

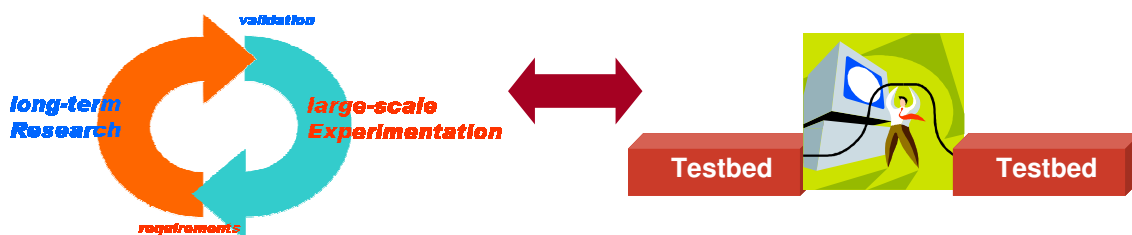
AREA 6 "Future Internet Research and Experimentation"

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*

Integrated Projects

- OneLab2
- PII

Specific targeted research projects

- ECODE
- NANODATACENTERS
- OPNEX
- RESUME-NET
- Vital++
- Wisebed

Co-ordination and Support Actions

- FireWorks
- PARADISO

Examples of other relevant Integrated Projects related to this area:

- FEDERICA (CAPACITIES Programme)
- ANA (FP6, ending 2010)
- HAGGLE (FP6, ending 2010)

* 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.