federated with the PlanetLab US. The future work includes strengthening of the three pillars, namely platforms, tools and customers. Currently liaisons are

established with the projects ANA, PRISP and 4ward. International cooperation is being developed especially with Japan, Australia and the Federica project.

### **1.3.2 Anastasius Gavras, Panlab / PII**

The main goal of Panlab and PII is to federate independent testbeds without imposing restrictions to the individual testbeds. A testbed repository will store the necessary information for identifying suitable testbeds or testing components. The discovery, composition and provisioning of testing environments will be supported by the Teagle tool.

PII will develop mechanisms to assess and compare testbeds and testing components based on user/customer feedback. PII is able today to offer testing environments based on the offerings of the partners in isolated testbeds. In about 2 years PII will be able to offer federated testing environments.

### **1.3.3 Mauro Campanella, Federica**

Federica is a new FP7 project, which started in January 2008 in the infrastructure programme. Its goal is to better understand virtualisation and to provide a network factory for researchers. The network factory provisions "slices" which are composed of computing elements and networking capabilities offering an agnostic environment for testing. The user will be offered full control of its slice.

The project being an infrastructure project is not doing extended research, but rather focuses on control management and monitoring of virtualised infrastructures. Federica uses resources of GÉANT2 and of the national research and education networks (NRENs). It is open to interconnect to other infrastructures.

By October 2008 the project will be open for first experimentations up to and including the network layer. In later phases the allowed experimentation will include also the data link and physical layers.

The usage will be in principle free of charge, unless special needs need to be considered. It will be open to anybody including the private sector.

### **1.3.4 George Kormentzas, UNITE**

The project UNITE provides a virtual distributed testbed enabling the sharing of hardware and software components for simulation. The project developed a simulation plan editor, which helps a researcher to configure a simulation environment. The current environment consists of 7 clusters on top of which simulation plans can be deployed.

Two Greek SMEs are currently considering the commercialisation of the tools. The project results will be demonstrated at the ICT summit in Stockholm (June 2008) and the International Week on Management of Network and Services in Samos, Greece (Sept. 2008).

### **1.3.5 Discussion**

On the question of how interconnection is done, Anastasius Gavras said that Teagle knows about available and possible connectivity. Controlling the connectivity is done via IMS.

Max Lemke added that there is an umbrella project called FIREworks which facilitates exchange between Panlab / PII and Onelab / Onalab II.

On the question when an experimental facility in Panlab will be available, Anastasius Gavras answered that in 2 years, Teagle will be able to offer interconnected distributed testbeds. The more resources are in the repository, the richer will be the testing environments.

On the question of how PII and Onelab2 compare, it was stated that while Onelab2 is based on the PlanetLab concepts and extends them, PII is starting from existing available testbeds.

FIREworks is the vehicle that aims to support any possible convergence among the two projects. One possible area is the sharing of tools, especially for network monitoring.

On the question of PII impact on the clusters, it was stated that the ambition is not to require any changes inside the individual testbeds that are being federated.

## **1.4 The testbed offering and the testing needs of the ETPs**

### **1.4.1 The eMobility White Paper on Experimental Research: Rahim Tafazolli, University of Surrey**

Experimental facilities are needed for post-IP future Internet research, especially in a clean-slate approach. There is a need for a pan-European testbed. eMobility has published a white paper with recommendations in this area. The most important requirement is not to be constrained by current architectures and technologies. Such a pan-European testbed should be flexible in various directions and facilitate IPR protection in order to involve all stakeholders.

The main recommendations for the experimental facilities are:

- Provide unconstrained connectivity to experimental facility to address challenges in Future Internet design: overall architecture, manageability and governance;
- Provide dependable Post-IP research and technology development facilities that enable the set up of experiments at the right scale under realistic operational conditions;
- Provide a framework for investigation, prototyping and evaluation that is neither limited by current technologies nor by the current Internet architecture and that encompasses any device, content and system present in the world that is not directly and naturally part of the Internet today;
- Provide effective and efficient test-bed control/management architecture that guarantees isolation, protection and correct behaviour under different and extreme conditions

To support the definition of experimental facilities the white paper includes a reference model that describes all the issues that need to be addressed and which is available from the eMobility web site.

### **1.4.2 NESSI: Serge Druais (including the NEXOF project), Thales**

The NESSI members will be users of testbed infrastructures. The NESSI vision is to establish a full-scale European demonstrator as a proof-of-concept of the NESSI open framework. This demonstrator is a network of testbeds and will be able to host industrial users, academics as well as other users, such as institutions from the EC or the member states. The users care less about networks and protocols, but about access to services.

The aim is global convergence of services and users with testing capabilities at all layers. To support this aim end-to-end scenarios with real applications are needed. FIRE is an opportunity for research and collaboration across domains.

### **1.4.3 Discussion**

On the question how to populate a testbed with real-life usage scenarios, there was no answer but the acknowledgement that we must address this issue.

The experimental infrastructures that can support the requirements of the ETPs must be very flexible and well defined.

## **1.5 The needs of the research community**

### **1.5.1 ANA: Martin May, ETH Zürich**

Many testbeds are available but there is a lack of awareness about them. We need testbeds that go beyond PlanetLab and include access to the media (fibre, cable, wireless...), heterogeneity of devices (routers, mobile devices, sensors...), users (not only research traffic, platforms to host experimental services...) as well as application and services.

ANA is designing and building a new network architecture, while Haggie is building a platform for opportunistic networking. Ultimate goal is to have developers using these frameworks to build new networks/protocols/services. ANA will integrate its architecture in smaller/mobile devices.

ANA sees several challenges and expectations towards future networks, such as federation of testbeds and their management, how to initiate large-scale measurement campaigns, how to integrate social interactions, what is the inter-relationship between service and network layer and finally how to handle data sharing (e.g. anonymisation of monitoring data).

### **1.5.2 4WARD, Henrik Abramovicz, Ericsson**

4WARD is working on a clean slate approach to define architecture and concepts for the future Internet. Issues are naming, addressing, business relations.

4WARD follows a cyclic approach: Architecture > Design > Demo > Testing

Sustainability and coordination of testbeds are important issues.

### **1.5.3 Trilogy, PSIRP: Dirk Trossen, BT**

Dirk Trossen presented perspectives on needs of the research community. The customer perspective is partitioned in (i) relevance, (ii) liveability, and (iii) evolvability.

On the relevance, it seems obvious that a test bed should be driven by the needs of the research community. Contemporary research areas can drive the extension (and therefore increase in usefulness) of any test bed

On the liveability he asked for controlled experiments with direct end user participation, which is hard to achieve because it requires means to work with a different community, means to isolate partitions of the network and to easily federate/integrate purpose-built local testbeds.

Evolvability of the test bed (and its innovation processes) can be a model for evolving towards (a potentially disruptive) Future Internet.

### **1.5.4 SENSEI: Mirko Presser, University of Surrey**

The SENSEI project integrates wireless sensor networks into IMS service platforms and can be considered a consumer and a provider of experimental facilities. The project is committed to provide a long-term test platform for wireless sensor networks and their applications. First test on the SENSEI platform will start in 2008.

### **1.5.5 Resume-Net: Bernhard Plattner, ETH Zuerich**

The main objectives of Resume-Net is to systematically embed resilience into the future Internet along three dimensions: (i) conceptual framework, (ii) Mechanisms and algorithms for network and service resilience, and (iii) experimentation in testbeds.

The planned experiments include (i) resilient routing and medium sharing in wireless mesh networks, (ii) resilient forwarding in opportunistic networks, (iii) service-level resilience evaluation and (iv) resilient smart environments.

The desired properties of a wireless testbed include experimentation with real transmitters/receivers, scalability, mobility and repeatability

A sustainable experimentation facility required and the main question is how to transfer a project testbed to a sustainable testbed.

#### **1.5.6 SOA4ALL, BEINGRID: Santi Ristol, ATOS**

BeinGRID has performed 25 business experiments and is looking for common facilities in order not to repeat experiments that have already been performed.

The main objective of future work is towards a global interoperability test framework containing heterogeneous project results. The requirements for federated testbeds include hardware virtualisation to enable independent resource access and allocation and customisation of platform based on governance policies to enable simple management & sustainable operation.

There is a need for a common reference architecture and common interfaces, allowing a true SoA approach for tests.

#### **1.5.7 ASPIRE: Albena Mihovska, Aalborg University**

ASPIRE researches a new approach towards deployment of Radio Frequency Identification (RFID) solutions to overcome the cost-barriers for the successful adoption of this technology. It focuses on open source middleware, innovation in the field of RFID technology, a common framework for a multitude of users, standards and tools as well as on interoperability.

The main challenges are the wide range of software systems, including distributed objects and components, message-oriented communication, and mobile application support. Scalability, interoperability and complexity are hard problems. Further challenges include the integration of previously independent solutions with new developments, the agreement on common instead of dedicated interfaces and dealing with the heterogeneity of networked devices.

#### **1.5.8 HDTV-Optics: Sergi Figuerola, i2Cat**

The rapid development in the area of multimedia technologies (2K,4k in particular) creates a set of new requirements in terms of infrastructure, video technology, tools and digital repositories. There is a need for a Europe wide media e-Infrastructure for future research on visualisation and media.

There is a need to develop a federated multimedia content management and distribution infrastructure and to evaluate and refine the content distribution and transmission techniques. Further needs include a scalable storage repository strategies across heterogeneous networks and a semantic framework to describe services, storage, content and its connectivity to high speed transport networks

#### **1.5.9 Security: P. Soria-Rodriguez, Atos Research & Innovation**

Security is needed for protection of assets. This includes the infrastructure (physical and logical) as well as the content (applications, software and experiments).

Threats and vulnerabilities on the infrastructure include for example stealing of unassigned resources for slices, exceeding the time duration of experiments and access control to resources. Confidentiality might not be an issue since it is not a production network.

Threats and vulnerabilities on the content include unauthorized access to not owned content, vulnerability of non-mature experimental content, and confidentiality of experimental content (methods, software, etc.)

### **1.5.10 Discussion**

The main discussion accompanying the presentations of the research projects was centred around the challenge to converge the existing initiatives. As an example in the Internet of Things there is a large variety of protocols available. A good example of convergence is the case of Onelab2 that is working with Huggle to provide an experimental environment.

## **1.6 Overall Discussion**

### **1.6.1 Collect requirements**

#### **Scope and expected value of concrete and visionary research**

The central question that was discussed was “What must be supported by a large-scale experimental facility?”. Topics that must be addressed include:

- Establish methodologies to select the right experiments
- Establish methodologies for benchmarking experimental results
- Achieve repeatability and reuse of testbeds, but first we need an environment where testbeds are defined before we can repeat them
- Establish a repository of results and testing methodology
- Provide incentives for sharing testbed data
- Allow evolution of testing cases, because application requirements change over time. Allowing real-life users and real-life deployments is important.
- Consider the usability of platforms. Tools and interoperability are required.
- Do not aim for a general platform for all testing. One size doesn't fit all.
- Develop common, suitable methodologies for testbeds, to make them reusable
- Develop ways that allow testbeds to operate differently than the currently existing ones, e.g. via the deployment of overlay networks
- Consider previous experience to avoid duplication, e.g. consider the results, of the Grid community
- Support large scale data computation

#### **How to allow for testing of technologies on the network as well as on the service layer?**

The topics that must be addressed include:

- Need for testbeds to test the future Internet. We have to be careful in defining the scope
- Need for more non-networking testbeds: service testbeds, data-centric testbeds
- Need to stop distinguishing between services and networks

#### **How can end-users be effectively involved?**

Including users in the testbed is very beneficial since user stress the testbed. However users and testbeds are generally incompatible. The topics that must be addressed include:

- Provide incentives to users for using the testbeds
- Provide incentives to open up testbeds for other users
- Privacy and management issues involved in end-user tests.

### **How to incorporate user-driven innovation?**

There is a general agreement to find ways to connect technology testbeds with the Living Labs concept. In this context there is:

- Need to examine benchmarking models for user testing and apply them on network testing.

### **1.6.2 Supporting the research cycle**

#### **How can the experimental facility effectively support the research cycle?**

The main topic that was addressed is the question of how to plan for meeting the requirements for experimentation by ongoing research in the long term.

Approaches that should be followed in this direction include:

- Research needs to forward future requirements by getting involved in the platform and providing feed-back on the requirements
- Establish a cross area group
- Establish an evolutionary methodology to allow inclusion of new testbeds and retirement of non useful testbeds
- Work on the convergence of the different layers. PII plans to be layer agnostic and to support vertical integration of layers.
- Provide a clear and consistent testing schedule – Not everything can be tested at the same time.
- Provide schemata of testing scenarios
- Plan for broadening and renewal of testbeds
- Establish a critical mass for an experimental facility
- Establish a standardised methodology of research to support the research cycle
- Establish methodologies to combine two or more experiments.
- Provide incentives to attract testbed users
- Provide clarity on whose research cycle to support. It is mainly the research cycle of projects that has to be planned into the schedule of the testing facility
- Address trust and scale in services

### **1.6.3 Design principles of the experimental facility**

The main design principles that make an experimental facility useful are:

- Ease of accessibility and use of the testing facility
- Security and identity management. Some of the security aspects are inherent, as assets of testbed providers are federated.
- Minimum level of accountability
- Minimum quality of repeatability of tests
- Every testbed should be able to connect to the current internet and to other testbeds
- Build a facility that is completely QoS-proof; the testbed should run better than the real world network

#### **1.6.4 Sustainability, governance, industry**

Interesting testbeds emerge when a testing scenario is close to a commercial product or service, but issues of confidentiality and governance become crucial.

The experimental facility must address the following issues:

- Clarity of what type of contracts are offered to the users of the testbed
- Clarity on the openness of the testbed. The facility will be open to everyone
- Define level of guarantees for confidentiality and anonymity. Anonymity is not easy although concepts with proxy functionality could be used.
- Define clear rules for liabilities

On the sustainability of the facility the financing issue must be clearly addressed. There exist several approaches:

- Paying model. This model implies service guarantees by the testbed service provider, which currently can hardly be provided
- Share resources. This model implies that the value of resources must be identified as well as the labour cost of the people that run the system.
- Pay partially. The UNITE model is to pay for access to the repository

Recognising the fact that the operational expenses of an experimental facility can be significant, further financing models include:

- Own funds of the projects
- EC or other public funding
- Industry or other interested sponsors pay for the commercial benefit

A joint approach to funding is necessary. Industry and academia should get equally involved in the elaboration of a financing model. This is a long-term approach.

However if the principle of federation is applied intelligently, then this could be sufficient for the sustainability of the facility. As a general principle an independent authority should be operating the facility. The vehicle of a Joint Technology Initiative (JTI) was proposed.

### **1.7 Participation**

Participation in the initiative is open to all parties interested in future internet research and experimentation. The initiative is organised through the support action FIREworks (<http://www.ict-fireworks.eu>)

# Annex A Introduction to AREA 6 "Future Internet Research and Experimentation"

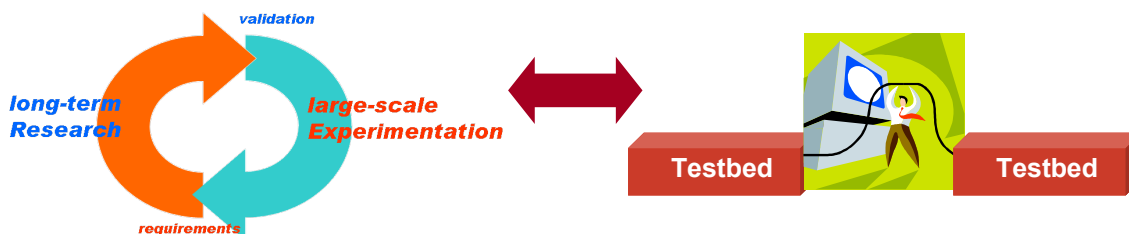
Draft Issues Paper for discussion at the conference "The Future of the Internet"

31 March – 2 April 2008, Bled - Slovenia

Work under the area of experimentally-driven research and experimental facilities, which is also known under the acronym FIRE – "Future Internet Research and Experimentation", has two related dimensions, for which a total of 14 projects has been selected in ICT Call2.

1. Experimentally-driven research on new paradigms and advanced networking approaches for the future internet: many networking researchers around the world have identified emerging limitations of the current Internet architecture and agree that it is time for research to take a long term view and to reconsider the basic architecture of the Internet, to see if any improvement can be identified, even if it does not appear to be backward-compatible at a first glance. To be effective and to produce applicable results, this fundamental research in new paradigms has to be tested, at least as a proof-of-concept, in large scale environments, so as to assess the feasibility of the new concepts, verify their large scale effects (not only at technological level, but also as for their foreseeable implications on users, society and economy) and derive further requirements, orientations and inputs for the research. This kind of experimentally-driven approach avoids that the research efforts will remain at the level of paperwork and will hopefully allow exploring significant improvements over the current Internet.

2. Interconnected testbeds on networks and services: it is envisaged that the interconnected testbeds supported in this area will evolve from gradually federated testbeds towards becoming a sustainable, dynamic, and integrated large scale experimentation facility supporting academia, research centres and industry in their research on networks and services. As opposed to the functionality of individual testbeds, the federation of testbeds will allow testing at larger scale and at system-level. The interconnected testbed activities in this area are open to any relevant European projects within other Objectives of FP7, as well as national, regional or multinational initiatives. These projects will be able to use the facilities or to federate their testbeds within the facility.



The FIRE approach considers the Internet not just as an "interconnection of networks", in terms of component technologies, but as a complex system, where the introduction of a new technology or protocol, even if confined to a specific layer, may have profound consequences on other layers of the Internet or implications in terms of the possible services and applications which can be supported, and ultimately on socio-economic aspects, given the increasing role and shaping effect of the Internet on the very fabric of our society.

In their first report published in May 2007, the FIRE expert group has defined FIRE as "a research environment for investigating and experimentally validating highly innovative and revolutionary ideas". Several workshops held in recent months have confirmed the necessity of developing the FIRE experimental facility in close collaboration with experimentally-driven research on new architectures and paradigms for the Future Internet which need large scale testing or proof of concept.

## FIRE experimentally-driven research vision

There is an increasing demand from academia and industry to bridge the gap between long-term research and large-scale experimentation, which can be done through *experimentally-*

*driven research* consisting of iterative cycles of research, design and experimentation of new networking and service architectures and paradigms for the Future Internet addressing all levels. FIRE experimentally-driven research in future is suggested to address broad system-level research which views the Future Internet as a complex system and which proves and exploits the full value of the FIRE Facility:

- doing truly multidisciplinary experimental research
- testing new internet architectures and paradigms including at service level
- doing socio-economic impact assessments for future changes to the internet

FIRE research is characterized by its methodology, not only by the scope of the research topics. From the projects submitted and selected for the first call, a number of innovative ideas have emerged, some of which can be considered as paradigms shifts (e.g.: Cross-layer and cooperative design; Multi-hop optimization-based network design; Content and human centric networking; Autonomic, self-configured, and self-managed networking; Minimizing energy footprint and cost; Rethinking the distribution of the intelligence within the network; Integrated and flexible exploitation of heterogeneous resources such as storage, bandwidth, energy, computation, mobility, etc.; Virtualization).

In future any innovative idea relevant to future Internet architectures or paradigms would fit into FIRE research, provided that it is based, at least as a proof of concept, on real experimentations, exploiting the FIRE experimental facility or implementing a testbed on its own, to be subsequently made available in the framework of the federated experimental facility. This open approach will allow exploring more traditional as well as alternative paths, which challenge mainstream concepts. This research on alternate paths may appear high-risk but ultimately will reduce the global risk of concentrating all efforts on a promising technology which may eventually prove to be the wrong choice.

FIRE Research is suggested to focus on research which is not limited to specific layers or technologies, but is truly multidisciplinary, cutting across several relevant domains or layers, including physics, human sciences or economics.

Issues which need to be discussed include:

1. Examples of research areas that benefit from this experimentally-driven approach.
2. Which disciplines should be specifically addressed, e.g. networking and communication, service architectures...?
3. How to effectively involve additional disciplines in the research: motivation of researchers, structural problems, etc.?
4. Which kind of socio-economic impact assessments of future changes to the Internet can be effectively forecasted?
5. The time-span of the research, and need for appropriate long-term instruments.

#### **Long term cross domain perspective of the FIRE facility**

According to many researchers, the Internet itself has been the largest-scale laboratory for emerging applications and services (skype, youtube, OSN, etc.). However, it is evident that it cannot be considered as a testbed for the basic protocols, architectures and services (see for instance the long deployment time necessary just for an updated version of the Internet Protocol and the need to keep this critical resource operational). The FIRE experimental facility will provide an open playground for this kind of research, being gradually built, based on a federation of existing relevant testbeds, and will grow according to the research needs specified by the related "customer" research projects.

The FIRE experimental facility is planned to be broadly scoped to support research on the Future Internet and its services:

- to include testbeds for different stages of the research and development cycle - from proof-of-concept type testbeds to pre-commercial testbeds

- to support testing the impact of changes to the Internet not only in technical but also in socio-economic terms
- to cover all levels from fast network connectivity to service architectures at different levels
- to be available to academia, research centers and industry including the relevant ETPs
- to allow experimentation with advanced architectures of the Future Internet taking a system view
- to build on the design principle of "open federation of testbeds"
- to allow for access of broad user communities for experimenting on "user experience"
- to become a sustainable research infrastructure for the Future Internet serving both industry and academia in their Future Internet related research and to overcome limited availability of testbeds for the duration of the projects under which they are provided

Issues which need to be discussed include:

1. **Configuration, offering and roadmap of relevant projects** in terms of availability of testbed services to the Future Internet research community as they expect it to be in 2 - 3 years from now.
2. The desired scope of the FIRE facility and the expected added value of federating testbeds by **deriving concrete, visionary, and challenging research scenarios** of experimentally-driven research which the potential users would like **to be supported by the FIRE large-scale experimental facility**.
3. The **most important design principles and characteristics of the FIRE facility**, e.g. federation, virtualisation, auto-configuration, modularisation, security, adherence to open standards, use of open source....
4. How will **fundamental federation principles** be applied, e.g. openness in provisioning and use, excellence of the offering, governance and management of the federation?
5. How can the **experimental facility effectively support the research cycle?**
  - a. Definition of the mechanisms to upgrade the facility to meet future requirements for experimentation by ongoing research
  - b. Elaboration on the incentives for both the facility providers and the research projects to engage in a testing relationship as well as definition of the mechanisms that support the planned future inclusion, integration, and use of maturing testbed prototypes in the facility
6. How can the FIRE facility be set-up to **allow for testing a broad range of technologies on the network as well as on the services levels** (protocols, architectures, services, middleware, etc.), considering the internet not just as an interconnection of networks in terms of component technologies but as a complex system cutting across many layers.
7. How to ensure **joint industry commitment and academic involvement** in the FIRE facility? How to promote close collaboration between industry and academia for investigating and experimentally validating highly innovative and revolutionary ideas? How does this collaboration contribute to the sustainability of the facility and its components?
8. How can **end-users be effectively involved** in order to provide real-world feedback? In which cases is this necessary to assess also **usability and socio-economic impact?**

**Examples of proposals selected for negotiation in this area<sup>1</sup>**

<b>Integrated Projects</b>	<b>Specific targeted research projects</b>	<b>Co-ordination and Support Actions</b>
<ul style="list-style-type: none"><li>• OneLab2</li><li>• PII</li></ul>	<ul style="list-style-type: none"><li>• ECODE</li><li>• NANODATACENTERS</li><li>• OPNEX</li><li>• RESUME-NET</li><li>• Vital++</li><li>• Wisebed</li></ul>	<ul style="list-style-type: none"><li>• FireWorks</li><li>• PARADISO</li></ul>

**Examples of other relevant Integrated Projects related to this area:**

- FEDERICA (CAPACITIES Programme)
- ANA (FP6, ending 2010)
- HAGGLE (FP6, ending 2010)
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<sup>1</sup> Important notice: because all proposals selected within this area are at this stage under negotiations between the European Commission and the consortia proposing the project, the following information is provided based on the proposal submitted and may evolve during the negotiations.